SOCIETÀ ITALIANA DI FISICA

107° CONGRESSO NAZIONALE

13-17 settembre 2021

A cura di B. Alzani, M. Bellacosa e G. Bianchi Bazzi
Redazione dei testi a cura dello Staff editoriale della SIF
Progetto grafico a cura di S. Oleandri
Società Italiana di Fisica

ISBN: 978-88-7438-127-2

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INFORMAZIONI GENERALI

Sede del Congresso

L'inaugurazione si terrà online nella mattinata di lunedì 13 settembre alle ore 9.30.

Iscrizioni

La scadenza per l'iscrizione è il 6 settembre.
I soci in regola si potranno iscrivere gratuitamente.
Per i non Soci la quota di iscrizione al Congresso è di 60,00 Euro.

Relazioni Generali, Relazioni su Invito e Comunicazioni

Nel programma sono segnalate dai seguenti simboli:

■ Relazioni Generali
▲ Relazioni su Invito
● Comunicazioni

Le Relazioni Generali, guidate dai relativi Presidenti di Sezione, e le Relazioni su Invito, guidate dai Presidenti delle Sezioni Parallele, saranno tenute "live" con possibilità di intervenire con domande e commenti.

Per le Comunicazioni è richiesta una presentazione registrata in formato mp4 della durata massima tassativa di 10/12 minuti e per un massimo di 50 Mb. I video saranno accessibili agli iscritti per tutta la durata del Congresso a partire dall'apertura della piattaforma congressuale online qualche giorno prima dell'inizio dei lavori.

L'autore, il cui nome figura sottolineato, sarà il presentatore della comunicazione. Almeno uno degli autori, possibilmente il presentatore, deve essere Socio della Società Italiana di Fisica.

Migliori comunicazioni

Un'apposita commissione segnalerà al Consiglio di Presidenza della SIF una o più comunicazioni per ogni Sezione giudicate migliori sulla base del contenuto e dell'esposizione. La premiazione dei relatori avrà luogo durante la cerimonia inaugurale del Congresso Nazionale SIF del 2022. Inoltre circa il 25-30% delle comunicazioni presentate saranno selezionate per la pubblicazione di un breve articolo (4 pagine) nonostante non facciano parte della rosa dei vincitori.

Si ringraziano i seguenti Enti che, con il loro contributo finanziario, hanno reso possibile l'organizzazione del Congresso

GSSI - Gran Sasso Science Institute
INFN - Istituto Nazionale di Fisica Nucleare
INGV - Istituto Nazionale di Geofisica e Vulcanologia
INRIM - Istituto Nazionale di Ricerca Metrologica

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CERIMONIA DI INAUGURAZIONE
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Prof. Angela Bracco

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Premio "Giuseppe Occhialini" SIF-IOP (Institute of Physics)
Premio "Friedel-Volterra" SIF-SFP (Société Française de Physique)
Premio per la Didattica o Storia della Fisica
Premio per la Comunicazione Scientifica
Premio "Laura Bassi" per le Donne nella Fisica
Premio SIF-SoNS "Neutrons Matter"
Premio congiunto SAIt-SIF "Giovanni Bignami"
Premio "Giuliano Preparata"
Borsa "Ettore Pancini"
Premi per giovani laureati in Fisica dopo il maggio 2014 e dopo il maggio 2018
Premi per le Migliori Comunicazioni al Congresso Nazionale 2020
Soci Benemeriti della SIF

Aula Plenarie **ore 11:00 – 11:55**

Sezione I

Fisica nucleare e subnucleare

Presiede: Nania R. (INFN, Sezione di Bologna)

Relazione Generale

Stato del progetto EIC, un laboratorio di QCD e di tecnologie sperimentali.

Dalla Torre S.
INFN, Sezione di Trieste

Il collisore ad alta luminosità Electron-Ion Collider (EIC) è, da fine 2019, un progetto USA approvato. Prevede lo studio della diffusione di elettroni su un'ampia gamma di ioni, dal protone all'uranio, e offre uno strumento unico per l'esplorazione degli effetti di spin grazie a fasci di elettroni e ioni leggeri polarizzati. È dunque uno strumento progettato per lo studio della QCD e per rispondere a fondamentali domande di fisica adronica ancora aperte: la comprensione della massa e dello spin dei nucleoni a partire dai loro costituenti, la loro tomografia, il comportamento di stati ad alta densità gluonica, fra cui i fenomeni di saturazione a piccoli valori di x-Bjorken. Le prime collisioni sono previste nel 2030. Il progetto è, altresì, un laboratorio tecnologico sia nell'ambito degli acceleratori (crab-crossing, strong cooling, regione di interazione e rivelatore integrati), che in quello dei rivelatori (tecnologie di frontiera per il rivelatore di vertice, ruolo fondamentale dell'identificazione di particelle in un intervallo assai ampio dello spazio delle fasi). Si descrive il progetto nella sua interezza e si riporta il suo stato di avanzamento.

Aula Plenarie **ore 12:00 – 12:55**

SEZIONE II
Fisica della materia
Presiede: PARIS M. (Università di Milano)

Relazione Generale

Unified theory of thermal transport in crystalline solids and glasses.

MAURI F.
Dipartimento di Fisica, Sapienza Università di Roma

Thermal conductivity in crystalline solids with well-separated phonon branches (namely with few atoms per unit cell) is well described by a particle-like Boltzmann equation for phonons, where the main source of scattering is anharmonicity. In such systems the conductivity decreases with temperature (T), with a $1/T$ law for T larger than the Debye Temperature (T_D). In amorphous solids the main source of scattering is the static and T-independent disorder, well described by the harmonic theory introduced by Allen and Feldman. In these systems the conductivity increases with temperature and, within the Allen and Feldman theory, reaches a constant value for $T > T_D$. Finally periodic solids with large super-cells and very low thermal conductivity can exhibit a glass-like behavior, that cannot be described by existing theories. Anharmonicity or disorder are the limiting factors for thermal conductivity in crystals or glasses; hitherto, no transport equation has been able to account for both. Here, we derive such equation, resulting in a thermal conductivity that reduces to the Peierls and Allen-Feldman limits, respectively, in anharmonic crystals or harmonic glasses, while also covering the intermediate regimes where both effects are relevant. This approach also solves the long-standing problem of accurately predicting the thermal properties of crystals with ultralow or glass-like thermal conductivity, as we show with an application to a thermoelectric material representative of this class.

Aula Chien Wu **ore 14:00 – 17:30**

SEZIONE I
Fisica nucleare e subnucleare
Presiede: MERONI C. (INFN, Sezione di Milano)

Relazioni su invito

▲ Il primo risultato all'esperimento Muon $g-2$ al Fermilab.

BOTTALICO E.
Dipartimento di Fisica, Università di Pisa, Italia e INFN, Sezione di Pisa, Italia

L'esperimento Muon $g-2$ al Fermilab (E989) ha come scopo la misura dell'anomalia magnetica del muone (a_μ) con una precisione di 140 parti per miliardo (ppb). Il 7 aprile 2021 è stata annunciata la prima misura di a_μ sui dati di Run-1 che ha confermato il risultato dell'esperimento precedente al Brookhaven Nation Laboratory (E821), migliorandone la precisione con il raggiungimento di un'incertezza complessiva pari 460 ppb inferiore rispetto alle 540 ppb di E821. Combinando le due misure sperimentali è stata osservata una tensione di 4.2 sigma con il valore teorico calcolato dal Modello Standard. Vi presenterò il risultato di questa misura di altissima precisione, approfondendo il metodo sperimentale e l'analisi eseguita.

▲ Standard model physics at the LHC.

CAPPATI A. ([1]), VITTORI C. ([2])
([1]) *Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS in Palaiseau, France*
([2]) *Università di Bologna, Italia*

The most recent results from standard model physics analyses at ATLAS and CMS are presented. In particular, an overview of the results obtained by the two experiments on Higgs and vector bosons and on top quark is reported. The results are obtained with the full dataset collected by the two experiments during Run II period at the CERN Large Hadron Collider.

▲ Fisica oltre il Modello Standard in ATLAS e CMS.

PRESILLA M. ([1]), GRAVILI F. G. ([2])([3])
([1]) *Università di Padova, Italia*
([2]) *Dipartimento di Matematica e Fisica "E. De Giorgi", Università del Salento, Italia*
([3]) *INFN, Sezione di Lecce, Italia*

Gli esperimenti ATLAS e CMS ad LHC hanno la possibilità di estendere le ricerche dirette e indirette di nuova fisica oltre il Modello Standard con le collisioni del Run 2 a 13 TeV. Queste ricerche si sviluppano su fronti molto diversi sia teorici sia sperimentali, includendo modelli supersimmetrici ed esotici con stati finali spesso complessi che pongono nuove sfide agli algoritmi di ricostruzione. Verranno presentati alcuni dei risultati di maggior interesse in tale contesto da un punto di vista fenomenologico e sperimentale, con accenni alle prospettive di ricerca nei collider di prossima generazione.

▲ Open issues in the SM and exploration of BSM dynamics at colliders.

FRANCESCHINI R.
Università degli Studi e INFN Roma Tre

I will review the open issues and observational limitations of the Standard Model and will put them in perspective for the exploration of possible dynamics related to these issues at current and future particle colliders. I will put special emphasis on the issues that may find a conclusive answer at the next generation of experiments.

▲ **Test di universalità leptonica e decadimenti rari di mesoni B a LHCb.**
Santimaria M.
INFN-LNF
Durante i passati 10 anni, varie misure sperimentali su processi $b \to s\ell^+\ell^-$, caratterizzati da corrente neutra con cambiamento di sapore, hanno mostrato interessanti deviazioni rispetto alle predizioni del Modello Standard (MS). Tuttavia, l'attuale conoscenza delle incertezze adroniche coinvolte in queste predizioni impedisce l'interpretazione dei risultati in termini di Nuova Fisica. Per aggirare questo ostacolo sono quindi fondamentali le misure di osservabili, in processi accidentalmente soppressi nel MS, in cui sia possibile una predizione teorica di alta precisione. I decadimenti estremamente rari $B_s^0 \to \mu^+\mu^-$ e i test di universalità leptonica con il rapporto $R_K = \mathrm{BR}(B^+ \to K^+\mu^+\mu^-)/\mathrm{BR}(B^+ \to K^+e^+e^-)$ sono due esempi chiave per questo scopo. Nella relazione verranno discussi i recenti risultati di queste due misure, ottenuti dal campione completo di dati raccolto all'esperimento LHCb durante il Run 1 e il Run 2 di LHC.

▲ **Recent kaon results at NA62.**
Corvino M.
CERN, Geneva, Switzerland
The NA62 experiment is a fixed-target experiment located in the CERN North Area, which analyzes data produced by the in-flight decays of a high-intensity beam of kaons with a momentum of 75 GeV/c. NA62 main goal is the measurement of the branching ratio of the very rare decay $K^+ \to \pi^+\nu\bar{\nu}$ at 10% precision level, which is a golden candidate to search for new physics beyond the Standard Model (SM). NA62 collected data from 2016 to 2018, providing the most precise measurement of this branching ratio to date. The result of the $K^+ \to \pi^+\nu\bar{\nu}$ analysis has been also used to set limits on the $K^+ \to \pi^+X$ decay, where X is a scalar or pseudo-scalar particle. Apart from $K^+ \to \pi^+\nu\bar{\nu}$, NA62 has a broad physics program to search for new physics beyond SM at the intensity frontier, thanks to the large amount of kaon decays collected in three years of data taking. In the talk, an overview of the recent results obtained by NA62 will be presented, including searches for lepton number and lepton flavour violations, search for heavy neutral lepton production and precision measurements of radiative kaon decays.

Presiede: Bettoni D. (INFN, Sezione di Ferrara)
Relazioni su invito

▲ **Present scientific achievements and future perspectives at Legnaro National Laboratory, INFN.**
Mengoni D.
University and INFN, Padova
The Legnaro National Laboratory (LNL) of INFN is at the dawn of a new era with the production of radioactive ion beams by the SPES facility. The ISOL facility will produce high intensity, high purity beams, primarily fission fragments, at an energy of 10 MeV/A for mass 130. In the forthcoming years, the LNL accelerator complex will guarantee forefront research in nuclear structure, reaction dynamics as well as in nuclear astrophysics on nuclei far away from the valley of beta stability. Cutting-edge instrumentation is being designed or upgraded to guarantee ultimate performances in detection of gamma rays, with the AGATA array for example, neutrons, light-charged particles and ions. These state-of-the-art detectors and radioactive beams will reveal the finer details of the structure and reaction dynamics of atomic nuclei to elevate our understanding of matter and the stellar creation of elements. This contribution will report present scientific achievements and future perspectives of the nuclear physics and astrophysics community based at LNL-INFN.

▲ **Nuclear physics perspectives at LNS with new high-intensity beams.**
Carbone D., per la Collaborazione NUMEN
INFN-Laboratori Nazionali del Sud
The three-year upgrade project POTLNS for the production of high-intensity beams has already started at INFN-Laboratori Nazionali del Sud. The NUMEN project promoted the specific R&D activity with the upgrade of the whole INFN-LNS research infrastructure. NUMEN aims to provide experimental information on the nuclear matrix elements involved in the expression of $0\nu\beta\beta$ decay half-life by measuring the cross section of nuclear double charge exchange reactions. The main experimental tools are the K800 superconducting Cyclotron and the MAGNEX magnetic spectrometer at the INFN-LNS. Preliminary results and the foreseen experimental campaigns will be presented. The high-intensity beams will open new nuclear physics research perspectives at LNS, like that to produce and study very neutron-rich or even new nuclides in previously unexplored regions of the nuclear landscape. Moreover, a new FRAgment Inflight SEparator (FRAISE) will be also constructed to deliver radioactive ion beams. Many opportunities will be open with this new set-up, an example is the study of the isoscalar Giant Monopole Resonance in unstable nuclei, to access the nuclear matter incompressibility.

▲ **Le attività di Fisica Nucleare presso i laboratori GSI/FAIR.**
Russotto P.
INFN-Laboratori Nazionali del Sud
Il talk presenterà le attività di fisica nucleare condotte presso il laboratorio GSI/FAIR di Darmstadt (Germania), relativamente ai contributi di gruppi italiani. In dettaglio si presenteranno le attività delle collaborazioni: FOOT, focalizzata sulla misura di reazioni nucleari e sezioni d'urto di interesse per applicazioni adroterapiche e per la radioprotezione nello spazio; FORTE, focalizzata sulla misura di reazioni di interesse per la produzione di elementi superpesanti e di nuclei ricchi di neutroni intorno alla chiusura di shell $N = 126$; GAMMA, focalizzata sullo studio della struttura nucleare di nuclei esotici tramite misure di spettroscopia gamma, all'interno della collaborazione HISPEC-DESPEC; R3B, focalizzata sullo studio di reazioni fra ioni radioattivi ad energie relativistiche con un apparato di misura che consente la completa ricostruzione cinematica degli eventi di reazione.

▲ **L'attività di ricerca del Laboratorio di Frascati dell'INFN.**
Sirghi F. C., Gatti C.
Laboratori Nazionale di Frascati, Frascati, Italy
Il Laboratorio Nazionale di Frascati (LNF) è stato il primo tra i Laboratori Nazionali dell'INFN e ancor oggi è il più grande per estensione e personale. Fin dalla sua fondazione, le attività svolte in sede sono state lo sviluppo, costruzione e operazione di acceleratori di particelle e la progettazione e la costruzione di rivelatori innovativi da utilizzarsi in esperimenti di fisica delle particelle, nucleare e astro-particellare. Accanto allo sviluppo delle nuove tecnologie acceleranti, l'attività di ricerca fondamentale del laboratorio si è rivolta a nuovi settori: la ricerca della light Dark Matter (DM) tra cui quella di assioni galattici, ipotetiche particelle originariamente introdotte per spiegare il problema della "CP forte" che costituiscono un ottimo candidato per la materia oscura nel nostro Universo; lo studio della QCD a bassa energia, che ha caratterizzato già la ricerca scientifica dei laboratori, che riguarda le cosiddette particelle "strane", cioè particelle, come i kaoni, che contengono un quark strano. I risultati forniti dagli esperimenti in corso o previsti per il prossimo futuro ai LNF forniranno importanti indicazioni sulla struttura di queste particelle.

Aula Cornelia Fabri **ore 14:00 – 17:30**

Sezione II
Fisica della materia
Presiede: Giovannetti V. (Scuola Normale Superiore, Pisa)

Relazioni su invito

▲ **Hybrid Josephson junctions opportunity for quantum hardware.**
Tafuri F.
Università di Napoli Federico II, Dipartimento di Fisica "E. Pancini"
We will explore the horizons of the Josephson effect (JE) which provides unique solutions to cutting edge problems in condensed-matter physics as well as to very advanced applications, including in the emerging field of quantum computing. An integrated quantum device can be better than the sum of its ingredients. A smart combination of different platforms can provide transformational solutions. The JE offers the potential to manipulate the macroscopic wave function of a condensate. Progress in material science and nanofabrication gives opportunities to create unique hybrids Josephson junctions (JJs) which can be smartly integrated with other quantum platforms. We will report on special properties of hybrid JJs on how to engineer the macroscopic phase in quantum circuits, which make possible alternative layouts for the superconducting modules inside a more general architecture. We classify some significant behaviors of unconventional junctions through a comparative study of fluctuations and of electro-dynamical properties. These methods can be successfully applied to the new generation of the van der Waals heterostructures. Much has to be expected in the future.

▲ **Vacancy-like dressed states in topological waveguide QED.**
Carollo A. (1)(2), Leonforte L. (1), Ciccarello F. (1)
(1) *University of Palermo*
(2) *Lobachevsky State University of Nizhni Novgorod*
We identify a class of dressed atom-photon states forming at the same energy of the atom at any coupling strength. As a hallmark, their photonic component is an eigenstate of the bare photonic bath with a vacancy in place of the atom. The picture accommodates waveguide-QED phenomena where atoms behave like perfect mirrors, connecting in particular dressed bound states (BSs) in the continuum with geometrically confined photonic modes. When applied to photonic lattices, the framework establishes a one-to-one correspondence between topologically robust dressed states and topologically robust photonic BSs seeded by a vacancy. This is used to predict new classes of dressed BSs in the photonic Creutz-ladder and Haldane models. In the latter case, states with nonzero local photon flux occur in which an atom is dressed by a photon orbiting around it.

▲ **Quantum computing with semiconductor spins: The flip-flop qubit universal quantum gates set.**
Ferraro E.
CNR-IMM Agrate Unit, Via C. Olivetti 2, 20864 Agrate Brianza, MB, Italy
A full-scale quantum processor would have applications in a variety of different scientific, social and economical contexts. Silicon technology is definitely in strong competition with current technologies, *i.e.* superconductive qubits and trapped ions and provides a valid alternative to achieve comparable results in the medium term. Semiconductor qubits represent a

rich platform for universal quantum computation due to their long coherence times, easy manipulation and fast gate operations. The possibility of using the well-assessed semiconductor manufacturing paves the way towards the large-scale quantum computation era. Several proposals are based on quantum dot and donor-based qubits. I will focus on the donor-based flip-flop qubit realized implanting P donor in isotopically purified Si and encoding the logical states in the donor nuclear spin and in its bound electron. I propose a universal set of quantum gates composed by the single qubit gates $R_z(-\pi/2)$ and Hadamard and the two-qubit $\sqrt{iSWAP}$ gate. Then, the effect of the realistic $1/f$ noise on the gate fidelity is studied providing quantitative information about the reachable fidelity when experiments are performed.

▲ **Thermal rectification through a nonlinear quantum resonator.**
Paladino E. (1)(2)(3), Bhandari B. (4), Erdman P. A. (4), Fazio R. (5)(6), Taddei F. (7)
(1) *Dipartimento di Fisica e Astronomia Ettore Majorana, Università di Catania, Via S. Sofia 64, I-95123, Catania, Italy*
(2) *INFN, Sez. Catania, I-95123, Catania, Italy*
(3) *CNR-IMM, Via S. Sofia 64, I-95123, Catania, Italy*
(4) *NEST, Scuola Normale Superiore and Istituto Nanoscienze-CNR, I-56126 Pisa, Italy*
(5) *The Abdus Salam International Centre for Theoretical Physics, Strada Costiera 11, I-34151 Trieste, Italy*
(6) *Dipartimento di Fisica, Università di Napoli "Federico II", Monte S. Angelo, I-80126 Napoli, Italy*
(7) *NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, I-56126 Pisa, Italy*
We present a systematic study of thermal rectification in a prototypical low-dimensional quantum system —a nonlinear resonator: we identify necessary conditions to observe thermal rectification and we discuss strategies to maximize it. In the strongly anharmonic regime where the system reduces to a qubit, we derive general upper bounds on rectification in the weak system-bath coupling regime, and we show how the Lamb shift can be exploited to enhance rectification. We then go beyond the weak-coupling regime by employing different methods: i) including cotunneling processes, ii) using the nonequilibrium Green's function formalism, and iii) using the Feynman-Vernon path integral approach. We find that the strong-coupling regime allows us to violate the bounds derived in the weak-coupling regime, providing clear signatures of high-order coherent processes visible in the thermal rectification. In the general case, where many levels participate to the dynamics, heat rectification is calculated with the equation of motion method and with a mean-field approximation. We find that the former method predicts, for a small or intermediate anharmonicity, a larger rectification coefficient.

▲ **Molecular spin qudits: A promising ingredient for quantum computers.**
Carretta S. (1)(2)
(1) *Dipartimento di Scienze Matematiche, Fisiche e Informatiche, Università di Parma*
(2) *UdR Parma, INSTM, Parma*
The potential to solve problems with large impact on science, society and economy makes the realization of quantum computers one of the hottest topics in current research. A promising platform in the race towards quantum devices is represented by molecular nanomagnets (MNMs). These magnetic molecules are characterized by a sizeable number of accessible low-energy states that can be coherently manipulated by microwave and radiofrequency pulses, thus opening the possibility use them as molecular qudits. In my presentation, I review some recent results on molecular qudits/qubits. In particular, I show that MNMs can

be exploited to define qubits with embedded quantum error correction in single molecules, thus circumventing the large overhead in the number of physical units required by standard quantum error correction codes. Moreover, I show that molecular qudits can improve the potential for quantum simulations. Then, I briefly report the characterization of promising molecular qudits using broadband NMR. At last, I discuss some recent results on the study of the two main sources of decoherence in MNMs, *i.e.*, interactions with nuclear spins and phonons.

▲ **Metastability and signatures of topology in open quadratic bosonic dynamics.**

Viola L. (1), Flynn V.P. (1), Cobanera E. (2)
(1) *Department of Physics and Astronomy, Dartmouth College, Hanover, NH, USA*
(2) *Department of Mathematics and Physics, SUNY Polytechnic Institute, Utica, NY, USA*

Unlike free fermions, Hamiltonian systems of free bosons cannot be topological. We will show how, for free bosons undergoing Markovian dissipation, topologically non-trivial phases and "Majorana bosons" may emerge in metastable regimes, along with a continuous manifold of nearly degenerate quasi-steady states. Each Majorana boson pair consists, in general, of a distinct zero mode and a symmetry generator, reflecting the breakdown of Noether's theorem in open quantum dynamics. We will further discuss observable signatures of Majorana bosons in steady-state power spectra, along with candidate platform implementations. Our results points to a new paradigm for exploring topological physics in driven-dissipative quantum matter.

▲ ***D*-wave as a generator of structural models for order-disorder transitions in materials science.**

Di Felice R. (1)(2), Carnevali V. (3), Siloi I. (1), Fornari M. (3)
(1) *University of Southern California*
(2) *CNR-NANO Modena*
(3) *Central Michigan University*

The efficient computational generation of realistic structural models in Physics is a topic that is gaining increasing interest nowadays, facing the limitations of classical methods. In this paper we propose a new method for structural model generation based on quantum annealing techniques implemented on *D*-wave quantum computers. We develop a series of quadratic unconstrained optimization problems for modeling melting, entropy stabilization and order-disorder phase transitions for silicon, high-entropy alloys, and perovskites, respectively. This approach reproduces known results and provides access to a considerable portion of structural models for each physical system, demonstrating the feasibility of quantum computing as tool for generating models of physical interest.

Aula Margherita Hack **ore 14:00 – 17:30**

Sezione III
Astrofisica
Presiede: Gemme G. (INFN, Sezione di Genova)

Relazioni su invito

▲ **Tests of general relativity from gravitational waves observations of coalescing binaries.**

Del Pozzo W.
University of Pisa

Gravitational waves from the coalescence of compact binary systems provide an observational window on the dynamical high-curvature regime of space-time, allowing for tests of general relativity in a regime not accessible otherwise. During this talk, I will review some of the motivations for testing general relativity and highlight key observational results on the dynamics of space-time and on the nature of black holes from the current generation of gravitational wave detectors.

▲ **Present status and future prospects of the Advanced Virgo gravitational wave detector.**

Bersanetti D., on behalf of the Virgo Collaboration
INFN, Sezione di Genova, I-16146 Genova, Italy

The status of the Virgo detector will be presented, with a description of the configuration and the main technological developments in operation at the end of the last Observation Run 03 (concluded in March 2020). With the detector currently in the Commissioning Phase in view of the next Observation Run O4, starting in mid-2022, an overview of the main upgrades of the instrument, and their impact in terms of operation and performances will be given. Lastly, the integration of Virgo in the International Gravitational Wave Network with the two LIGO (US) detectors and the KAGRA (JAP) detector will be summarized.

▲ **Einstein Telescope: The 3rd-generation, underground and cryogenic gravitational wave observatory aiming to explore the Universe at cosmological scale.**

Greco G. on behalf of the ET Collaboration
INFN, Sezione di Perugia

The initial exploration of the Universe through gravitational-wave observations with the 2nd generation of ground-based detectors, namely Virgo and LIGO, has provided important breakthroughs in the fundamental physics, cosmology and astrophysics until the birth of multi-messenger astronomy. The Einstein Telescope (ET) represents the amazing evolution in the third generation of gravitational-wave observatories with remarkable technological developments. The design of housing ET in underground sites, the extension of the arms up to 10 km, a triangular shape for a more isotropic antenna pattern and the cryogenic conditions to reduce thermal disturbance are some of the technological challenges that will lead ET to be operational in the mid 2030's. We will provide an overview of how the wider access to low frequencies and the increased sensitivity of about one order of magnitude allow us to probe the Universe at cosmological scales, for the very first time. Finally, a brief review of the potential for discoveries will be documented also in the perspective of electromagnetic facilities operating at the time of the ET observatory.

▲ From LISA Pathfinder to LISA: Paving the way to the first gravitational wave observatory from space.

Vetrugno D.
Università di Trento

LISA is the third large mission of the ESA Cosmic Vision program and its launch is due in 2034. The observatory aims to look at the Universe through a yet undisclosed window, that of the mHz and sub-mHz gravitational waves, dominated by the dance of supermassive black holes or that of millions of galactic binaries, extending potential discoveries from the astrophysics of the Milky Way to cosmography and cosmology. LISA will require cutting-edge technologies, such as pm interferometry at million kilometres distances, sub femto-g residual acceleration of proof masses and novel post-processing techniques as the Time Delay Interferometry (TDI). In particular, having test-masses in space with the required level of purity of their geodetic motion has been for years a major unexplored experimental challenge. In 2016, the first in-orbit results of LISA Pathfinder, the LISA technological demonstrator, showed that such a requirement was achievable, paving the way for the realisation of LISA. In this talk, I will review the LISA mission challenges connecting them to the LISA Pathfinder results and their implications in the new mission design.

▲ The kinesthetic universe: What can we learn?

Salafia O.S. (1)(2), Ghirlanda G. (1), Colpi M. (2)(3), Branchesi M. (4)
(1) *INAF - Osservatorio Astronomico di Brera, Merate, LC, Italia*
(2) *INFN - Sezione di Milano-Bicocca, Milano, MI, Italia*
(3) *Università degli Studi di Milano-Bicocca, Milano, MI, Italia*
(4) *Gran Sasso Science Institute, L'Aquila, AQ, Italia*

Information about the Universe travels through four channels: the fundamental interactions. For millennia astronomers could access only one of these channels, the electromagnetic one, thanks to our built-in optical detector —the eye— which is only sensitive to a limited range of wavelengths. The extension of electromagnetic observing techniques to other wavelengths during the past century revolutionized our understanding of the cosmos, expanding the horizon of our understanding beyond our immagination. We are now facing a new such revolution: multimessenger astronomy is opening the way to combining information on astronomical sources carried by photons to that encoded in weak interactions (through neutrinos) and gravity (through gravitational waves). In this talk I will review the results achieved so far in this new branch of astronomy, and I will discuss how this kind of observations in the future will shed light on various aspects of fundamental physics, ranging from cosmology, to nuclear physics, to the theory of gravity.

▲ The CMB route to neutrino properties: Current status and future prospects.

Gerbino M.
Istituto Nazionale di Fisica Nucleare - INFN, Sezione di Ferrara

Neutrino unknowns are clear gateways to new physics. Cosmology offers a unique arena to unveil neutrino secrets in a way that is separate from, but complementary to astrophysical and terrestrial searches. Among cosmological surveys, CMB experiments play a crucial role in tracking the cosmological impact of cosmic neutrinos and deliver strong constraints on neutrino physics. The next generation of CMB surveys will supersede the current one, which is already highly sensitive to neutrino fundamental properties. In this talk, I will review the state of the art of cosmological limits on neutrino properties and provide an overview of the expected sensitivity from Simons Observatory, CMB-S4 and LiteBIRD in the next decade.

▲ **Observing the Cosmic Microwave Background now and in the next decade.**

Tartari A.
Dipartimento di Fisica "E. Fermi" - Università di Pisa e Istituto Nazionale di Fisica Nucleare - Sezione di Pisa

In this talk I briefly recall all the most important experimental facts about the Cosmic Microwave Background (CMB), from its Planckian frequency spectrum on the monopole scale to its polarized anisotropies, the so-called E- and B-modes. Then, I will show how the deployment of large arrays of superconducting detectors has radically changed the game, allowing the current (and the next) generation experiments to be on the tracks of primordial B-modes, thus enabling the test of a key prediction of inflation, *i.e.*, the production of gravitational waves in the Early Universe. To conclude, I will provide the landscape of future CMB polarization experiments, with particular emphasis on those exploring the large angular scales, which are the most relevant for the search of primordial B-modes.

▲ **The Hubble parameter and quasars as standard candles.**

Lusso E.
Università di Firenze, Dipartimento di Fisica e Astronomia e INAF - Osservatorio Astrofisico di Arcetri, Firenze

In observational cosmology, the Hubble parameter ($H0$) describes the expansion rate of the Universe, and it has been mostly considered important for being inversely proportional to the age of the Universe. However, in recent years, the estimates of $H0$ from different astrophysical and cosmological observations have shown a tension within the standard cosmological model, which is still an open issue in modern cosmology. I will briefly review the measurements of the Hubble parameter obtained with different techniques. I will then focus on the use of bright active galactic nuclei (quasars) as standard(izable) candles to provide new constraints on the expansion rate of the Universe through the distance modulus-redshift relation, also known as the Hubble-Lemaître diagram, at high redshifts.

Aula Inge Lehmann **ore 14:00 – 17:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Lapenna V. (CNR-IMAA, Tito Scalo, PZ)

Relazioni su invito

▲ **Simultaneous Algebraic Reconstruction Technique (SART) for retrieving 1D shear-wave quality factor Q_S profiles using seismic noise.**

Dreossi I. (1), Parolai S. (2)
(1) *National Institute of Oceanography and Applied Geophysics - OGS, Udine, Italy*
(2) *National Institute of Oceanography and Applied Geophysics - OGS, Sgonico, Italy*

Assessing the shear-wave quality factor (Q_S) is important for a complete seismic site response. Focusing on a local scale, Parolai (2014) proposed an approach based on a least squares algorithm with positivity Q_S constraint (Menke, 1989) to estimate 1D Q_S profiles using seismic noise. Although providing robust solutions, it needs accurate trial-and-error tests of the damping factor in the preliminary phase. Here we present our outcomes obtained by substituting the least squares algorithm with the Simultaneous Algebraic Reconstruction Technique (SART) (Andersen and Kak, 1984), that allows to easily set a positivity Q_S constraint to the solutions.

▲ **Integration of Ground Penetrating Radar and Seismic Refraction tomography for buried active fault detection.**

Ludeno G. (4), Nappi R. (1), Paoletti V. (2), D'Antonio D. (3), Soldovieri F. (4), Capozzoli L. (5), Porfido S. (2)(6), Maria Michetti A.M. (7)
(1) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Napoli Osservatorio Vesuviano, Via Diocleziano 328, 80124 Naples, Italy;*
(2) *Department of Earth, Environment and Resources Science, University Federico II, Complesso di Monte S. Angelo, Via Cintia, Edifice L, 80126 Naples, Italy*
(3) *Geophysical consultant, Vicolo III San Nicola, 2, 86013 Gambatesa, CB, Italy*
(4) *Institute for Electromagnetic Sensing of the Environment, National Research Council, Via Diocleziano 328, 80124 Naples, Italy;*
(5) *Institute of Methodologies for Environmental Analysis, National Research Council, C.da S. Loja-Zona Industriale, 85050 Tito Scalo, PZ, Italy*
(6) *Consiglio Nazionale delle Ricerche-Isa, Via Roma 64, 83100 Avellino, Italy*
(7) *Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, Via Valleggio, 11, 22100 Como, Italy;*

We describe a study aimed at the detection and characterization of active fault segments by means of geophysical surveys integrated with traditional geomorphologic and structural observations. Specifically, we investigated the active buried fault system bordering the western edge of the "Il Lago" Plain (Pettoranello del Molise, Italy) through the combination of seismic refraction tomography and low-frequency Ground Penetrating Radar (GPR). The results suggest that the application of these geophysical techniques may allow a quick fault-detection for an accurate siting of paleoseismological exploratory trenches. In fact, our GPR and seismic data allowed inferring the relatively deep (ca. 100 m) architecture and spatial continuity of fault systems previously unknown.

▲ An integrated geophysical approach for structural behavior characterization of the Gravina Bridge (Matera, Southern Italy).

SERLENGA V. (1), GALLIPOLI M.R. (1), PETROVIC B. (2), DITOMMASO R. (3), PONZO F.C. (3), TRAGNI N. (3), PERRONE A. (1), STABILE T.A. (1), CALAMITA G. (1), VIGNOLA L. (4), CARSO R.F. (5), PIETRAPERTOSA D. (5)
(1) *National Research Council of Italy - Institute of Methodologies for Environmental Analysis, Tito Scalo, Potenza, Italy*
(2) *National Institute of Oceanography and Experimental Geophysics, Sgonico, Trieste, Italy*
(3) *School of Engineering, University of Basilicata, Potenza, Italy*
(4) *Mallet S.r.l., Villa d'Agri, PZ, Italy*
(5) *ANAS S.p.A., Roma, Italy*

In this study we describe how geophysical techniques may be exploited for the structural characterization of critical infrastructures, such as bridges, and to investigate possible soil-infrastructure interaction effects. This approach, which consisted of low-cost, fast executable, non-invasive and non-destructive seismic and electromagnetic sensing carried out during both permanent real-time acquisitions and on-demand campaigns, was tested and applied on the Gravina Bridge, a bow-string bridge located in Matera, Southern Italy. The analysis of the acquired geophysical data allowed retrieving the main structural parameters of the investigated infrastructure, that is its eigenfrequencies, the related equivalent damping factors and the mode shapes. The strong agreement between results obtained from independent geophysical data by applying different data analyses have strengthened the reliability of both the proposed approach and estimations of the main bridge parameters. The latter are fundamental for defining the zero-time state of the Gravina Bridge, which is a necessary element for further studies aiming at the structural health monitoring.

▲ Joint seismic and electromagnetic directionality with quantified fracture patterns at Campi Flegrei caldera.

VENTOLA I. (1), RIZZO R.E. (2), DE SIENA L. (3), SINISCALCHI A. (1)
(1) *Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari - Aldo Moro, Bari, Italy*
(2) *School of Geosciences, University of Edinburgh, Edinburgh, UK*
(3) *Institute of Geosciences, Johannes Gutenberg University, Mainz, Germany*

Ambient seismic noise is a state-of-the-art parameter to image fluid and magma bodies inside the Earth, with its directionality showing potential for monitoring faults and volcanoes. The directionality of the electromagnetic field is an essential parameter when imaging magma and fluids in the crust. Both quantities are dependent on the underlying fluid-filled fracture networks. Here, we quantify fracture patterns in analogues to Campi Flegrei caldera (Southern Italy) to forward model seismic directionalities recorded across the volcano and compare them with electromagnetic strike estimates. The results offer a new tool to analyse seismic and electromagnetic data jointly with fracture network characteristics.

▲ Automated detection and characterization of seismic tremors associated with non-volcanic gas emission: New insights on the Mefite d'Ansanto site in Southern Italy.

PANEBIANCO S. (1)(2), SATRIANO C. (3), STABILE T.A. (1), PICOZZI M. (4), STROLLO A. (5)
(1) *National Research Council of Italy, CNR-IMAA, Tito Scalo, Italy*
(2) *Department of Science, University of Basilicata, Potenza, Italy*
(3) *University of Paris, Institut de Phisique du Globe de Paris, Paris, France*

([4]) *Department of Physics, University of Naples, Italy*
([5]) *GFZ German Research Centre for Geoscience, Potsdam, Germany*

Developing techniques to monitor and quantitatively analyze non-volcanic gas emissions could be crucial to understand the role of crustal fluids in large earthquakes generation, particularly in high seismic hazard areas. We implemented an automated detection algorithm for seismic tremors recorded at Mefite D'Ansanto (Southern Apennines), the largest natural emission of non-volcanic, CO_2-rich gases ever measured on the Earth. It was applied on continuous recordings from a temporary seismic network installed at site between 30-10-2019 and 02-11-2019, collecting 8561 signals. Both DBSCAN Clustering and KNN Classification algorithms were applied to characterize tremor signals and discriminate them from accidentally detected anthropic noise.

▲ **Geophysical surveys for the characterization of an engineering infrastructure: Laboratory and field tests.**

FORNASARI G. ([1])([2]), CAPOZZOLI L. ([2]), DE MARTINO G. ([2]), GIAMPAOLO V. ([2]), RIZZO E. ([1])([2])
([1]) *Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Ferrara, Ferrara, Italia*
([2]) *CNR - IMAA, Laboratorio Hydrogeosite, Marsico Nuovo - Tito, Italia*

The development of new technologies and methodologies able to conduct surveys in urban areas becomes an important source in terms of saving time and money. Lapenna V. (2017) describes this concept highlighting the Urban Geophysics approaches and analyses the contribution that geophysical methodologies can give for providing useful information about the subsoil, environment, buildings and civil infrastructures and supporting the public administrations in planning interventions in urban scenarios. In this work, a laboratory tests performed at the CNR laboratory of Marsico Nuovo (Basilicata region, Italy) on an analogue engineering models are setting in order to apply multi-geophysical methods for controlled experiments. Thanks to the possibility to work in laboratory conditions, a detailed knowledge of the structure was available, providing great advantages for assess the capability of the geophysical methodologies for analyse engineering issues. In the second part of this work, a multi-geophysical approach was used for the engineering characterization applied on an old railway tunnel without having any information of the infrastructure project.

▲ **CLARA WebGIS: Sharing soil and building geophysical data for seismic characterization of the city of Matera (Southern Italy).**

TRAGNI N. ([1])([2]), CALAMITA G. ([1]), LASTILLA L. ([3])([4]), BELLONI V. ([5]), RAVANELLI R. ([5]), LUPO M. ([1]), SALVIA V. ([1]), GALLIPOLI M.R. ([1])
([1]) *National Research Council of Italy, CNR-IMAA, Tito Scalo, Italy*
([2]) *School of Engineering, University of Basilicata, Potenza, Italy*
([3]) *Department of Computer, Control and Management Engineering Antonio Ruberti, DIAG, Sapienza University of Rome, 00185 Rome, Italy*
([4]) *Sapienza School for Advanced Studies, 00161 Rome, Italy*
([5]) *Geodesy and Geomatics Division, DICEA, Sapienza University of Rome, 00184 Rome, Italy*

The holistic vision of the city means studying not only its urban soil characteristics, like guideline for seismic microzonation do, but also including built environment, taking a step forward in the context of seismic risk mitigation. Moreover, in Smart Cities and Digital Twin perspectives, the digital archiving of all geological, geotechnical, geophysical, and engineering data of cities should become a useful tool to plan strategies for seismic risk mitigation in terms of urban planning, seismic retrofitting, and management of post-earthquake crises. Based on this principle, this study analyses the interactive CLARA

WebGIS (https://smartcities-matera-clara.imaa.cnr.it/), the first publicly available database that reports for the whole urban area the spatial distribution of the fundamental frequencies for soils and the overlying 4043 buildings, along with probability levels of soil-building resonance.

Aula Ida Ortalli **ore 14:00 – 17:30**

Sezione V
Biofisica e fisica medica
Presiede: Tecchio F. (CNR-ISTC, Roma)

Relazioni su invito

▲ **Neurophotonics: Noninvasive optical techniques for monitoring brain functions.**

Torricelli A. (1)(2), Amendola C. (1), Contini D. (1), Frabasile L. (1), Lacerenza M. (1), Levoni P. (1), Re R. (1)(2), Spinelli L. (2)
(1) *Dipartimento di Fisica, Politecnico di Milano, Italy*
(2) *Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Italy*

We present the state-of-the-art of neurophotonics, a novel discipline at the interface of optics and neuroscience. While neurophotonics includes also invasive techniques for animal studies, in this review we focus only on the noninvasive methods that use near infrared light to probe functional activity in the brain, specifically, functional near infrared spectroscopy (fNIRS) and diffuse correlation spectroscopy (DCS). We also present an overview of the physical principles for light propagation in biological tissues, and of the main physiological sources of the signal. A discussion on the open issues in models, instrumentation, data analysis and clinical approaches is finally reported.

▲ **fNIRS-MRI integration for monitoring chronic neurological diseases.**

Bonilauri A. (1), Sangiuliano Intra F. (2), Baglio F. (2), Baselli G. (1)
(1) *Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milan, Italy*
(2) *IRCCS Fondazione Don Carlo Gnocchi Onlus, Milan, Italy*

During the last decades, functional Near-Infrared Spectroscopy (fNIRS) has gained increasing relevance in the context of chronic neurological diseases. Limited spatial and depth resolution of commercial systems can be overcome through integration of anatomical MRI, which is often available in a clinical context. Hence, we explored the potential benefits of using fNIRS for the characterization of hemodynamic response in Parkinson's disease patients over an atlas-based MRI anatomy according to motor task. Optical signal pre-processing steps were optimized in terms of data filtering, motion artifact correction and removal of systemic signals not due functional brain activity. The forward projection from optodes to cortical elements was approached by Monte Carlo simulation, while the inverse problem was solved according to Tikhonov regularization optimized by the L-curve method. Significant activations were found over the motor cortex together with a good correlation between the channel-wise measurements and cortical mapping. In conclusion, fNIRS-MRI integration is a promising tool for monitoring neurodegeneration.

▲ **Comparison of protein conformational properties in solution and in the crystalline state by Fourier transform infrared spectroscopy.**

Natalello A. (1), Diletta A. (1), Sala B. M. (2), Le Marchand T. (3), Pintacuda G. (3), Camilloni C. (2), Ricagno S. (2)
(1) *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Milano, Italy*

([2]) *Dipartimento di Bioscienze, Università degli Studi di Milano, Milano, Italy*
([3]) *Centre de Résonance Magnétique Nucléaire à Très Hauts Champs, FRE 2034 CNRS, UCBL, ENS Lyon, Université de Lyon, Villeurbanne, France*

A comparative characterization of the protein conformational features and stability in solution and in the crystalline state by the same experimental approach is highly desirable in different fields, from biomedicine to enzymology. In the present work, we investigated by Fourier transform infrared (FTIR) spectroscopy the secondary structures and thermal stability of wild type and mutants of β-2 microglobulin (β2m), the protein involved in the dialysis-related amyloidosis. The study shows that FTIR spectroscopy allows to detect specific conformational features imposed by the crystal packing, that result in the downshift of the main β-sheet band, in more resolved spectral features and in increased thermal stability for β2m in crystallo for each variant compared to the protein in solution. Interestingly, when the thermal stability of the different β2m variants was compared, the same trend was observed for the proteins in solutions and in the crystalline state. This study highlights the potential of FTIR spectroscopy to obtain useful structural information on protein crystals and shows that relevant biophysical properties of protein crystals reflect their behaviour in solution.

▲ Imaging system based on silicon photomultipliers and light emitting diodes for functional near-infrared spectroscopy.

<u>Maira G.</u> ([1])([3]), Chiarelli A. M. ([2]), Libertino S. ([1]), Fallica G. ([3]), Merla A. ([2]), Lombardo S. ([1])
([1]) *CNR-IMM, Catania, Italia*
([2]) *Institute of Advanced Biomedical Technologies and Department of Neuroscience, Imaging and Clinical Sciences, University G. D'Annunzio of Chieti - Pescara, Chieti, Italia*
([3]) *STMicroelectronics, Catania, Italia*

We built a fiber-less prototype of a 156 channels optical system using optodes made of silicon photomultipliers (SiPM) and light emitting diodes (LEDs) operating at 700 nm and 830 nm. The system uses functional near-infrared spectroscopy (fNIRS) and diffuse optical tomography (DOT) imaging of the cortical activity of the human brain at frequencies above 1 Hz. We discuss testing and system optimization performed through measurements on a multi-layered optical phantom with mechanically movable parts that simulate near-infrared light scattering inhomogeneities. The baseline optical characteristics of the phantom are carefully characterized and compared to those of human tissues. Here we discuss several technical aspects of the system development, such as LED light output drift and its possible compensation, SiPM linearity, corrections of channel signal differences, and signal-to-noise ratio (SNR). We implement an imaging algorithm that investigates large phantom regions. Thanks to the use of SiPMs, very large source-to-detector distances are acquired with a high SNR and 2 Hz time resolution. The overall results demonstrate the high potentialities of SiPMs in biomedical applications.

▲ Advanced imaging techniques with X-rays beams from inverse Compton scattering sources: A preliminary study.

<u>Fantoni S.</u> ([1]), Cardarelli P. ([2]), Paternò G. ([1])([2]), Taibi A. ([1])([2])
([1]) *Dipartimento di Fisica e Scienze della Terra, Università di Ferrara, via G. Saragat 1, 44122 Ferrara, Italia*
([2]) *INFN, Sez. Ferrara, via G. Saragat 1, 44122 Ferrara, Italia*

Synchrotron light sources are the gold standard for biomedical X-ray imaging techniques that require monochromatic, coherent and intense beams. Inverse Compton scattering (ICS) sources, based on the interaction between an electron beam and a laser beam, are a promising compact alternative to synchrotron radiation. In fact, they can provide quasi-monochromatic spectra, tunable energies, high coherence of emitted radiation and high intensities, but using an electron beam at lower energies compared to synchrotron facilities. This feature leads to the reduction of machine size and costs, allowing the installation in clinical structures or laboratories. In the framework of the MARIX_rad project, supported by INFN, potential applications of ICS sources to advanced X-ray imaging techniques have been studied. In this contribution, simulations based on dual-energy techniques, aimed for contrast enhancement of structures with the aid of radio-opaque contrast agents, are carried out. The results will be presented and discussed.

▲ **Multi-parametric polarization resolved microscopy imaging of zebrafish embryonic development.**

Le Gratiet A. (1), Mohebi A. (1)(2), Callegari F. (1)(2), Bianchini P. (1), Diaspro A. (1)(2)
(1) *Istituto Italiano di Tecnologia - IIT*
(2) *DEFILAB, Department of Physics, University of Genoa*

Zebrafish are powerful animal models for understanding biological processes and the molecular mechanisms involved in different human diseases. Advanced optical techniques based on fluorescence microscopy have become the main imaging method to characterize the development of these organisms at the microscopic level. However, the need for fluorescence probes and the consequent high light doses required to excite fluorophores can affect the biological process under observation including modification of metabolic function or phototoxicity. Here, without using any labels, we propose an implementation of a polarization-based microscopy techniques based on the analysis on the 4×4 Mueller matrix to characterize the polarimetric transformation of zebrafish preserved at different embryonic developmental stages. By combining the full polarimetric measurements with statistical analysis of mathematical decompositions, we demonstrate that it is possible to quantify the structural changes of the biological organization of fixed zebrafish embryos and larvae at the cellular scale in a label-free approach.

▲ **Fluorescence microscopy techniques to investigate 3D cell culture and tissue regeneration.**

Jacchetti E.
Dipartimento di Chimica, Materiali e Ingegneria Chimica "G. Natta", Politecnico di Milano

Extracellular microenvironment plays a fundamental role in tissue homeostasis and regeneration control. At the basis, there are complex processes that cannot be modelled, neither for basic nor for translational science, using conventional 2D cultures. In the last two decades, multidisciplinary efforts to improve experimental systems have led to novel approaches involving 3D culture formats that more accurately reflect biochemical, spatial and mechanical properties of cells and their environment, requiring ever more precise and sophisticated investigation techniques. In order to inspect biological process and to improve tissue regeneration effectiveness, our group has developed miniaturized optically accessible bioengineered tools (microstructured scaffolds and bioreactors) to observe complex and dynamic phenomena in real time, using spatially and temporally highly resolved fluorescence microscopy techniques. Our research is in particular focalized on mechanobiology, an emerging field investigating how mechanical process governs cell and tissue functions in health and disease, such as vessel formation, cellular stemness maintenance, gene activation and protein expression and localization.

▲ **CovidStat: Monitorare l'andamento di una pandemia con l'analisi dei dati.**

Bonifazi G. (1)(2), Lista L. (3)(4)(8), Menasce D. (5), Mezzetto M. (6), Pedrini D. (5), Spighi R. (2), Zoccoli A. (2)(7)
(1) *Università Politecnica delle Marche*
(2) *INFN Sezione di Bologna*
(3) *Università degli Studi di Napoli Federico II*
(4) *INFN Sezione di Napoli*
(5) *INFN Sezione di Milano Bicocca*
(6) *INFN Sezione di Padova*
(7) *Alma Mater Studiorum Università di Bologna*
(8) *Scuola Superiore Meridionale*

Con la comparsa dei primi casi di COVID-19 in Italia l'Istituto Nazionale di Fisica Nucleare (INFN) ha avviato un'unità di crisi interna per il controllo della pandemia ed ha costituito il gruppo di lavoro CovidStat per effettuare un'analisi statistica dei dati forniti dalla Protezione Civile. Ad oggi, nel sito `https://covid19.infn.it` sono più di 2000 i grafici e le mappe interattive prodotte quotidianamente, con informazioni dettagliate per il territorio italiano e mondiale. Il gruppo CovidStat ha realizzato inoltre diversi articoli scientifici su temi legati alla pandemia. In particolare, ha proposto un metodo innovativo, e computazionalmente meno oneroso rispetto ai precedenti, per il calcolo dell'effettivo numero di riproduzione del virus (R_t); ha poi effettuato un'analisi statistica sui decessi notificati negli anni 2015-2020, comparandoli con quelli associati al COVID-19; ha effettuato uno studio sui possibili meriti dell'uso dei soli casi sintomatici per valutare l'andamento pandemico ed infine, ha valutato analiticamente gli effetti delle misure di contenimento utilizzate nelle regioni italiane durante la seconda fase dell'epidemia. Nel talk verranno presentati questi articoli e i lavori del gruppo CovidStat.

Aula Ada Lovelace **ore 14:00 – 17:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiedono: Bossi F. (INFN-LNF) e Cerullo G. (Politecnico di Milano)

Relazioni su invito

▲ Future circular collider feasibility study taking off.

Zimmermann F. ([1]), Boscolo M. ([2]), Migliorati M. ([3])([4]), Milardi C. ([2])
([1]) *European Organization for Nuclear Research, CERN, Geneva, Switzerland*
([2]) *INFN-LNF, Frascati, Italy*
([3]) *INFN Roma, Roma, Italy*
([4]) *Sapienza, Roma, Italy*
The 2020 Update of the European Strategy for Particle Physics requests a global feasibility study of a future 100 TeV hadron collider at CERN, with an electron-positron Higgs and electroweak factory as a possible first stage. This request is well aligned with the proposed Future Circular Collider (FCC) programme, which consists of a luminosity-frontier high-energy electron-positron collider (FCC-ee) followed by an energy-frontier hadron collider (FCC-hh). A H2020 EU co-funded design study "FCCIS", involving INFN Frascati and Roma, will carry out the core work on the FCC-ee collider optimisation. INFN is also participating in the design of the FCC-ee injector complex, and it is leading the efforts on machine detector interface and collective effects. This presentation will summarize the designs of FCC-ee and FCC-hh, covering the latest accelerator layouts and beam parameters, the R&D plan for key technologies, in particular for the SRF system, ongoing placement studies, a possible implementation schedule, and a few of the proposed future additions or upgrades.

▲ EBS and beyond.

Raimondi P.
ESFR
An overview of the EBS commissioning and performances will be presented. A glance on possible accelerators developments based on the EBS concepts will also be discussed.

▲ La ricerca in fisica applicata al centro nazionale TIFPA (Trento Institute for Fundamental and Applied Physics).

Battistoni G.
INFN, Sezione di Milano, Italia
TIFPA è un'iniziativa congiunta di INFN, Università di Trento, Fondazione Bruno Kessler e Agenzia Provinciale per i Servizi Sanitari della Provincia di Trento. L'attività del centro copre diversi settori di ricerca, sia fondamentale che applicata. Quest'ultima riguarda principalmente la sensoristica elettronica, l'attività di ricerca in missioni spaziali e la fisica medica. Una struttura che caratterizza in particolar modo il ruolo di TIFPA è l'area sperimentale esistente presso il servizio di protonterapia dell'Azienza per i Servizi Sanitari. Tale facility offre opportunità importanti per tutti i settori citati e quindi parte della relazione sarà dedicato a presentare lo stato di tale infrastruttura.

▲ 2D materials for THz photonics and nanoelectronics.

Vitiello M.S.
NEST, National Research Council CNR-NANO and Scuola Normale Superiore, Piazza San Silvestro 56127, Pisa, Italy

Artificial semiconductor heterostructures played a pivotal role in modern electronic and photonic technologies, providing a highly effective means for the manipulation and control of carriers, from the visible to the Terahertz (THz) frequency range. Despite their exceptional versatility, they commonly require challenging epitaxial growth procedures, due to the need for clean and abrupt interfaces, lattice matching or limited and controlled lattice mismatch, which proved to be major obstacles for the development of room-temperature (RT) devices, like sources, detectors or modulators, especially in the far infrared. The discovery of graphene and the related fascinating capabilities have triggered an unprecedented interest in inorganic two-dimensional (2D) materials. van der Waals (vdW) layered materials such as graphene, hexagonal boron nitride (hBN), transition metal dichalcogenides, and the more recently re-discovered black phosphorus (BP) display an exceptional technological potential for engineering nano-electronic and nano-photonic devices and components "by design", offering a unique platform for developing devices with a variety of properties. The talk will review our latest achievements in engineereing ultrafast nanodetectors, optical frequency comb syntesizers, frequency and aplitude modulators and near-field probes operating across the far infared, all integrating 2D nanomaterials heterostructures.

▲ Halide perovskite nanocrystals: Synthesis and optical properties.

Manna L.
Istituto Italiano di Tecnologia, Via Morego 30, 16163 Genova, Italy

Halide perovskite semiconductors can merge the highly efficient operational principles of conventional inorganic semiconductors with the low-temperature solution processability of emerging organic and hybrid materials, offering a promising route towards cheaply generating electricity as well as light. Following a surge of interest in this class of materials, research on halide perovskite nanocrystals (NCs) as well has gathered momentum in the last years. While most of the emphasis has been put on $CsPbX_3$ perovskite NCs, more recently the so-called double perovskite NCs, having chemical formula $A_2^+B^+B^{3+}X_6$, have been identified as possible alternative materials, together with various other metal halides structures and compositions, often doped with various other elements. This talk will also discuss the research efforts of our group on these materials. I will highlight how for example halide double perovskite NCs are much less surface tolerant than the corresponding Pb-based perovskite NCs and that alternative surface passivation strategies will need to be devised in order to further optimize their optical performance.

▲ Colloidal solutions of gold nanoparticles as colorimetric immunosensors for fast detection of SARS-CoV-2.

Velotta R., Della Ventura B., Minopoli A.
Dipartimento di Fisica "Ettore Pancini", Università di Napoli "Federico II", Italia

Lateral flow immunoassays are at the basis of many rapid tests in clinical diagnostics and, hence, they have been immediately extended to target SARS-CoV-2. Nevertheless, their use in conditions like the current pandemic is controversial because of their poor sensitivity. As an alternative strategy, we demonstrated that the change of the absorption spectrum of a colloidal solution —containing properly functionalized gold nanoparticles against SARS-CoV-2 envelope, membrane, and spike proteins— is detectable when it is made to react with specimens of nasopharyngeal as well as saliva swabs. The performances of the tests greatly rely on an easy-to-implement photochemical functionalization procedure that results in oriented antibodies onto gold surfaces. Since the method is sensitive to the infecting viral particle rather than to its RNA, the achievements reported here open a new perspective not only in the context of the current and possible future pandemics, but also in microbiology as the biosensor itself proves to be a powerful though simple tool for measuring the viral particle concentration.

▲ **Quantum technologies experimental platform.**

Dao T.H. (1)(2), De Matteis F. (1)(2), Salamon A. (1)(2), Sargeni F. (1)(2), Bonaiuto V. (1)(2), Salvato M. (1)(2), Prosposito P. (1)(2), Francini R. (1)(2), Paoluzzi G. (2), Rigato V. (3), Roncolato C. (3), Campostrini M. (3), Liberali V. (4)(5), Stabile A. (4)(5), Trucco G. (4)(5), Frontini L. (4)(5), Foglini D. (4), Armani F. (5), De Iudicibus M. (4), Shojaii J.S.R. (6), Gunnella R. (7), Di Giuseppe G. (7), Vitali D. (7), Natali R. (7), Piergentili P. (7), Attanasio C. (8), Spinella F. (9), Magazzu G. (9), Pedreschi E. (9), Donati S. (9)(10), Saponara S. (9)(10), Cammarata S. (9)(10), Rossi D. (9)(10), Morsani F. (9), Fioretti A. (9)(11), Gabbanini C. (9)(11), Toncelli A. (9)(10), Bellani V. (12)(13), Lacava C. (12)(13), Fontana A. (12)(13), Kaplan A.E. (12)(13), Rossella F. (14)(15), Candini A. (16), Brosco V. (17), Forneris J. (18)(19), Calvo D. (19), Olivero P. (18)(19), Ditalia Tchernij S. (18)(19), Degiovanni I.P. (19)(20), Genovese M. (19)(20), Corte E. (18)(19), Andrini G. (19)(21), Iadanza S. (22)(23)
(1) *Università degli Studi di Roma Tor Vergata*
(2) *INFN Sezione di Roma Tor Vergata*
(3) *INFN Laboratori Nazionali di Legnaro*
(4) *Università degli Studi di Milano*
(5) *INFN Sezione di Milano*
(6) *University of Melbourne*
(7) *Università di Camerino and INFN Sezione di Perugia*
(8) *Università degli Studi di Salerno, INFN Gruppo Collegato di Salerno*
(9) *INFN Sezione di Pisa*
(10) *Università di Pisa*
(11) *CNR Istituto Nazionale di Ottica*
(12) *Università degli Studi di Pavia*
(13) *INFN Sezione di Pavia*
(14) *NEST Laboratory, Scuola Normale Superiore and Istituto Nanoscienze-CNR, Università di Modena e Reggio Emilia*
(15) *INFN Sezione di Pavia*
(16) *CNR Istituto per la sintesi organica e la fotoreattività*
(17) *CNR Istituto dei Sistemi Complessi*
(18) *Università di Torino*
(19) *INFN Sezione di Torino*
(20) *Istituto Nazionale di Ricerca Metrologica*
(21) *Politecnico di Torino*
(22) *Cork Institute of Technology*
(23) *Tyndall National Institute*

The QUANTEP project aims at the development and implementation of a complete silicon photonic integrated circuit in the approach of linear optics quantum computing. A prototype of this kind of circuits is the universal two-qubit Controlled-NOT gate. This scheme makes use of linear, coincidence basis gate that performs all the operations of a controlled-NOT gate and requires only single photons at the input. Single photon sources will be integrated through ion implantation in silicon of emitter centers in the telecom C-band. A heterojunction of Bi_2Se_3, a topological insulator with efficient IR absorption and Dirac-like metallic surface, and n-Si will be used on the optical chip for the detection stage. The potential of novel quantum-device concepts, realized by using heterostructured semiconductor nanowires as basic building blocks, graphene and other 2D materials will be explored in order to control over the light polarization. In the first stage, the optimization of the directional coupler has been performed by FDTD simulation software and first devices have been produced with the aim to characterize the different couplers necessary for quantum C-NOT gate implementation.

Aula Nella Mortara **ore 14:00 – 17:30**

Sezione VII
Didattica e storia della fisica
Presiede: Malgieri M. (Università di Pavia)

Relazioni su invito

▲ **Overview su 15 anni di PLS-Fisica. Una svolta nel raccordo Scuola-Università.**

Immè J.
Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania e Coordinamento Nazionale Piano Lauree Scientifiche-Fisica

Il piano PLS-Fisica ha avviato nel 2005 e consolidato negli anni un'attività coordinata nel progettare, sperimentare e diffondere sul territorio nazionale iniziative atte a dare agli studenti delle scuole superiori una corretta percezione della Fisica, fornendo loro opportunità di consolidamento delle competenze fisiche di base e offrendo agli insegnanti occasioni di aggiornamento delle conoscenze disciplinari. Un sicuro successo perseguito dal PLS è l'aver introdotto modalità innovative nel raccordo Scuola-Università, superando nei riguardi degli studenti il tradizionale approccio orientativo e nei riguardi degli insegnanti una formazione ex cathedra. Il coinvolgimento attivo di entrambi, in particolare in attività di laboratorio, è stato il punto di forza del PLS e il confronto costante fra i docenti coinvolti ha reso possibile monitorare costantemente l'efficacia delle azioni realizzate, evidenziando sia punti di forza che eventuali fattori di criticità. Il ricco bagaglio di esperienze accumulate offre sicuramente suggerimenti per una futura efficace progettualità basata su un rapporto tra scuola e università che tenda sempre più a favorire il successo formativo degli studenti.

▲ **Physics4Teenagers: Attività PLS a Pavia affidate a giovani fisici.**

Montagna P. (1)(2), Aimè C. (1)(2), Aurelio D. (3)(4)(5), Budassi E. (1)(2), Maragnano D. (1), Pirola M. (1)(2), Restelli S. (1), Santostasi D. (6), Venturini S. (1)(2), Zatti L. (1)
(1) *Dipartimento di Fisica, Università di Pavia*
(2) *INFN Sezione di Pavia*
(3) *Liceo "Copernico" Pavia*
(4) *Liceo "Taramelli" Pavia*
(5) *Liceo "Galilei" Voghera, PV*
(6) *Liceo "Cairoli" Vigevano, PV*

Negli ultimi anni a Pavia una decina di giovani fisici (gruppo "Physics4Teenagers" del Dipartimento di Fisica Università di Pavia), in collaborazione con il Piano Lauree Scientifiche, propone diverse iniziative che comprendono attività didattiche-divulgative di promozione della Fisica e orientamento universitario, realizzate a sostegno sia del corso di laurea in Fisica (azioni antiabbandoni e esperienze extracurriculari per studenti del primo anno), sia delle scuole secondarie superiori (stage estivo di fisica moderna "TendaysPhysics4Teenagers" per studenti di 4a superiore, Notte Europea dei Ricercatori con stand proposti dagli studenti di Fisica, seminari con dimostrazioni sperimentali nelle scuole, corsi di aggiornamento per docenti di Matematica e Fisica). Le attività, documentate in `https://fisicapaviaeducational.it/phys4teens/`, sono realizzate con forte taglio laboratoriale e interattivo e in stile informale e amichevole, nella profonda convinzione che la passione e l'entusiasmo per la fisica negli studenti liceali e universitari siano stimolati e mantenuti più facilmente attraverso l'esperienza sul campo e la trasmissione mediante "contagio" diretto da giovani a giovani.

▲ Il ruolo del laboratorio nella didattica della fisica.

Montalbano V.
Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, Università di Siena, Italia, Istituto Nazionale di Fisica Nucleare, sezione di Pisa, Italia e Associazione per l'Insegnamento della Fisica, sezione di Siena, Italia

Il laboratorio è fondamentale nel processo di insegnamento-apprendimento della fisica. Stimare, misurare, approssimare, modellizzare, confrontare qualitativamente e quantitativamente le previsioni teoriche con la realtà sperimentale permettono di superare la descrizione astratta dei fenomeni naturali, centrale nei libri di testo e spesso anche nelle lezioni tradizionali. Le attività laboratoriali favoriscono anche la formazione e il consolidamento di abilità trasversali utili nelle società avanzate. La ricerca didattica ha sviluppato metodologie volte a favorire l'apprendimento attivo e cooperativo in contesti molto diversi (per esempio con materiali "poveri" o virtuali) dove la necessità di laboratori attrezzati può essere superata. La molteplicità di metodi in cui lo studente è protagonista e la ricchezza delle attività che si possono proporre in laboratorio rendono questo momento didattico coinvolgente e motivante. E nel mondo reale? Quanto sono diffuse le innovazioni, proposte da decenni dalla ricerca, nella scuola o nelle università? A fronte di una situazione spesso desolante, quali azioni possono promuovere il laboratorio nella didattica della fisica?

▲ Galilei's two new sciences for modern readers.

De Angelis A.
Dipartimento di Fisica e Astronomia "Galileo Galilei" dell'Università di Padova

I present a new rendition of Galilei's "Discorsi e dimostrazioni matematiche" including translations of the original geometrical demonstrations into algebraic formulae in modern notation, allowing the non-specialist reader to follow the thread of Galilei's thought in a way that was barely possible until now. This work, published in Italian (Codice) and in English (Springer) with prefaces by Ugo Amaldi and Telmo Pievani, includes a new version of the original Galilei's drawings, digitally restored in collaboration with the Italian National Library in Florence, and anticipates the 2022 800th anniversary of the foundation of the University of Padua, for which a revival of Galilei can be expected.

▲ Renovating a university physics museum: Challenges and perspectives.

Talas S.
Museum of the History of Physics, University of Padua

The Museum of the History of Physics was founded at the Department of Physics of the University of Padua in 1995. It holds thousands of scientific instruments that were used for physics research and teaching in Padua from the 18th century onwards. We are now developing a project to renovate the Museum, with the aim of focusing on the way physicists in Padua have been carrying out their research and teaching activities throughout the centuries. The paper will discuss some of the main peculiarities of the project. We will for instance outline how the new display contributes to enlighten the intersections between local research and teaching paths and the global maps of knowledge, and how it sheds light on the role of the political, social and economic context scientists lived in, both at local and international level. Starting from historical instruments, the Museum actually aims at contributing to promote a heightened knowledge on several aspects of today's scientific processes and issues, in order to stimulate critical thinking in the public.

▲ Polvani's Institute of Physics in Milan before the Post-War Reconstruction.

Gariboldi L.
Università degli Studi di Milano, Dipartimento di Fisica "Aldo Pontremoli"

Giovanni Polvani was called as professor of Experimental Physics and director of the Institute of Physics in Milan after Pontremoli's death declaration. We shall reconstruct the teaching and research activities during the 1930's and early 1940's, during the Fascist regime up to the collapse of the Italian Social Republic. Some fundamental results of Polvani's direction were the foundation of the degree courses in Physics and in Mathematics and Physics, and the support to researches in cosmic ray physics (with team led by Giuseppe Cocconi who worked with counters and cloud chambers), and in theoretical physics (Giovanni Gentile).

I lavori della prima parte della mattina si svolgeranno dalle 9:30 alle 11:40 nell'Aula Margherita Hack in una Sessione Congiunta con la Sezione III - Astrofisica.
Per il programma si veda alla pagina 34.

Aula Chien Wu **ore 11:40 – 13:00**

Sezione I
Fisica nucleare e subnucleare
Presiede: Gialanella L. (Università della Campania)

Relazioni su invito

▲ **Recent studies on fission: Reaction dynamics and nuclear structure.**
Crespi F.C.L.
Dipartimento di fisica dell'Università degli studi di Milano e INFN Sezione di Milano
At the end of the 1930s nuclear fission was discovered by Hahn and Strassman, while Meitner and Frisch published the correct theoretical interpretation. This process, in which a nucleus splits into two fragments, still has fascinating unknown aspects. For example, the fragments are observed to emerge spinning, but how the angular momentum generates has been a mystery for decades. Recent results, published in *Nature*, revealed that the fragments obtain their intrinsic angular momentum after fission (not before), contrary to the present consensus. Fission is also a way to produce a variety of neutron-rich nuclear systems, allowing to study their structure.

▲ **Hunting down Internal Pair Creation anomalies: An overview of the forthcoming nuclear physics experiments to solve the X17 puzzle.**
Marchi T., Gustavino C.
Istituto Nazionale di Fisica Nucleare
A laboratory experiment in Hungary has recently spotted anomalies in the internal pair creation emission from the decay of $^{8}Be^{*}$ and $^{4}He^{*}$ nuclei. The excited states have been populated by proton-induced reactions on ^{7}Li and ^{3}H targets at very low energy. Clear deviations from the expected electron-positron angular correlations have been reported and interpreted as the evidence of an unknown 17 MeV/c^2 neutral boson, named X17. If confirmed, such experimental results could mean the discovery of a new fundamental Nature's force. In this contribution we will summarize the status of the Italian nuclear physics community for providing new experiments capable of shedding light on the present X17 puzzle.

▲ **The calculation of the nuclear matrix element for the neutrinoless double-beta decay within microscopic approaches.**
Coraggio L.
Dipartimento di Matematica e Fisica, Università degli Studi della Campania "Luigi Vanvitelli", Caserta e Sezione INFN di Napoli
At present, the search for evidence of neutrinoless double-beta decay is among the major goals in experimental physics, since it will shed light on the understanding of both the limits of the standard model and the intrinsic nature of the neutrino. On the theoretical side, a

reliable calculation of the nuclear matrix element (NME) of this process is of paramount importance, because this quantity relates the half-life of the decay to the neutrino effective mass. Here, we review the current developments to calculate the nuclear matrix element for the neutrinoless double-beta decay by way of microscopic approaches, namely many-body methods which are based on the degrees of freedom of single-nucleon states, and that are fashionable to employ modern realistic nuclear potentials. We show recent results obtained by calculating neutrinoless double-beta decay NME within the framework of *ab initio* methods and realistic shell model, for nuclei that are of current experimental interest. Moreover, the theoretical advances to tackle the long-standing issue of the quenching of the axial coupling constant g_A will be briefly discussed.

▲ **Nuclear fragmentation measurements for hadrontherapy with FOOT.**

Kraan A.
INFN, Sezione di Pisa

FOOT (FragmentatiOn Of Target) is an applied nuclear physics experiment conceived to conduct high-precision cross section measurements of nuclear fragmentation processes relevant for particle therapy and radiation protection in space. In radiotherapy treatments with proton or carbon ions, secondary fragments can modify the dose in patients. In the context of deep space explorations, a detailed knowledge of fragmentation processes is essential for the design of spacecraft shielding and radioprotection of astronauts. At present, the limited experimental precision achieved on the relevant nuclear cross sections compromises the reliability of the computational models used to estimate the dose impact of secondary fragments in human tissue. The FOOT Collaboration designed an experiment to study these nuclear processes and measure the corresponding fragmentation cross sections. In this contribution, we discuss the motivations, design, current status, and future plans of the FOOT experiment. Moreover we present the most recent physics results obtained from dedicated runs taken at the National Center of Oncological Hadrontherapy (Pavia, Italy) and the GSI laboratory (Darmstadt, Germany).

Aula Cornelia Fabri **ore 09:30 – 13:00**

Sezione II
Fisica della materia
Presiede: Cepek C. (IOM-CNR, Trieste)

Relazioni su invito

▲ Towards phonon engineering at the nanoscale: Material design and innovative experimental techniques.

Zardo I. (1), De Luca M. (1), Swinkels M. Y. (1), de Matteis D. (1), Fasolato C. (1)(2), Cartoixá X. (3), Rurali R. (4)
(1) *Department of Physics, University of Basel, Switzerland*
(2) *Department of Physics and Geology, Università degli Studi di Perugia, Italy*
(3) *Departament d'Enginyeria Electrònica, Universitat Autònoma de Barcelona, Spain*
(4) *Institut de Ciència de Materials de Barcelona - ICMAB-CSIC, Spain*
The recently growing research field called "Nanophononics" deals with the investigation and control of vibrations in solids at the nanoscale. Phonon engineering leads to a controlled modification of phonon dispersion, phonon interactions, and transport. However, engineering and probing phonons and phonon transport at the nanoscale is a non-trivial problem. In this talk, we discuss how phononic properties can be engineered in nanowires and the challenges and progresses in the measurement of the thermal conductivity of nanostructures and low dimensional systems. Finally, we discuss our recent work on two-dimensional systems and their interest for the investigation of hydrodynamic transport.

▲ On the origin, dimensionality and control of defect states in (001) anatase TiO_2 thin films

Bigi C. (1)(2)(3), Troglia A. (2)(3), Pierantozzi G. M. (2), Fujii J. (2), Vobornik I. (2), Ciancio R. (2), Sangiovanni G. (4), Selloni A. (5), Rossi G. (2)(3), Orgiani P. (2)(6), Panaccione G. (2)
(1) *SUPA, School of Physics and Astronomy, University of St. Andrews, St. Andrews KY16 9SS, UK*
(2) *CNR-IOM, Area Science Park, I-34149 Trieste, Italy*
(3) *Dipartimento di Fisica, University of Milano, Via Celoria 16, I-20133 Milano, Italy*
(4) *Institut für Theoretische Physik und Astrophysik, Universitäat Würzburg, 97074 Würzburg, Germany*
(5) *Department of Chemistry, Princeton University, Princeton, NJ 08544, USA*
(6) *CNR-SPIN, UOS Salerno, 84084 Fisciano, Italy*
Anatase is a TiO_2 polymorph widely exploited in a number of applications, *e.g.*, in photocatalysis, sensors and solar cells. The optimisation and development of anatase-based devices is grounded in the understanding, and possibly the control, of its electronic properties. In this talk, I present the results of our x-ray and ultraviolet based electron spectroscopy investigation of (001) anatase thin and ultrathin films, *i.e.* down to the single unit cell thickness. We addressed the dimensionality, the formation mechanism, and the possible control of defect states formed at the (001) surface of anatase TiO_2. Our findings are completed by first-principles density-functional theory calculations.

▲ Dynamics of charge excitations in metal-oxide nanostructures for energy conversion.

Luches P.
Istituto Nanoscienze, Consiglio Nazionale delle Ricerche, Via G. Campi 213/a, 41121 Modena

Oxide-based materials find wide application as stable and non-critical compounds for solar energy conversion. A detailed understanding of the dynamics of photo-induced excited states is very relevant for the optimization of the light-induced functionalities. Starting from the case of cerium oxide based systems, also in combination with plasmonic Ag, Au and Cu nanoparticles, I will show how ultrafast spectroscopies have allowed to unravel relevant aspects of the excited states dynamics. In particular, femtosecond transient absorption studies have provided a solid basis for subsequent pump-probe X-ray absorption spectroscopy investigations at the FERMI free-electron laser. The results have allowed to demonstrate the formation of a small-polaron state after band-gap excitation, with influence on the transport properties and on the reducibility of the material. The excitation of localized surface plasmon resonances in Ag, Au and Cu nanoparticles, embedded in cerium oxide matrices, has been shown to decay via an ultrafast, efficient and stable charge transfer to the surrounding metal oxide, leading to a transient increase of the reducibility of the system.

▲ Conducting $LaAlO_3/SrTiO_3$ micro-membranes obtained by strain engineering: Characterization and possible electronic applications.

Sambri A. ([1]), Scuderi M. ([2]), Guarino A. ([1])([3]), Di Gennaro E. ([1])([4]), Dahm R. T. ([5]), Christensen D. V. ([6]), Erlandsen R. ([5]), Bjørlig A. V. ([5])([6]), Di Capua R. ([1])([4]), Mirabella S. ([2])([7]), Jespersen T. S. ([5]), Nicotra G. ([2]), Spinella C. ([2]), Miletto Granozio F. ([1])([4])
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([5]) *Niels Bohr Institutet, Universitetsparken 5, bygn. D, 2100 København, Denmark*
([6]) *Department of Energy Conversion and Storage, Technical University of Denmark, Roskilde, Denmark*
([7]) *Dipartimento di Fisica e Astronomia, Università di Catania, Via S. Sofia 64, I-95123, Catania, Italy*

The discovery of 2D conductivity at the $LaAlO_3/SrTiO_3$ interface has triggered an active research in materials science. Notably, despite the 2D nature of the interfacial electron gas (2DEG), samples are 3D objects with thickness in the mm range. This prevented researchers from effectively exploiting degrees of freedom related to strain, strain gradient and curvature. Here we present a method for obtaining freestanding $LaAlO_3/SrTiO_3$ micro-membranes purely based on strain engineering. The results open a new path for adding oxide functionalities into semiconductor electronics, potentially allowing for ultra-low voltage gating of a superconducting transistors, micro-mechanical control of the 2DEG and on-chip straintronics.

▲ Quantum pumps and quantum phase batteries.

Citro R., Strambini E., Iorio A., Durante O., Romeo F., Sanz-Fernández C., Guarcello C., Tokatly I. V., Braggio A., Rocci M., Ligato N., Zannier V., Sorba

L., Bergeret F. S., Giazotto F.
Department of Physics, University of Salerno and CNR-SPIN, Via Giovanni Paolo II, 132, Fisciano, SA, Italy
The access to quantum physics at nanoscale has revolutionized our daily life opening the way to quantum computing, quantum information and novel forms of energy harvesting. In particular, batteries and pumps are ubiquitous in our everyday lives, with lithium-ion batteries being the most commonly used type. The quantum phase battery and pumps are different devices altogether. While classical batteries convert chemical energy into voltage, which powers electronic circuits, quantum technologies use circuits or devices based on superconducting materials or nanostructures. In superconducting materials, similarly to quantum pumps, currents flow without the need for an applied voltage. Therefore, when it comes to quantum computers, there is no need for a classical battery. Supercurrents do not exhibit any energy losses as they are induced from a phase difference of the wave function of the quantum circuit, similarly in a pump a persistent current is generated by the geometric phase of the quantum system when some parameters are slowly varied in time. We discuss here the realization of a quantum phase battery based on InAs nanowires, quantum pumps in optical lattices and nanostructures.

▲ **The photophysics of carbon dots and their nanocomposites.**

Sciortino A. (1), Panniello A. (2), Minervini G. (2), Gelardi F.M. (1), Buscarino G. (1), Agnello S. (1), Cannas M. (1), Striccoli M. (2), Messina F. (1)
(1) *Department of Physics and Chemistry - Emilio Segrè, Universiy of Palermo, Italy*
(2) *CNR-IPCF, Bari, Italy*
Carbon Nanodots (CDs) are an emerging family of carbon-based nanoparticles characterized by intense and tunable light absorption-emission in the visible range. Besides, their optical response is very sensitive to external agents (solvent molecules, ions in solution, nanoparticles ...), a property which may be very useful for several applications, if deeply understood. For example, CD emission decreases in the presence of metal ions in solution because of a high electron donor capability of CDs. In contrast, CD emission can be strongly enhanced, under certain conditions, through the interaction with plasmonic metal nanoparticles. The versatility of their possible behaviours promisingly projects the use of CDs as suitable substitutes of quantum dots in many optoelectronic or photo/electro-catalysis applications. Here we will present a summary of our scientific work on the photophysics of CDs. In particular, we will focus on the fundamental photophysics of two different classes of composite nanomaterials, obtained by coupling CDs to carbon nanotubes or gold nanoparticles respectively, in order to show the variety of CD optical responses and the wide range of possible applications.

▲ **Two-membrane cavity optomechanics: Linear and non-linear dynamics.**

Piergentili P. (1)(2), Wenlin L. (1), Natali R. (1)(2), Malossi N. (1)(2), Vitali D. (1)(2)(3), Di Giuseppe G. (1)(2)
(1) *Scuola di Scienze e Tecnologie, Divisione di Fisica, Università di Camerino, Italia*
(2) *INFN, Sezione di Perugia, Italia*
(3) *CNR-INO, Largo Enrico Fermi 6, Firenze, Italia*
The linear and non-linear dynamics of an optomechanical system made of a two-membrane ethalon in a high-finesse Fabry-Pérot cavity is presented. The presence of the second membrane inside the optical cavity might enhance the optomechanical coupling making this system interesting to reach the strong-coupling regime. The first experimental characterization of the optical, mechanical, and especially optomechanical properties of a sandwich constituted of two parallel membranes within an optical cavity will be presented. We find that the optomechanical coupling strength is enhanced by constructive interference when the

two membranes are positioned to form an inner cavity which is resonant with the driving field. Furthermore, the behaviour of the non-linear dynamics of such a system in a pre-synchronization regime will be discussed. We establish that the non-linear dynamics of the mechanical oscillator provides a novel procedure for the determination of the single-photon optomechanical rate, that is the optomechanical interaction strength of the system.

Aula Margherita Hack **ore 09:30 – 11:40**

Sessione congiunta delle Sezioni
I - Fisica nucleare e subnucleare e III - Astrofisica
Presiede: Re A. (INFN, Sezione di Milano)

Relazioni su invito

▲ **Dark matter candidates.**

Arina C.
Institute for research in mathematics and physics, IRMP, UCLouvain

Whilst the need for dark matter was established almost a century ago, only its gravitational interaction has been confirmed so far and its viable mass range spans 90 orders of magnitude. The Weakly Interacting Massive Particles (WIMPs) category has received by far the biggest attention as they are thermal relics promising for detection. Yet, despite the enormous experimental efforts, WIMPs remain elusive. The attention of the community has hence moved on and re-opened the dark matter landscape over all its viable mass range. In this talk I will possibly review the landscape of dark matter models well above and below the TeV and GeV scales, respectively. The widening of the dark matter landscape is due either to new avenues and new dark matter candidates that have emerged in highly motivated theoretical results or to appealing (new) experimental data or improved analyses. I will further connect these dark matter candidates and their signature to the current and future experimental sensitivity and highlight the models which are compatible with existing data or that are around the corner for discovery.

▲ **On top of Dark Matter at the LHC.**

Pani P.
DESY

Astrophysical observations have provided compelling evidence for the existence of a non-luminous component of the universe: Dark Matter. If Dark Matter is a particle, characterised by weak-scale interactions with the Standard Model, it can be recreated in the high-energy proton-proton collision at the Large Hadron Collider (LHC) at CERN. The LHC experiments have a vast and diversified experimental programme, designed in collaboration with the theoretical community, which aims to discover and precisely measure dark matter. In this talk I will provide an overview of this programme, outlining both the fundamental assumptions and the experimental challenges of this effort. Finally, I will briefly detail one specific aspect of these searches, which focus on the particularly interesting possibility that the interaction between ordinary matter and Dark Matter is mediated by new scalar particles that extend the Higgs sector and couples dominantly to top quarks.

▲ **First experimental constraints on the antinucleus-nucleus inelastic cross section and their implications to the predicted antihelium-3 flux near Earth.**

Colocci M. per la Collaborazione ALICE
CERN

The detection of antideuterons and antihelium in space might be a striking evidence for Dark Matter annihilation in our galaxy, being the signal-to-background ratio for antinuclei much larger than the one expected for antiprotons. The expected flux of antinuclei near Earth depends both on their production rates and on their attenuation in the interstellar gas, both of which currently are poorly constrained, and hence need to be better studied. In high-energy pp, p-A and A-A collisions at the LHC, light nuclei and antinuclei are produced almost at the same rate. This, together with the unique tracking and particle identification capabilities of the ALICE detector, allows for a high-precision study of the production cross sections of antinuclei as well as to measure the absorption process of produced antinuclei in the ALICE detector material. In this contribution, the first ever measurement of the inelastic cross section of low momentum antideuteron and antihelium-3 will be presented and the implications of these results on the predicted antinuclei flux in Space and near Earth will also be discussed.

▲ Bringing the Dark Sector into the light.

Oceano I. (1)(2), Bondí M. (3)
(1) *Università del Salento*
(2) *INFN - Sezione di Lecce*
(3) *INFN - Sezione di Genova*

Many astrophysical and cosmological observations suggest the existence of Dark Matter (DM). While the constraints from WIMPs searches are becoming more and more severe, new ideas to solve the DM puzzle have been blooming. One of them foresees the existence of a Dark Sector, with its own particles and interactions. A comprehensive experimental program has been launched to probe this hypothesis. The Italian community is significantly contributing to this effort working on several promising experiments using different techniques: PADME@INFN-LNF, BDX and HPS @JLAB, POKER@CERN. In this talk a review of on-going and future experiments will be shown

▲ Introduzione alle ricerche dirette di Dark Matter e il caso dell'esperimento CRESST.

Olmi M.
INFN-LNGS

La ricerca diretta di materia oscura ha conosciuto negli ultimi decenni un crescente interesse che si è tradotto nella nascita di numerosi esperimenti che utilizzano tecnologie diverse ma complementari. Una delle tecnologie più diffuse in questo ambito utilizza rivelatori criogenici e uno dei progetti attualmente leader mondiali del settore è l'esperimento CRESST, situato presso i Laboratori Nazionali del Gran Sasso (LNGS). CRESST utilizza bolometri criogenici i cui assorbitori sono cristalli scintillanti di $CaWO_4$ associati a rivelatori di luce criogenici. Tutti i rivelatori sono dotati di Transition Edge Sensors (TESs) operati ad una temperatura di $\sim$ 15 mK. La rivelazione di segnali di calore e luce e l'impiego dei TES rendono CRESST estremamente sensibile a interazioni di WIMP di massa inferiore al GeV/c^2. Con l'ultimo upgrade i rivelatori di CRESST-III sono stati ulteriormente ottimizzati per la rivelazione di WIMP leggere riducendo la massa dei cristalli da $\sim$ 300 gr a $\sim$ 25 gr. CRESST è al momento l'unico esperimento di ricerca diretta di materia oscura che può vantare una soglia energetica di 30.1 eV e una sensibilità a WIMP di massa da 1.8 GeV/c^2 fino a 0.16 GeV/c^2.

▲ Segnali di materia oscura dallo spazio.

Munini R.
INFN - Trieste

L'esistenza della materia oscura è fortemente supportata da diverse misure di tipo gravitazionale ma la sua natura è ancora oggi sconosciuta. Le Weakly Interacting Dark Matter Particles (WIMPs) appaiono come naturali candidati nei modelli teorici meglio motivati per la materia oscura. Queste particelle pesanti, caratterizzate da interazioni di tipo gravitazionale e debole, dovrebbero permeare la Via Lattea e tutte le strutture su larga scala dell'universo. Uno degli approcci sperimentali sviluppato negli ultimi decenni prevede la ricerca di segnali di materia oscura attraverso la precisa misura degli spettri energetici della radiazione cosmica, primariamente raggi cosmici, raggi gamma e neutrini. In particolare si ricercano eccessi di segnale rispetto al fondo astrofisico che possano essere imputati all'annichilazione o al decadimento delle particelle di materia oscura all'interno della Via Lattea. In questa presentazione verrà fatta una panoramica dei risultati nel campo della ricerca indiretta di materia oscura ottenuti con diversi esperimenti su satellite, pallone e array di detectors a terra.

Aula Margherita Hack **ore 11:40 – 13:00**

Sezione III
Astrofisica
Presiede: Re A. (INFN, Sezione di Milano)

Relazioni su invito

▲ **Searching for new worlds: A recent and intense story.**

Giacobbe P.
Osservatorio Astrofisico di Torino, INAF, Italia

Although over twenty years have passed, we are still in the early days of exoplanet discovery. The exoplanetary science is now entering a mature phase, in which scientific goals are shifted toward the determination of the physical properties of planets and the origin of their observed, astonishing diversity. Detections of extrasolar planets allow to measure the frequency of planets with different masses, sizes, orbital characteristics and host-star properties, and are now beginning to probe the diverse outcomes of planet formation and evolution. However, we have yet to map out the full complexity of multi-planet architectures or to detect Earth analogues around nearby stars. Reaching these ambitious goals will require further improvements in instrumentation and new analysis tools. Here, we provide an overview of observational techniques that are currently employed in the detection and characterization of exoplanets. Furthermore, we discuss forefront developments in both techniques and instrumentation that will result in new discoveries.

▲ **Shaping the Universe as we see it today: The late evolution of galaxies in their local environment.**

Fossati M.
Università degli Studi di Milano-Bicocca

I will review the evolution of galaxies from the epoch of the peak of their star formation activity (roughly 9 billion years ago) until the present day. I will follow the evolution of the main properties of the galaxy population (their mass, star formation rate, morphology and environment) and explain it in terms of the balance of gas feeding, outflows and gas removal phenomena ultimately leading to the Universe as we see it today. I will put the emphasis on the different histories that galaxies experience as a function of the local environment in which they live, highlighting the stark contrast between the properties of galaxies in isolation compared to those living in the most dense cosmic megalopolis: the clusters of galaxies.

▲ **Galaxies at the Cosmic Dawn: Exploring the first billion years of the Universe.**

Carniani S.
Scuola Normale Superiore di Pisa

One of the key questions of modern extragalactic astronomy is to determine when and how the first galaxies formed across cosmic history. Great progress has been made in understanding the build-up of the first generations of galaxies based on deep ground- and space-based observations over the last decade: observational data have enabled us to explore the star-formation activity and gas content in galaxies during the first billion years of the Universe, also called Cosmic Dawn, setting stringent constraints on galaxy-formation models. I will review the latest results on the search for the most distant sources, showing the most crucial findings on their physical properties and gas kinematics. I will also highlight the revolutionary possibilities to probe the physics of early galaxies that will be in reach thanks to the upcoming launch of the James Webb Space Telescope, the largest telescope ever on space.

Aula Inge Lehmann **ore 09:30 – 13:00**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: De Santis A. (INGV, Sezione di Roma 2)

Relazioni su invito

▲ Recent advances in ionospheric scintillation on Global Navigation Satellite System signals.

Spogli L.
Istituto Nazionale di Geofisica e Vulcanologia

The positioning based on the use of Global Navigation Satellite System (GNSS) signals is threatened by ionospheric irregularities. When a planar wave crosses such irregularities, fluctuations of both amplitude and phase of the received signal at ground may occur. The nature of such fluctuations is ruled by the Fresnel's filtering, being the Fresnel's scale the fine line between purely refractive fluctuations and mostly diffractive fluctuations. Amplitude scintillation of the GNSS signals is purely driven by refractive effects, being the most disruptive of GNSS positioning. What is actually the phase scintillation is still a matter of debate. Being the refractive effects the bulk of the first-order ionospheric effect and covering the full phase spectrum, the phase scintillation identification should require an extraction of structure that follows the inverse frequency dependence or at least a reliable detrending scheme that is able to properly identify the Fresnel's frequency, upon which the phase scintillation index definition is based. In this contribution, a selected review of the recent results addressing how to properly address scintillation on GNSS signals is provided.

▲ New particle formation around the globe: From laboratory experiments to the Everest Base Camp.

Bianchi F.
University of Helsinki

Atmospheric aerosols affect the climate by acting as Cloud Condensation Nuclei (CCN). A major fraction of these CCN comes from gas to particle conversion (nucleation). During the last decade, several nucleation studies have been published based on field observations, however most of them in the planetary boundary layer. Therefore, only little information is available about the free troposphere. The aim of this presentation is to elucidate the last studies about what species contribute to new particle formation in the free troposphere. We used several state-of-the-art instruments such as advanced mass spectrometer and particle counters, first at the Swiss high alpine research station Jungfraujoch (3580 m asl) and then at the Himalayan Nepal Climate Observatory Pyramid (NCO-P) site on the southern slope of the Himalayas, not far from Everest base camp (5079 m asl). During the presentation, in addition to show the results of these two studies, I will also compare them with laboratory experiments. I will present a detailed analysis of the particles evolution during nucleation and also the chemical composition of the small clusters measured.

▲ Geomagnetic jerks and South Atlantic Anomaly: A link during satellite era.

Campuzano S.A. (1), De Santis A. (2)(3), Pavón-Carrasco F.J. (4), González-López A. (1)(4), Qamili E. (5)
(1) *Department of Earth Dynamics and Observation, Geosciences Institute, Spain*
(2) *Istituto Nazionale di Geofisica e Vulcanologia, Italy*

([3]) *Università La Sapienza, Italy*
([4]) *Faculty of Physics, Complutense University of Madrid, Spain*
([5]) *Serco S.p.a, Italy*
The South Atlantic Anomaly (SAA) is one of the most important features of the present geomagnetic field, related to the presence of reversed flux patches at the Core-Mantle Boundary. Geomagnetic jerks are sudden changes in the geomagnetic field secular variation related to changes in outer core flow patterns. A link between the geomagnetic jerks occurrence and the minima of acceleration of the SAA areal extent calculated using the CHAOS-7.2 model was observed for the last 2 decades. Here, using the new updated CHAOS-7.6 release, we confirm these results, especially relevant in very recent times when edge effects could have affected previous calculations. This reinforces the proposed link and weaken the idea of a connection by chance. We have also analyzed the acceleration of the areal extent of South American and African reversed flux patches at the Core-Mantle Boundary related to the presence of the SAA at surface and have registered minima in the same periods when they are observed in the SAA at surface. This could mean that the core dynamics involved in the origin of jerks is related to the physical processes that produce the reversed flux patches, and in turn the SAA evolution.

▲ **An improved and continuous synchronization of the Greenland ice-core and U-Th timescales using probabilistic inversion.**

Muschitiello F.
Department of Geography, University of Cambridge, Cambridge CB2 3EN, United Kingdom and NORCE Norwegian Research Centre, Jahnebakken 5, 5007 Bergen, Norway
The Greenland ice-core chronology (GICC05) and the Hulu Cave speleothem U-Th timescale are the most established independently dated frameworks of the last ice age, and serve to constrain the timing of abrupt climate change recorded in a variety of paleoclimate archives. Within the 14C dating range, the U-Th timescale also provides the backbone for the IntCal20 radiocarbon calibration curve. As a result, potential offsets and dating biases of the order of hundreds of years complicate the comparison between 14C-dated and ice-core climate records. Here I employ an automated method to synchronize proxy records (climate and cosmogenic radionuclide data) and produce the first continuous quantification of the offset between the GICC05 and U-Th chronologies of the last ~50,000 years. The method minimizes the misfit between proxy time-series while accounting for prior knowledge on the uncertainty in annual layer identification in ice cores using Bayesian inversion. The new results strongly reduce the absolute dating uncertainty of GICC05 and indicate fast fluctuations in the timescale offset during the LGM, suggesting a previously unrecognized bias in the ice-core annual layer counting.

▲ **Recent long-term variations of the Mediterranean Sea state.**

Simoncelli S., Fratianni C., Guarnieri A., Oliveri P., Delrosso D., Mattia G., Di Pietro P.
Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Italy
The Mediterranean Sea presents, according to the recent literature, the largest warming rate of the whole global ocean. The amplification of climate change effects in this regional basin can be ascribed to its peculiar topography and thermohaline circulation. Some major changes of its water masses characteristics and its circulation have been recorded by observations and reproduced by model reanalysis. An overview of the main Mediterranean Sea variations from 1950 until nowadays will be presented considering the latest Mediterranean Sea climatological product computed from historical in situ temperature and salinity data within the framework of SeaDataCloud project and the existing reanalysis products from INGV and the Copernicus

Marine Service. One of the principal indicators of global warming is the Ocean Heat Content (OHC). Its estimate and evolution derived from several and multi-year products, confirms a progressive warming of the Mediterranean basin characterized by spatial variability in different sub-regions and in different depth layers as a consequence of the hydrodynamics.

▲ **Depth resolution of potential fields.**

Fedi M., Florio G., Cella F.
Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università di Napoli Federico II

In the applied geophysical community, it is often sentenced that gravity and magnetic fields do not have depth resolution. In addition, such lack of depth resolution would be responsible of being the solution of the inverse problem (density or magnetic susceptibility, respectively) concentrated at very shallow depths. And that this effect could not be avoided, because the theoretical kernel would be unable to define deep sources. We discuss thoroughly the issue of depth resolution, and show that any assessment of depth resolution must relate to the assumed a priori info. In this framework, we refer to: a) the forward problem, which encloses theoretical assumptions about the source distribution; b) the quantities affected by inherent ambiguity. For instance the depth to the center (and the mass) of a homogeneously dense sphere is uniquely determined from its gravity anomaly, while the radius and the density are not; c) the existence of non-ambiguous bounds (maximum depth) or of ensemble average estimates (depth estimates from spectral analysis); d) the dependency of the depth resolution on the inversion algorithms, including the role of the constraints.

Aula Ida Ortalli **ore 09:30 – 13:00**

SEZIONE V
Biofisica e fisica medica
Presiede: CIOCCA M. (CNAO)

Relazioni su invito

▲ **Radiomica e Intelligenza Artificiale: Nuove frontiere della Fisica Medica.**
ORIGGI D.
Servizio di Fisica Medica, IEO, Istituto Europeo di Oncologia, IRCCS, Milano
La Radiomica è una disciplina recente che punta ad estrarre informazioni quantitative da immagini biomediche digitali, allo scopo di evidenziare caratteristiche di interesse clinico che sono presenti nelle immagini ma che non possono essere apprezzate dal medico attraverso la semplice analisi visiva. In oncologia, viene tipicamente utilizzata per lo studio delle proprietà dei tumori, visibili nelle immagini di tomografia computerizzata (TC), risonanza magnetica (MR), tomografia ad emissione di positroni (PET) e nell'imaging radioterapico. Combinando i parametri estratti dalle immagini, le cosiddette features, con dati clinici è possibile costruire dei modelli predittivi in grado di supportare il medico nella sua decisione clinica, verso diagnosi sempre più precise e terapie personalizzate. L'analisi di tali dati vede sempre più il coinvolgimento di tecniche di Intelligenza Artificiale, quali il Machine Learning ed il Deep Learning, particolarmente efficienti nell'analisi di grandi moli di dati. Numerosi studi sono in corso per studiare la riproducibilità di tali tecniche e valutarne l'applicabilità clinica.

▲ **Diffusion MRI: Signal representations and models to probe tissue microstructure.**
MASTROPIETRO A.
Istituto di Tecnologie Biomediche - Consiglio Nazionale delle Ricerche
Diffusion MRI is a valuable technique that allows the non-invasive characterization of tissue microstructure. The complexity of the microstructural properties of tissue —cells dimensions, intra/extra cellular environment, spatial arrangement, etc.— can be revealed from the diffusion-weighted signal using the most appropriate acquisitions methods and multi-compartmental models. This talk provides an overview of the tissue microstructure assessment using diffusion MRI and reviews the state of the art. In particular, the evolution of mathematical representations and computational models related to diffusion MRI —with a focus on their limitations and strength— will be discussed, as well as some relevant biomedical applications.

▲ **Analisi quantitativa di suscettività magnetica dei tessuti cerebrali.**
CONTARINO V.E.
Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milano
Il Quantitative Susceptibility Mapping (QSM) è una tecnica di risonanza magnetica finalizzata a quantificare la distribuzione spaziale della suscettività magnetica di oggetti o tessuti. Si basa sulla misurazione delle disomogeneità del campo magnetico statico causate dalle variazioni locali di suscettività tramite Gradient Recalled Echo (GRE) phase imaging e da successiva risoluzione del problema inverso di calcolo della distribuzione di suscettività a partire dai campi locali misurati. Il QSM è utilizzato nelle applicazioni di ricerca come metodo

quantitativo, a differenza del Susceptibility-Weighted Imaging (SWI) che è ampiamente utilizzata nelle applicazioni cliniche come tecnica qualitativa. Nello studio dei tessuti cerebrali, il QSM può essere utilizzato per indagare depositi di ferro e calcio, demielinizzazioni e infiammazioni, microsanguinamenti e tasso metabolico di ossigeno.

▲ **Digital image processing solutions for spectral photon-counting computed tomography with a CdTe detector.**

Brun F. (1)(2), Di Trapani V. (3)(4), Rigon L. (2)(5), Longo R. (2)(5), Delogu P. (3)(4)
(1) *Dipartimento di Ingegneria e Architettura, Università degli Studi di Trieste, Trieste, Italia*
(2) *Istituto Nazionale di Fisica Nucleare - Sezione di Trieste, Trieste, Italia*
(3) *Dipartimento Scienze fisiche, della Terra e dell'ambiente, Università di Siena, Siena, Italia*
(4) *Istituto Nazionale di Fisica Nucleare - Sezione di Pisa, Pisa, Italia*
(5) *Dipartimento di Fisica, Università degli Studi di Trieste, Trieste, Italia*

When considering a conventional polychromatic X-ray spectrum, innovative high-resolution X-ray Photon Counting Detectors (XPCDs) permit the collection in a single shot of multiple images having different energetic content. In contrast to multiple acquisitions with different tube spectra, this approach eliminates the risk of misregistration as well as the dark noise by rejecting all the events below the signal threshold. The adoption of XPCDs for biomedical imaging is very promising but its practical application is being hampered by several practical technological issues, such as inhomogeneities in the energy threshold calibration and polarization effects of high-Z sensors. When considering the application of XPCDs for computed tomography (CT), these issues result in several artifacts corrupting the reconstructed images. This contribution presents and discusses the most recurrent artifacts occurring in the raw images acquired with the innovative CdTe Pixirad-1/Pixie-III detector when considering its charge sharing recovery solution. Effective digital image processing solutions to cope with these artifacts will be shown as well as a few practical applications.

▲ **Model-free semantic segmentation for the early detection of metabolic abnormalities through machine-learning algorithms.**

Bianchetti G. (1)(2), De Spirito M. (1)(2), Maulucci G. (1)(2)
(1) *Dipartimento di Neuroscienze, Sezione di Biofisica, Università Cattolica del Sacro Cuore, Roma, Italia*
(2) *Fondazione Policlinico Universitario "A. Gemelli" IRCSS, Roma, Italia*

The peculiar metabolic features of cancer cells constitute the basis for the imaging techniques currently used in clinical practice. However, there are several factors that may alter the efficacy of these strategies in detecting lesions. A powerful tool for solving these drawbacks is constituted by the increasing and widespread artificial intelligence-based approaches for image analysis relying on the properties of individual pixels. To this aim, I hereby present an innovative and fully automatized model-free method that, through a machine learning-based supervised pixel-classification, will allow the early detection of metabolic abnormalities thus improving the precision in lesions identification and localization.

▲ **The role of radiomic analysis in neurodegenerative disease: A preliminary study on patients with Essential Tremor.**

Borgese R. F. (1)(2), Collura G. (1)(2), Putortì V. (3), Pignolo A. (3), D'Amelio M. (3), Gagliardo C. (3), Marrale M. (1)(2)
(1) *Department of Physics and Chemistry "Emilio Segrè", University of Palermo*
(2) *Istituto Nazionale di Fisica Nucleare, Sezione di Catania*

([3]) *Department of Biomedicine, Neuroscience and Advanced Diagnostics University of Palermo, Italy*

Radiomics is an emerging field of research in the context of medical image analysis. It is based on the extraction and analysis of quantitative imaging features from medical images in order to exploit them in clinical decision algorithms. We explored the predictive power of radiomic features extraction in patients with essential tremor, the most common movement disorder. The aim of the work is to correlate radiomic features extracted from segmented brain eloquent areas of patients with ET and tremor severity score obtained from The Essential Tremor Rating Assessment Scale (TETRAS). Patients underwent brain MRI scan with a 1.5 T scanner. A wide set of MR images such as T1/T2-weighted FSE/FRFSE images, T2-weighted 2D FLAIR with FAT saturation, DWI, DTI and SWAN images and probabilistic tractography maps were analyzed. Radiomic features were extracted from these images and were correlated to clinical parameters used to characterize tremor disease.

▲ Evaluation of the radiomic feature robustness with heterogeneous insert simulating CT lung lesions.

Rinaldi L. ([1])([2]), Pezzotta F. ([3]), Santaniello T. ([3]), De Marco P. ([2]), Origgi D. ([2]), Cremonesi M. ([2]), Mariani M. ([1]), Lascialfari A. ([1]), Milani P. ([3]), Botta F. ([2])

([1]) *Dipartimento di Fisica Università di Pavia, Italia*

([2]) *IEO, Istituto Europeo di Oncologia IRCCS Milano, Italia*

([3]) *Centro Interdisciplinare Materiali e Interfacce Nanostrutturati - CIMaINa, Dipartimento di Fisica, Università degli studi di Milano, Italia*

Radiomic features extracted from medical images may be affected by low stability under different imaging conditions. Repeatability and reproducibility can be assessed with phantoms, allowing multiple measurements in controlled setting. However, objects mimicking tissue signal and heterogeneity are not commercially available. In this study, prototypes simulating lung lesion texture were realised for CT acquisitions: one prototype made of sodium polyacrylate with iodinated contrast medium and another one 3D-printed using Polyethylene Terephthalate (PET-G). The inserts were placed in a container filled with cork, surrounded by water to simulate body attenuation. Ten consecutive scans were performed on two CT scanners, applying a tube voltage of 100 and 120 kVp, using the clinical chest protocols adopted in our Institute. Radiomic features were extracted with Pyradiomics and compared against a group of NSCLC patients acquired with the same scanners and voltages. Repeatability was evaluated with the coefficient of variation, reproducibility with the concordance correlation coefficient. Preliminary measurements of similarity with real lesion texture and feature robustness were performed.

Aula Ada Lovelace **ore 09:30 – 13:00**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Ferraro P. (ISASI-CNR, Pozzuoli, NA)

Relazioni su invito

▲ **Advanced nanotechnologies for bio applications.**
Pirri C.F. (1)(2), Canavese G. (1), Cocuzza M. (1), Frascella F. (1), Marasso S. (1), Napione L. (1)
(1) *Politecnico, C.so Duca degli Abruzzi 24, 10129 Torino, Italy*
(2) *Center for Sustainable Future Technologies, Istituto Italiano di Tecnologia, Via Livorno 60, 10144 Torino, Italy*
In recent years nanotechnologies applied to medicine have been proposed for comprehensive monitoring, control, construction, repair, defence and improvement of all human biological systems, working from the molecular level using engineered devices and nanostructures, ultimately to achieve high-impact medical benefit. Opportunities include superior diagnostics and biosensing, improved imaging techniques —from molecules to human beings— and, not least, innovative therapeutics and technologies to enable tissue regeneration and repair. In the present talk, the most recent results in the field of biosensors, Lab-on-chip and Organ-on-chip of the Materials and Processes for Micro & Nano Technologies Labs of Politecnico of Torino will be presented and discussed. Particular focus will be dedicated to rapid and low-cost diagnostic devices and biosensors for different diseases markers detection, innovative solutions for *in vitro* drug testing and physiological scenarios mimicking and new technologies for tissue regeneration and repair.

▲ **Single-molecule organic transistors sensors: Investigation and modeling.**
Torricelli F. (1), Macchia E. (2), Sarcina L. (3), Di Franco C. (4)(5), Kovács-Vajna Z.M. (1), Scamarcio G. (4)(5), Torsi L. (3)(6)
(1) *Department of Information Engineering, University of Brescia, 25123 Brescia, Italy*
(2) *The Faculty of Science and Engineering, Åbo Akademi University, 20500 Turku, Finland*
(3) *Dipartimento di Chimica, Università degli Studi di Bari "Aldo Moro", 70125 Bari, Italy*
(4) *Dipartimento Inter-Ateneo di Fisica "M. Merlin", Università degli Studi di Bari "Aldo Moro", 70125 Bari, Italy*
(5) *CNR, Istituto di Fotonica e Nanotecnologie, Sede di Bari, 70125 Bari, Italy*
(6) *CSGI, Centre for Colloid and Surface Science, 70125 Bari, Italy*
A label-free single-molecule detection platform based on biofunctionalized organic transistors has been recently proposed. In contrast to state-of-art approaches based on nano- transducers, the aforementioned single-molecule transistor (SiMoT) sensing technology is based on millimeter-sized transistors where the gate is bio-functionalized with about a trillion of antibodies. In this work we provide a detailed investigation of SiMoT biosensors by studying and quantifying the device parameters affected by the biorecognition event. The study combines both measurements and theoretical analyses, showing that a single protein detection taking place at nanometer scale affects a millimeter-scale area of the biofunctionalized gate electrode. The dimension of the bioprobe domains affected by the binding is calculated as a function of the nominal protein concentration in the analyte solution. These results provide insights into the SiMoT biosensor technology, supporting the development of multi-modal SiMoT detection and integrated SiMoT biosensors arrays.

▲ **Silicon nanowires for optical sensing.**

Lo Faro M.J. (1)(2)(3), Leonardi A.A. (1)(2)(3), Morganti D. (1)(3), Musumeci P. (1), Fazio B. (3), Priolo F. (1), Irrera A. (3)
(1) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università di Catania, Via Santa Sofia 64, 95123 Catania, Italy*
(2) *CNR-IMM UOS Catania, Istituto per la Microelettronica e Microsistemi, Via Santa Sofia 64, 95123 Catania, Italy*
(3) *CNR-IPCF, Istituto per i Processi Chimico-Fisici, V.le F. Stagno D'Alcontres 37, 98158 Messina, Italy*

We proved the realization of label-free optical biosensors based on the room-temperature luminescence of silicon nanowires (NWs) for proteins, vesicles and pathogen genome detection. 2D fractal NW arrays with desired structure obtained by Au-assisted chemical etching present tunable luminescence and strong light scattering, allowing the first experimental observation of Raman coherent backscattering. Fast NWs biosensors are reported with tailored sensitivity of fM in different biofluids over a broad concentration range. Their high selectivity opens the route toward noninvasive analysis in saliva, for the early diagnosis of the C-reactive protein, the major cardiovascular biomarkers. Innovative label- and PCR-free NWs optical biosensors for direct genome detection with detection limit of 2 DNA copies/reaction were proved for the *Hepatitis B virus* in buffer and of 20 copies/reaction in blood. Recently we investigate the NW optical biosensors for extracellular vesicles detection fostering application in liquid biopsy.

▲ **Implantable and wearable technologies for health monitoring and control.**

De Vittorio M., Pisanello F.
Center for Biomolecular Nanotechnologies, Istituto Italiano di Tecnologia, Arnesano, LE e Dipartimento di Ingegneria dell'Innovazione, Università del Salento, Lecce, Italy

The combination of genetics, photonics, electronics and micromechanics is enabling completely new micro- and nano-technological approaches for compact and effective tools for diagnostics and therapeutics, which can be disposable, wearable, implantable or tattooable. These new approaches are paving the way to closed-loop theranostics, *i.e.*, devices integrating diagnostic capabilities and therapeutic response. In this talk, new technological approaches to produce innovative implantable/wearable devices for optogenetics and fiber photometry, for recording and manipulating brain activity *in vivo* will be shown. A second technology based on piezoelectric microelectromechanical systems (MEMS) for wearable skin sensing and actuation will be also presented. The possibility to integrate brain technologies with body technologies can enable new solutions for measuring and controlling neurological disorders in closed loop and real time.

▲ **Textile organic biosensors for advanced wearable healthcare.**

Fraboni B.
Department of Physics and Astronomy, University of Bologna

Real-time and non-invasive monitoring of physiological and biological parameters by means of wearable bio-sensors holds great promise for next-generation personalised healthcare. Organic electrochemical transistors (OECTs) are interesting candidates that can interface the biological domain with electronic devices at low operating voltage (< 1 V) providing intrinsic signal amplification and high sensitivity without the need for a reference electrode. Recent developments allowed to realize wearable, real-time and selective biosensors based on the conducting polymer PEDOT:PSS (poly(3,4-ethylenedioxythiophene) poly(styrene sulfonate)) for the detection of a large variety of analytes (dopamine, adrenaline, glucose, lactate, etc.), that can be fabricated onto non-conventional substrates, *e.g.*, flexible and textiles. Two examples will be discussed: i) a selective *p*H sensors based on PEDOT doped with the *p*H dye Bromothymol Blue (BTB) and ii) a chloride concentration sensor based on blending the PEDOT:PSS with Ag/AgCl nanoparticles. Sensor operation is validated in artificial sweat also for fully textile device, fabricated directly onto a cotton yarn for real-time monitoring.

▲ Multiplex plasmonic biosensor to detect the humoral response against the SARS-CoV-2 in blood plasma.

Funari R., Shen A.Q.
Micro/Bio/Nanofluidics Unit, Okinawa Institute of Science and Technology Graduate University, 1919-1 Tancha, Onna-son, Okinawa, 904-0495, Japan e Dipartimento di Fisica "M. Merlin", Università degli Studi di Bari "Aldo Moro", Bari, 70126, Italy

Measuring the specificity and detecting the antibodies produced in response to the infection from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is fundamental to optimize therapeutic strategies and support vaccine development. This motivated us to develop a multiplex nanoplasmonic biosensor to detect the humoral response in serums against multiple antigens. Nanoplasmonic sensing relies on the wavelength shift of the localized surface plasmon resonance (LSPR) peak of gold nanostructures upon binding interactions between the antibodies and the immobilized antigens. The antigens are immobilized on the nanomaterial by using a strategy based on the streptavidin-biotin biomolecular interaction involving biotinylated proteins. We validate the multiplex platform by detecting the presence of 3 monoclonal antibodies against 3 antigens, including 2 different hemagglutinins (HAs) from influenza viruses, and the SARS-CoV-2 Spike RBD (receptor binding domain). We also measure the humoral response in murine serums collected before and after the immunization with the SARS-CoV-2 Spike protein, in good agreement with the results obtained by the ELISA assay.

▲ A new microprocessor platform for implementing surface differential reflectivity and reflectance anisotropy spectroscopy.

Ferraro L. (1), Bussetti G. (1), Bossi A. (2)(3), Campione M. (4), Duò L. (1), Ciccacci F. (1)
(1) *Dipartimento di Fisica, Politecnico di Milano, Italia*
(2) *Istituto di Scienze Chimiche e Tecnologie Chimiche, CNR, Italia*
(3) *SmartMatLab Center, Italia*
(4) *Department of Earth and Environmental Sciences, Università degli Studi di Milano - Bicocca, Italia*

Surface differential reflectivity (SDR) and reflectance anisotropy spectroscopy (RAS) are two well-known optical techniques employed in surface physics and in the investigation of both hybrid and buried interfaces. By using an optical probe in the energy range of 0.3–6.2 eV, the optical set-up can work on different experimental conditions (vacuum, controlled atmosphere and liquid environment), allowing for the investigation of traditional surface states (vacuum environment) and more complex systems (solid-liquid interface). In these circumstances, the combined analysis of the sample with both techniques is mandatory in view of obtaining a full and precise picture of the sample optical properties. In this work, we describe and discuss a microelectronic hardware system useful to drive both the SDR and RAS apparatus. To test and show the performances of our original set-up, we applied it to traditional silicon surfaces and hetero-structures, showing the potentialities of the combined measures. Finally, we note that the proposed microprocessor platform can be easily replicated by other researchers in teams involved in the study of surfaces and interfaces optical properties.

Aula Nella Mortara **ore 09:30 – 13:00**

Sezione VII
Didattica e storia della fisica
Presiede: Gaudenzi R. (Max Planck Institute for the History of Science, Berlin, Germany)

Relazioni su invito

▲ "Marie Sklodowska née Curie": 1911.

Robotti N.
Dipartimento di Fisica, Università di Genova, Italia, Istituto Nazionale di Fisica Nucleare, Sezione di Genova e Museo Storico della Fisica e Centro Ricerche Enrico Fermi

Novanta anni fa, Marie Curie riceveva il suo secondo Premio Nobel, questa volta per la Chimica. Si analizzeranno le motivazioni che hanno portato Marie Curie a questo prestigioso riconoscimento. Il 1911 è stato anche l'anno in cui Marie Curie partecipò al Primo Congresso Solvay, dando grossi contributi alle discussioni sui processi di emissione di radiazione, in relazione ai fenomeni radioattivi. Sempre il 1911 è l'anno del primo viaggio di Marie Curie in Italia, in particolare a Genova, dove su invito di Antonio Garbasso, tenne una Conferenza sul Radio. L'amicizia nata in questa occasione tra Marie Curie e Garbasso, fece sì che durante la Grande Guerra Marie Curie tornò nuovamente in Italia per studiare i nostri giacimenti di materiale radioattivo.

▲ Ettore Majorana and the neutral proton.

Guerra F.
Department of Physics, Sapienza University of Rome, Italy, National Institute for Nuclear Physics, Section of Rome e Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi"

According to a well established historical tradition in Via Panisperna, Ettore Majorana was the first to understand that the experiments by Frédéric Joliot e Irène Curie on the Bothe-Becker penetrating radiation, communicated at the beginning of 1932, were an indication of the existence of a new neutral particle with a mass equal to the proton mass (the neutral proton). This was in marked contrast with the Joliot-Curie interpretation, for which the new radiation was an electromagnetic radiation. Only few days after, James Chadwick communicated on Nature that some new experiments led to the evidence of the existence of the neutron, in full agreement with Majorana conclusions (neutron=neutral proton. We will examine all physical aspects of the new penetrating radiation arising from the bombardment of light nuclei with alpha particles, discovered by Walther Bothe e Herbert Becker, then studied by the Joliot-Curie, and finally clarified by Chadwick with the conclusion of the existence of the neutron. We will describe also the features of the experimental set up exploited in the research. Finally, we will make a critical analysis about the presumed role played by Majorana.

▲ Il protone, cento anni dopo.

Leone M.
Dipartimento di Filosofia e Scienze dell'Educazione, Università di Torino, Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi, Roma e INFN, Sezione di Torino

Quasi cento anni fa, nel 1919, Rutherford realizzò la prima trasmutazione artificiale del nucleo scoprendo, così, il protone. In questa relazione si ricostruisce il percorso che, a partire dalle esperienze sullo scattering delle particelle alfa su atomi leggeri, e in particolare attraverso idrogeno, portò Rutherford a cogliere alcune anomalie di comportamento. Tali anomalie, interpretate dapprima come una nuova forma di decadimento nucleare, portarono a ulteriori esperimenti che si conclusero, infine, con la scoperta di un nuovo costituente nucleare (battezzato poi come "protone" nel 1920). La ricostruzione di questa scoperta, oltre a essere di interesse per la storia della fisica nucleare, presenta significative, e largamente inesplorate, potenzialità didattiche, soprattutto in riferimento al rapporto tra teoria ed esperimento e, più in generale, alla costruzione di una scientific literacy tra gli studenti della scuola secondaria.

▲ **Bruno Touschek: Vita e opere di un grande scienziato europeo.**

Pancheri G. ([1]), Bonolis L. ([2])
([1]) *INFN Frascati National Laboratories, Via Enrico Fermi 54, I00044 Frascati, Italy*
([2]) *Max-Planck-Institut für Wissenschaftsgeschichte Boltzmannstraße 22, 14195 Berlin, Germany*

La vita di Bruno Touschek attraversa l'Europa nello spazio e nel tempo. Nato a Vienna nel 1921, viene espulso dall'Università di Vienna, a causa della sua origine ebraica. Su suggerimento di Arnold Sommerfeld, nel 1942 prosegue gli studi di fisica in Germania, dove parteciperà durante la guerra al progetto del betatrone di Widerøe. Nel 1946, è assistente di Werner Heisenberg a Göttingen, nel 1949 consegue il dottorato a Glasgow, e frequenta Max Born, a Edinburgo. A Roma, negli anni '50, è autore di importanti lavori teorici, ed è fortemente influenzato da Wolfgang Pauli, e dal teorema CPT. Nel 1960, presso i Laboratori Nazionali di Frascati, propone la realizzazione del primo collisore al mondo per elettroni e positroni, AdA, e poi quella di ADONE. Negli anni 1962-63 è con AdA ad Orsay, dove dimostrerà la fattibilità del concetto di collisori materia-antimateria. A Frascati contribuisce alla costruzione di ADONE e crea un gruppo teorico, impostando una linea di risommazione in QED, estesa alla QCD dai suoi allievi. All'Università di Roma, le sue lezioni contribuiranno alla formazione di un importante gruppo di meccanica statistica.

▲ **AdA, il primo collisore positrone-elettrone.**

Iarocci E.
INFN, Laboratori Nazionali di Frascati

Nel 1960 a Frascati, quando il Sincrotrone a elettroni era da poco in funzione nei Laboratori appena fondati dall'INFN, Bruno Touschek lanciò l'idea che nel giro di un anno portò alla realizzazione di AdA, il primo Anello di Accumulazione positrone-elettrone. Al suo successo seguì la rapida diffusione nel mondo e nel giro di un decennio i collisori di particelle conquistarono un ruolo centrale nella fisica delle interazioni fondamentali, iniziando da Adone a Frascati fino al Lep e quindi Lhc al Cern di Ginevra. L'impiego della luce di sincrotrone emessa dai fasci accumulati in AdA, preannunciò le moderne sorgenti di radiazione.

▲ **Touschek e la Teoria Standard.**

Maiani L.
Dipartimento di Fisica, Università di Roma La Sapienza e INFN, Sezione di Roma 1

Negli anni sessanta, la fisica delle particelle romana si muoveva su due linee distinte. Da una parte, relazioni di dispersione, poli di Regge e, in seguito, dualità e modello di Veneziano. L'altra linea partiva dalla teoria dei campi, l'elettrodinamica quantistica e la teoria di Fermi delle Interazioni Deboli. Bruno Touschek era, con Raoul Gatto, tra gli ispiratori di questa seconda linea, ed è stato il relatore di tesi di uno dei futuri protagonisti, Nicola Cabibbo. In quegli stessi anni, Touschek era impegnato alla realizzazione dei primi collisori leptonici, AdA e poi ADONE. Nella mia relazione, illustro come i collisori leptonici e adronici di alta energia hanno portato alla moderna teoria delle particelle fondamentali basata su leptoni e quark con tre colori, la Teoria Standard.

▲ **L'uomo e lo scienziato Bruno Touschek visto attraverso le sue carte.**

COTUGNO A.
Sapienza Università di Roma - Dipartimento di Fisica

L'Archivio Touschek è stato il primo fondo di cui il Gruppo di storia della Fisica della Sapienza ha curato la salvaguardia, già nel 1980. Esso è costituito dalle carte provenienti dal suo studio (tra esse si trovano tra l'altro lettere autografe di Wolfgang Pauli e di Werner Heisenberg) e da quelle provenienti dalla sua abitazione (contenenti, per esempio, alcuni quaderni di laboratorio relativi al periodo di AdA) messe a disposizione dai familiari. Questo intervento vuole porre l'accento su ciò che emerge dai documenti: lo scienziato ma anche la persona intelligente, colta e dotata di un dissacrante umorismo.

Aula Plenarie **ore 14:00 – 14.55**

SEZIONE III
Astrofisica
Presiede: PAVAN M. (Università di Milano Bicocca)

Relazione Generale

Stato e prospettive dei progetti per la ricerca del decadimento doppio beta.

CREMONESI O.
INFN, Sezione di Milano Bicocca

A oltre ottant'anni dall'introduzione della teoria di Majorana, ancora non sappiamo se essa possa valere almeno per i neutrini. La questione se i neutrini siano particelle di Dirac (come gli altri leptoni e i quark) o di Majorana rimane quindi ancora oggi uno dei problemi più fondamentali della fisica delle particelle. L'osservazione del doppio decadimento beta senza emissione di neutrini dimostrerebbe inequivocabilmente che i neutrini sono particelle di Majorana oltre a fornire importanti informazioni sulle loro masse. Il legame con le masse dei neutrini è molto stretto ed in effetti, l'interesse per la ricerca del doppio decadimento beta è cresciuto enormemente dopo la scoperta del fenomeno delle oscillazioni. Tale interesse ha determinato lo sviluppo di un numero crescente di esperimenti sempre più sensibili, operati in grandi laboratori sotterranei e in condizioni di estrema radio purezza, caratterizzati da masse che ormai sono dell'ordine delle tonnellate e basati sulle tecnologie più disparate. Oltre a descrivere le principali caratteristiche e le sfide comuni a tutti gli esperimenti, mi soffermerò sui risultati di alcuni tra i più recenti, oltre a discutere le possibili prospettive dei progetti futuri.

Aula Plenarie **ore 15:00 – 15.55**

Sezione V
Biofisica e fisica medica
Presiede: Bianchi A.M. (Politecnico di Milano)

Relazione Generale

Le frontiere della radioterapia negli studi in vitro.

Croci S.
Dipartimento di Medicina e Chirurgia, Unità di Neuroscienze, Università di Parma

La fisica medica si occupa di due importanti ambiti: la terapia e la diagnosi. Entrambi vedono l'intersezione di diverse competenze, che oltre alla fisica includono la biologia, la biochimica fino ad arrivare alla medicina. In questa relazione si vuole dare esempi di nuovi sviluppi in ambito radioterapico relativamente alla terapia con protoni e alla modalità FLASH di irraggiamento, con particolare riferimento agli studi *in vitro*. La crescente conoscenza delle diverse a complesse strutture cellulari e delle loro funzioni, permette l'individuazione non solo di nuovi target per la terapia ma anche per lo studio e l'interpretazione degli effetti delle radiazioni sui quali ancora molte sono le domande aperte. Studi questi che oltre ai sistemi 2D di culture cellulari vedono un sempre maggiore interesse verso i sistemi 3D che riducono al massimo l'uso dell'animale in laboratorio in accordo con il principio delle 3R (Refine, Reduce and Replace) sancito dalla Direttiva UE 2010/63. Lo studio su culture cellulari (2D o 3D) permette di identificare, quantificare e modellizzare il danno e la risposta alle radiazioni ionizzanti usate in terapia al fine di trovare risposte ad effetti complessi come ad esempio la fibrosi o l'induzione di tumori secondari.

Aula Plenarie **ore 16:00 – 17:30**

Assemblea Generale dei Soci

L'Assemblea Generale dei Soci della Società Italiana di Fisica è convocata in occasione del Congresso Nazionale SIF 2021 in prima convocazione alle ore 15.30 e in seconda convocazione alle ore 16.00 di martedì 14 settembre 2021, l'Assemblea si riunirà online sulla piattaforma dedicata al Congresso che quest'anno si svolge per via telematica, con il seguente ordine del giorno:

1) Approvazione dell'ordine del giorno.

2) Approvazione del verbale dell'Assemblea Generale dei Soci del 15 settembre 2020.

3) Relazione del Presidente.

4) Relazioni del Collegio dei Revisori dei Conti e approvazione dei bilanci consuntivi 2020.

5) Ratifica e nomina dei Revisori dei Conti.

6) Discussione e approvazione della Relazione del Presidente.

7) SIF, la partecipazione in numeri.
Intervento di A. Marino.

8) La Commissione Didattica Permanente della SIF: presente e prospettive.
Intervento di E. Ercolessi

9) Varie ed eventuali.

Il Presidente della SIF
ANGELA BRACCO

Aula Chien Wu **ore 09:30 – 13:00**

Sezione I
Fisica nucleare e subnucleare
Presiede: Vagnoni V. (INFN, Sezione di Bologna)

Relazioni su invito

▲ **Risultati recenti nel campo della fisica del sapore ad ATLAS e CMS.**
Bragagnolo A.
Università e INFN, Padova
Negli ultimi anni la fisica del sapore si è rivelato uno dei settori più promettenti nella ricerca di nuova fisica, presentando innumerevoli "anomalie" di grande interesse teorico e sperimentale. In questo contributo gli ultimi risultati ottenuti in questo campo da parte di ATLAS e CMS sono presentati. Per quanto basate su apparati sperimentali di indirizzo generale, queste due collaborazioni hanno più volte dimostrato la capacità di produrre risultati di alta qualità in vari settori della fisica del sapore come spettroscopia, analisi angolari, ricerche di decadimenti rari, test di universalità leptonica e misure di violazione di CP. Avendo regioni di accettanza complementari a quelle di LHCb, l'esperimento dedicato alla fisica del sapore a LHC, le misure effettuate da ATLAS e CMS sono ottimi banchi di prova per indagare più a fondo ed eventualmente validare le anomalie attualmente più discusse.

▲ **Review of recent heavy-flavour measurements from the ALICE experiment.**
Colamaria F.
INFN, Sezione di Bari
The study of heavy quarks (charm and beauty) allows for investigating the properties of the quark-gluon plasma (QGP), the hot and dense deconfined medium produced in ultra-relativistic heavy-ion collisions. Being produced on shorter time scales than the typical QGP formation time and experiencing its full evolution, heavy quarks act as penetrating probes that interact with the partonic constituents of the QGP while traversing it, losing energy via radiative and collisional processes. Heavy-flavour studies are essential in proton-proton and proton-lead collisions, not only to build reference measurements for probing QGP effects on heavy quarks, but also to test perturbative QCD calculations at the LHC energies and study cold–nuclear-matter effects. Due to its excellent tracking, vertexing and particle identification performance, the ALICE experiment is able to reconstruct heavy-flavour hadrons, produced from the heavy-quark hadronization, as well as electrons and muons produced from heavy-flavour hadron decays. In this contribution, the most relevant ALICE heavy-flavour measurements in all the studied collision systems, and their comparison to model predictions, will be presented.

▲ **Produzione di heavy flavour e spettroscopia in LHCb.**
Marangotto D.
Università degli studi di Milano e INFN, Sezione di Milano
LHCb è uno spettrometro a singolo braccio che copre la regione in avanti delle collisioni protone-protone, corrispondente ad un intervallo di pseudorapidità $2 < \eta < 5$, dove si concentra la produzione di adroni contenenti quark pesanti (heavy flavour). Grazie alle sue peculiarità, in particolare la precisione del sistema di tracciamento e all'efficienza del sistema di identificazione di particelle, LHCb ha studiato in dettaglio la produzione di heavy

flavour dimostrando una spiccata capacità di analizzare la struttura degli stati legati di quark (spettroscopia adronica), sia i tradizionali barioni e mesoni, sia adroni esotici come tetraquarks e pentaquarks: dall'inizio delle sue misure LHCb ha scoperto più di 50 nuovi adroni. Lo studio della spettroscopia adronica è fondamentale per capire il comportamento dell'interazione forte a basse energie, regime in cui le predizioni di cromodinamica quantistica (QCD) sono più difficili. Presentiamo i risultati più recenti ottenuti dalla Collaborazione LHCb riguardo la produzione di heavy flavour e spettroscopia, con particolare attenzione ai nuovi stati esotici scoperti.

▲ Theory of heavy flavour production in heavy ion collisions at RHIC and LHC energies.

Plumari S.
Dipartimento di Fisica e Astronomia "E. Majorana", Università degli Studi di Catania, Italia e INFN, Laboratori Nazionali del Sud, Catania

The evidences collected in the last decades suggests that a new state of matter of deconfined quark and gluons plasma (QGP) has been created. Heavy quarks due to their large masses are excellent probes for its characterisation. The theoretical efforts made to describe D meson observables have led to estimate a large non-perturbative Ds space diffusion of charm quarks in agreement with lattice QCD. Also a new insight on the heavy flavour hadronization process is emerging and could play a key role in pp collisions. More recently, HQs are revealing to be excellent probes also of the strong initial magnetic flow and vorticity.

▲ Latest results on beauty and charm at LHCb.

Betti F.
CERN, Ginevra, Svizzera

The LHCb experiment, whose main purpose is the search for new physics, has been conceived to perform flavour-physics measurements at the Large Hadron Collider. An overview of the latest results obtained by the LHCb experiment will be presented, with a major focus on measurements of CP asymmetries in the decays of the beauty and charm mesons and searches for lepton universality violation.

▲ Recent results and future prospects from the Belle II experiment.

Manfredi R. per la Collaborazione Belle II
Università di Trieste e INFN Sezione di Trieste

The Belle II experiment at the energy-asymmetric SuperKEKB electron-positron collider started physics operations in 2019, aiming at collecting 50 times more data than previous B-factories. Belle II is expected to join soon existing experiments in probing the validity of the Standard Model in flavor dynamics. I discuss early Belle II results on bottom- and charmed-meson decays based on samples of up to 120 fb^{-1}, along with extrapolations of future performances and synergies with other experiments.

▲ Theoretical aspects of flavour physics.

Bordone M.
Università di Torino e INFN, Sezione di Torino

The understanding of flavour physics depends on two crucial factors: high experimental precision and high accuracy for the corresponding theoretical predictions based on the Standard Model. In the recent years, many efforts to address these issues have been made, leading to uncovering interesting discrepancies between measurements and theoretical predictions. These provide hints of possible Beyond Standard Model physics and could be a manifestation of a more fundamental theory of flavour. In this presentation, I review the current status of flavour physics and discuss some promising Beyond Standard Model theories that address the current data and the flavour puzzle.

▲ **Status of spectroscopy of exotic hadrons.**
Pilloni A.
INFN Sezione di Roma, P.le Aldo Moro 2, I-00185, Roma, Italy
Recently there have been dramatic advancements in accelerator technologies, detection techniques and on the theoretical side, algorithms for first-principle QCD analyses. These have led to several candidates for possible "exotic" hadrons, *e.g.*, multiquark states or quark-gluon hybrids, in particular in the heavy quark sector. It thus appears that interpreting the entire hadron spectrum in terms of the most naive constituent quark model is no longer possible. If confirmed, such exotic hadrons could shed new light on the inner workings of QCD in the nonperturbative regime. I will give an overview of the most successful phenomenological models that describe exotic hadrons, summarize our present understanding of the sector, and outline the expectations for the field in the near future.

Aula Cornelia Fabri **ore 09:30 – 13:00**

Sezione II
Fisica della materia
Presiede: Burioni R. (Università di Parma)

Relazioni su invito

▲ **Tensor network algorithms for high-dimensional quantum many-body systems.**

Montangero S.
University of Padua

We review some recent results on the development of tensor network algorithms and their application to high-dimensional many-body quantum systems and machine learning problems in High-Energy Physics. In particular, we present results on topological two-dimensional systems, two-dimensional Rydberg atom systems, and two- and three-dimensional lattice gauge theories in the presence of fermonic matter. Finally, we present their application to LHCb event classification and to the study of open many-body quantum systems, specifically to the computation of the entanglement of formation in critical many-body quantum systems at finite temperature.

▲ **Topological synchronization.**

Bianconi G.
School of Mathematical Sciences Queen Mary University of London, Alan Turing Institute

Topological signals are dynamical variables, that are defined not only on the nodes of a network but also on their links like fluxes. Topological synchronization combines algebraic topology to dynamical systems in order to reveal synchronization of topological signals. Here we show that topological synchronization of coupled topological signals of nodes and links leads to discontinuous synchronization transitions and anomalous dynamical states characterized by a fluctuating order parameter. This framework can be also extended to simplicial complexes formed not only by nodes and links but also by traingles, tethedra and so on. This work prescribes the topological filtering of the data necessary for revealing this new dynamical state in real systems.

▲ **A score-driven approach to time-varying parameters.**

Bormetti G.
University of Bologna, Department of Mathematics, Bologna, Italy

The world is changing, fast. Covid epidemics, climate shifts, the rise of artificial intelligence, evolving social media and their tight connection with transforming political landscapes all represent tremendous challenges for policymakers and researchers. Such challenges require a different approach to dynamic models: Model parameters should change in response to the revealing information and adapt to the likelihood of the new state of the world. Such a different perspective on time-varying parameter models opens the way to a widespread range of applications. In this talk, I will provide a gentle introduction to the class of Dynamic Conditional Score-driven (DCS) models. DCS are flexible, susceptible to straightforward maximum likelihood estimation, and able to effectively deal with high-dimensional problems and large amount of data. Then, I will review some recent theoretical achievements and present few applications ranging from macro-economics and high-frequency finance to the modelling of complex networks.

▲ **Models of cell membrane domains for surface interactions structural investigation.**

Rondelli V.
Dipartimento di Biotecnologie Mediche e Medicina Traslazionale, Università degli Studi di Milano

Cell membranes are complex aggregates made by thousands of molecular species unevenly distributed in the cross and lateral direction, playing a role in the local membrane structure and selectivity. Different experimental models have been developed to be suitably investigated by biophysical techniques as scattering and reflectometry of neutrons and X-rays and by calorimetry, to address the structural response of biomembranes to approaching macromolecules and to give hints about the interaction mechanisms. The possibility to create and study customized membranes, mimicking different cell membrane portions, is potentially predictive of the fate of extracellular macromolecules as proteins, peptides and nanoparticles intended to cross the extracellular medium and eventually enter cells.

▲ **Modelling realistic microgels in computer simulations.**

Zaccarelli E.
CNR Institute for Complex Systems, Roma

Microgels are soft particles individually made by cross-linked polymer networks which are nowadays widely used as a colloidal model system because of their swelling properties and their responsivity to external control parameters such temperature or pH. In this talk I will briefly illustrate the protocol that we recently developed to synthesize microgels *in silico*, providing a realistic description of the particles. I will also sketch the calculation of their elastic properties and of their effective interactions and compare the results with the famous Hertzian model.

▲ **Microscopic theory of plasmon-enabled resonant terahertz detection in bilayer graphene.**

Tomadin A. (1), Carrega M. (2), Polini M. (1)(3)(4)
(1) *Dipartimento di Fisica, Università di Pisa, Largo Bruno Pontecorvo 3, I-56127 Pisa, Italy*
(2) *CNR-SPIN, Via Dodecaneso 33, 16146 Genova, Italy*
(3) *School of Physics e Astronomy, University of Manchester, Oxford Road, Manchester M13 9PL, UK*
(4) *Istituto Italiano di Tecnologia, Graphene Labs, Via Morego 30, I-16163 Genova, Italy*

The electron gas hosted in a two-dimensional solid-state matrix under external driving supports the propagation of plasma waves. Nonlinear interactions between plasma waves generate a constant density gradient which can be detected as a dc potential signal at the boundaries of the system. This phenomenon is at the heart of a plasma-wave photodetection scheme which was first introduced by Dyakonov and Shur for electronic systems with a parabolic dispersion and then extended to the massless Dirac fermions in graphene. Motivated by a recent experimental breakthrough in the resonant detection of plasma waves in double-gated bilayer graphene, we develop the theory of plasma-wave photodetection in such geometry, where the dispersion relation depends locally and dynamically on the intensity of the plasma wave. We show that quantum capacitance effects, arising from the local fluctuations of the electronic dispersion, modify the intensity of the photodetection signal. An external electrical bias, *e.g.* induced by top and bottom gates, can be used to control the strength of the quantum capacitance corrections, and thus the photoresponse.

▲ **Plasma-wave interaction in present-day magnetic fusion research.**

Farina D.
Istituto per la Scienza e Tecnologia dei Plasmi, CNR, Milano

The plasma physics community is involved since long in the research to achieve the conditions for commercial fusion power, thus giving a contribution to the sustainable energy problem. This is an international effort, which takes place in a highly coordinated way in Europe within the magnetic confinement approach, aiming at the success of the ITER project in the near term and at the design of DEMO in the longer term. In addition, there is an active scientific accompanying programme on other tokamaks, to investigate the scientific and technological challenges still to be addressed. We focus here on the crucial role played by waves in present-day and future experiments. Injection of electromagnetic waves can assist the plasma discharge in its various stages for plasma start-up and burn-through, core heating, control of MHD instabilities, etc. Linear and nonlinear processes take place on various time scales and lengths, and advanced theory and modelling are required for propagation and absorption investigation. As an example, the physical analysis done at ISTP-CNR for the design of the EC system of ITER is presented.

Aula Margherita Hack **ore 09:30 – 13:00**

Sezione III
Astrofisica
Presiede: Zavattarelli A. (INFN, Sezione di Genova)

Relazioni su invito

▲ Up-to-date status of neutrino mass and mixing parameters.
Capozzi F.
Virginia Tech
We present up-to-date constraints on neutrino mass and mixing parameters within the standard three-neutrino framework. In particular, we focus on the currently unknown absolute neutrino masses and their ordering (either normal or inverted). We show that a combination of current data coming from neutrino oscillation experiments, beta decay and neutrinoless double beta decay searches and cosmological surveys, can provide a hint in favor of normal ordering and interesting constraints for such unknowns in the sub-eV mass range. We discuss current limits on absolute neutrino mass observables by performing a global data analysis, that includes the latest results from oscillation experiments, neutrinoless double beta decay bounds, and constraints from representative combinations of Planck measurements and other cosmological data sets.

▲ Review sulle misure di oscillazioni ai fasci, e risultati di T2K.
Magaletti L.
Politecnico di Bari e INFN Sezione di Bari
Le oscillazioni del neutrino evidenziano una prima, chiara indicazione di nuova fisica oltre il modello standard delle particelle elementari. In questo scenario, gli esperimenti che utilizzano fasci di neutrini si sono rivelati fondamentali per la comprensione di tale fenomeno. Nel recente passato, OPERA e T2K hanno ulteriormente confermato le oscillazioni di neutrino osservando per la prima volta l'apparizione di neutrini ν_{tau} e ν_e in un fascio di ν_{mu}. Inoltre, le misure di T2K e Nova indicano una possibile violazione di CP nel settore leptonico e una chiara preferenza per la gerarchia di massa diretta. Se questi risultati fossero confermati definitivamente dagli esperimenti di nuova generazione, Hyper-Kamiokande e DUNE, i neutrini potrebbero giocare un ruolo chiave nella comprensione del perché il nostro universo sia composto principalmente da materia anziché da anti-materia. Infine illustrerò come si cerchi anche di dare risposte definitive al problema dei neutrini sterili con il programma di oscillazioni short baseline al Fermilab.

▲ Direct neutrino mass measurements.
Ferri E.
Università di Milano Bicocca
Neutrino oscillation experiments have proven that neutrinos are massive particles, nevertheless the assessment of their absolute mass scale is still an outstanding challenge in nowadays particle physics and cosmology. The experiments dedicated to the effective electron-neutrino mass determination are the ones based on the study of nuclear processes involving neutrino, like single beta decay and electron capture decay. Based only on energy-momentum conservation, these kinematic measurements are the only ones which permit to estimate neutrino masses without theoretical assumptions on the neutrino nature. To date, the best limit

on the absolute neutrino mass has been set by KATRIN, a MAC-E filter spectrometer to analyze the end-point of ^{3}H beta decay. An appealing alternative respect to the ^{3}H single beta decay is the calorimetric measurement of ^{163}Ho Electron Capture (EC). Nowadays, the two experiments dedicated to this delicate measurement are ECHO and HOLMES. In this contribution, we present the methods and techniques aimed at measuring neutrino masses kinematically, focusing on recent experimental developments, results and perspectives.

▲ Da KLOE a DUNE: Dai kaoni ai neutrini cercando la violazione di CP.

Di Noto L.
Università degli Studi di Genova e Istituto Nazionale di Fisica Nucleare Sez. Genova

L'esperimento KLOE, che ha terminato la presa dati nel 2018, ha misurato i parametri relativi alla violazione di CP nel settore dei quark attraverso l'osservazione dei decadimenti dei kaoni prodotti dalla Phi-factory DAFNE dei Laboratori Nazionali di Frascati. Componenti essenziali del rivelatore di KLOE sono stati il magnete superconduttore solenoidale e il calorimetro elettromagnetico. Grazie all'elevata granularità il calorimetro ha dimostrato un'ottima risoluzione energetica e temporale, caratteristica che, unita all'alta efficienza per la rivelazione di neutroni e di particelle cariche, rendono il calorimetro e il magnete ben sfruttabili per altri esperimenti basati sulla ricostruzione di interazioni. Per questo motivo nei prossimi anni il magnete e il calorimetro di KLOE verranno trasportati al Fermilab in USA, per essere installati in SAND, parte del Near Detector System dell'esperimento DUNE. In questa presentazione verranno mostrate le performance del calorimetro per la ricostruzione degli eventi di neutrino e verrà illustrato il ruolo unico di SAND per il controllo delle sistematiche per la misura del parametro δ_{cp} nelle oscillazioni dei neutrini a lunga distanza.

▲ Sterile neutrino searches at FNAL within the Short Baseline Neutrino program.

Falcone A. per la Collaborazione ICARUS
Università degli Studi di Milano Bicocca e INFN Sez. di Milano Bicocca

The ICARUS T600 detector was employed in a successful three-year physics run at the underground LNGS laboratories, studying neutrino oscillations with the CNGS neutrino beam and searching for atmospheric neutrino interactions. After a significant overhaul at CERN, the T600 detector has been installed at Fermilab. It is presently in commissioning phase, collecting the first neutrino events from the Booster Neutrino Beam and the NuMI off-axis. The main goal of the first year of ICARUS data taking will be the definitive verification of the recent claim by the NEUTRINO-4 short baseline reactor experiment both in the ν_μ and ν_e channels. Then ICARUS will commence its search for evidence of sterile neutrino jointly with the SBND near detector, within the Short Baseline Neutrino program. Exposure to the NuMI beam will also give the possibility for other physics studies such as light dark matter searches and neutrino-argon cross-section measurements. The present talk will review the perspectives for sterile neutrino searches, emphasizing the ICARUS achievements, its status and plans for the Fermilab run and the ongoing developments of the analysis tools.

▲ Neutrino oscillations at nuclear reactors: Current status and the role of the upcoming JUNO experiment.

Grassi M.
Università di Padova

Neutrino experiments at nuclear reactors played a crucial role in shaping our understanding of the neutrino oscillation mechanism. The most recent groundbreaking result established at reactor experiments was to determine that the Θ_{13} mixing parameter was non-zero. This opened the door to the possibility of determining the neutrino mass ordering through the interference of the solar and atmospheric oscillation modes. The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation neutrino experiment —currently under construction— aiming to capitalize on this opportunity. That is, to determine what the lightest neutrino mass eigenstate is, exploiting a configuration where the uncertainties stemming from the unknown CP-violating phase and Θ_{23} octant are irrelevant. Additionally, JUNO aims to shed light on several open questions in fundamental particle physics and astrophysics, such as to improve the current limits on the proton lifetime, to help addressing the solar metallicity problem, to detect the diffuse supernova neutrino background and to be ready for the detection of a core-collapse supernova neutrino burst. This talk will provide an overview on the latest results of the ongoing reactor neutrino experiments, and will provide new insights into the JUNO physics program, by showing the latest sensitivity studies based on the most up-to-date detector parameters.

▲ **Neutrino astronomy in the Mediterranean and the KM3NeT/ARCA detector.**
Ferrara G. per la Collaborazione KM3NeT
INFN-LNS
The KM3NeT Collaboration started to build a multi-km^3 neutrino telescope in the Mediterranean sea, which represents the next generation of undersea neutrino detectors. The KM3NeT research infrastructure is composed of two parts: the ARCA detector is optimised for searches for high-energy neutrino sources in the Universe and it is under construction at the Capo Passero site, Italy, 80 km offshore at a depth of 3500 m; the ORCA detector, for the determination of the mass hierarchy of neutrinos, is located in the Toulon area, France, 40 km offshore at a depth of 2500 m. The KM3NeT/ARCA detector will extend the performances of neutrino telescopes located in the Northern Hemisphere and will largely improve the results in the detection of galactic cosmic neutrinos, aiming to constrain, or discover, point-like sources and diffuse hadronic components. In this contribution, the current status and the perspectives for the KM3NeT/ARCA telescope to detect the high-energy neutrino sources in the Universe are presented.

▲ **The puzzling behavior of candidate neutrino blazars observed by Fermi-LAT.**
Garrappa S.
Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany
The detection of the flaring gamma-ray blazar TXS 0506+056 in spatial and temporal coincidence with the high-energy neutrino IC-170922A represents a milestone of multi-messenger astronomy. This finding suggests that gamma rays represent an important tracer of neutrino production in blazars and the almost 13-years all-sky coverage of the Fermi-LAT provides unique opportunities for both long-term studies of sources as well as real-time follow-up. I will present our latest results on the search for neutrino-emitting blazar candidates, with an overview on the multi-wavelength studies we are conducting on archival and real-time observations of the high-energy events observed by IceCube.

Aula Inge Lehmann **ore 09:30 – 13:00**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Neri M. (INGV, Sezione di Catania, Osservatorio Etneo)

Relazioni su invito

▲ Joint inversions of deformation and gravity changes due to the inflation of an arbitrarily-shaped magmatic reservoir.

Rivalta E. (1)(2), Nikkhoo M. (1)
(1) *GFZ German research centre for geosciences, Potsdam, Germany*
(2) *Department of Physics and Astronomy, Alma Mater Studiorum University of Bologna, Italy*
We propose a new strategy for an efficient exploitation of gravity changes and deformation data at volcanoes. We first derive an analytical solution for the deformation and gravity changes due to the dilatation of a triaxial point source in an isotropic elastic half-space. We show that the gravity changes not only allow inferring mass changes within the reservoirs, but also contribute to better constrain location, shape and the volume change of the source, and that it is important to weight the individual datasets differently in order to reduce the uncertainty on the results. We show that gravity changes together with only vertical or horizontal displacements are sufficient to constrain the mass change and all the other source parameters. We discuss how complexities in the realistic shape of volcanic reservoirs play in concert with magma compressibility in affecting the density estimates. However, if the nature of the melt and the expected exsolved volatile species are well constrained, the results of joint inversions of gravity changes and deformation can help infer the in-situ volume fraction of exsolved volatiles, which is currently difficult with other techniques.

▲ SPH simulation of geophysical flows: Flexibility of the method and recent advances.

Zago V.
Department of Civil and Environmental Engineering, Northwestern University, Evanston, IL, USA
Smoothed Particle Hydrodynamics (SPH) is a Lagrangian mesh-free numerical method with a growing number of applications in Computational Fluid Dynamics (CFD). SPH is highly versatile thanks to its ability to deal with complex flow features and its extensible implementation to parallel computing hardware, which improves simulation speed. GPUSPH is a high-performance implementation of the SPH method that runs on Graphics Processing Units (GPUs). We will discuss some applications of GPUSPH to geophysical flows, starting with a very complex fluid: lava. The physical processes involved in lava flows make numerical simulation a challenging CFD task. Applications to coastal engineering will then be shown, where different types of dynamics, like wave propagation and fluid-structure interaction, are studied.

▲ Stochastic modeling of explosive eruptive events at Galeras volcano, Colombia.

Sandri L. (1), Garcia A. (1), Costa A. (1), Guerrero Lopez A. (2), Cordoba G. (3)
(1) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Bologna, Italy*

([2]) *Barcelona Supercomputing Centre, Barcelona, Spain*
([3]) *Department of Engineering, Universidad de Nariño, Pasto, Colombia*

Statistical analysis of eruptive events can give important clues on a volcano's behavior in the time and size domains. Thus, we analyzed in such domains an up-to-date catalog of eruptions at Galeras. The dataset was first checked for completeness, stationarity and independency of events. In the time-domain, we fit Inter-Event Times (IETs) by renewal models, to describe the observed repose times. Since a tendency to cluster in time into "eruptive cycles" was observed, we performed a cluster analysis to objectively identify clusters of events. The IETs between cluster onsets and between events belonging to the same cluster were also modeled by renewal models: the former IETs are best described by Brownian Passage Time, describing a periodical occurrence (mean return time $/sim36$ years) perturbed by a Gaussian noise; the latter IETs, by a Lognormal. In the size domain, we could not reject the null hypothesis of no characteristic eruption size. Finally, we found a significant inverse linear relationship between the log of the erupted mass in a cycle and the time to the subsequent one. These results provide hints on the possible feeding system of Galeras volcano.

▲ Hazard assessment from tephra dispersal and fallout in near-real-time at Mt. Etna, Italy.

Scollo S.
Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo

Explosive eruptions are one of the most devastating and dangerous volcanic phenomena and form volcanic plumes mostly composed by fragments of magma, known as pyroclasts or tephra, by water vapour and gas. Explosive eruptions can cause damages to infrastructures and crops, aviation operations, human and animal health diseases. In order to estimate their impact, remote sensing techniques (thermal and visual cameras, radars, lidar, satellite) represent a unique supporting tool allowing the observations of the evolution of some key parameters of the explosive activity. Moreover, the detected parameters can be used by models to forecast the volcanic plume dispersal and fallout. Mt. Etna, in Italy, is one of the most active volcanoes in the world and is a perfect natural laboratory to test new remote sensing and modelling approaches. In this talk, we show the recent studies performed at the INGV, Osservatorio Etneo, with the aim to characterize dispersal and fallout processes occurred in near real time. We describe our multidisciplinary approach and show how the results are used by the Volcanic Ash Advisory Centers and the Italian Civil Protection to mitigate volcanic risks.

▲ Towards a multi-hazard assessment at Mt. Etna volcano (Italy): Investigating the statistical relationship between flank eruptions and major earthquakes in the historical catalogs.

Bevilacqua A. ([1]), Azzaro R. ([2]), Branca S. ([2]), D'Amico S. ([2]), De Beni E. ([2]), Flandoli F. ([3]), Neri A. ([1])
([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa*
([2]) *Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo*
([3]) *Scuola Normale Superiore di Pisa*

The problem of evaluating the statistical dependence among different series of events is often encountered in geophysics. On active volcanoes, the typical question is to relate different phenomena having significant impact in terms of multi-hazard implications. At Mt. Etna volcano, flank eruptions are often related to the occurrence of damaging earthquakes; the last case-history is the 2018 flank eruption, accompanied by a seismic swarm producing a destructive earthquake (Mw 4.9). The statistical analysis of the seismic and eruptive records on a significant time-span may contribute to defining potentially hazardous conditions and enhancing civil protection preparedness.

▲ Volcano hazard monitoring from space using statistical methods and machine learning.

Corradino C. (1), Amato E. (1)(2), Torrisi F. (1)(3), Del Negro C. (1)
(1) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania, Osservatorio Etneo, Catania, Italy*
(2) *Dipartimento di Matematica e Informatica, University of Palermo, Palermo, Italy*
(3) *Dipartimento di Ingegneria Elettrica Elettronica e Informatica, University of Catania, Catania, Italy*

Monitoring of volcanic hazards presents challenging problems, from detecting and quantifying hazardous phenomena during eruptive events to forecasting their impact. The combination of pressing challenges and abundance of open and freely available satellite datasets with ever-improving temporal, spatial, and spectral resolutions is leading to the growing use of statistical analysis and methods of artificial intelligence to solve problems of volcanic hazards. Machine learning is gaining importance in volcanology, not only for monitoring purposes but also for later hazards analysis. This contribution shows technological innovations from satellite remote sensing, statistical methods and machine learning for a better understanding of volcanic hazards.

▲ The eruption in Geldingadalir (Iceland): An example on the usage of numerical models to assess volcanic hazards during emergency phases.

Barsotti S. (1), Birkefeldt Moller Pedersen G. (2), Ivarsdóttir H. (1), Pfeffer M.A. (1), Ólafsdóttir B.A. (1), Tarquini S. (3), de' Michieli Vitturi M. (3)(4)
(1) *Icelandic Meteorological Office, Reykjavík*
(2) *Institute of Earth Sciences - University of Iceland*
(3) *Istituto Nazionale di Geofisica e Vulcanologia - Sezione di Pisa*
(4) *Department of Geology - University of Buffalo*

After 800 years the Reykjanes peninsula hosts a new eruption. An eruptive fissure opened on the 19th of March after three weeks of intense unrest (seismic and deformative) featuring a small effusive eruption in Geldingadalir (Fagradaslfjall). Two months since its beginning, the eruption is now characterized by one single active crater which shows pulsating lava fountaining. The opening of new fissures, lava flows, volcanic gas pollution, tephra and scoria fallout represent the main volcanic hazards of an eruption which is attracting thousands of tourists per day. Numerical models are widely used in volcanology to support the interpretation of volcanic processes and describing their evolution. During this eruption, a variety of models have been adopted to quantify and assess the potential impact of lava flows, volcanic gases and scoria and lapilli fallout on the surroundings, both in the near and far field. Here we provide an overview of such models, their applications, their limitations and their final usage for an operational hazard assessment. Danger area maps have been produced to inform the civil protection agencies and to advice them on needed mitigation actions.

Aula Ida Ortalli **ore 09:30 – 13:00**

Sezione V
Biofisica e fisica medica
Presiede: Origgi D. (IEO, IRCCS, Milano)

Relazioni su invito

▲ **Dosimetria di fasci di ioni a scansione per adroterapia.**

Ciocca M.
Fondazione CNAO - Centro Nazionale di Adroterapia Oncologica

L'interesse della comunità scientifica verso la radioterapia con fasci di ioni a scansione (protoni e ioni carbonio) per il trattamento di tumori solidi sta rapidamente crescendo a livello mondiale. La determinazione della dose assorbita in acqua in condizioni di riferimento è tuttora basata sul protocollo IAEA TRS-398, pubblicato nel 2000, quando ancora erano diffusi i sistemi di tipo passivo (scattering). Verranno discussi i limiti del protocollo e la necessità di un suo aggiornamento. Per la dosimetria in condizioni di non riferimento, sulla base dell'esperienza maturata al CNAO, verranno presentate le criticità legate alla caratterizzazione dei rivelatori attualmente disponibili (camere a ionizzazione, semiconduttori, microdiamanti, pellicole radiocromiche), in termini soprattutto di dipendenza della loro risposta dal LET. Infine verranno discussi gli ambiti di ricerca, orientati in particolare allo sviluppo di metodologie di verifica del range delle particelle in vivo e di assicurazione della qualità mediante test di tipo end-to-end.

▲ **Robotic technologies for image guidance in particle therapy.**

Baroni G.
Dipartimento di Elettronica Informazione e Bioingegneria - Politecnico di Milano

Radiotherapy is an effective cancer treatment based on the deposition of energy by ionizing radiation, which leads to DNA damage and thereby to the death of irradiated cells. The main objective in radiotherapy consists in delivering the highest dose to the target, while maintaining a low dose to the surrounding healthy tissues. The quantification and verification of anatomo-pathological changes occurring between and during each fraction is needed to ensure the effectiveness of the treatment. This motivated the introduction of computer-aided and robotic assisted image guidance technologies for high-precision radiotherapy, which turns out to be particularly crucial in particle therapy. At the CNAO Foundation (Pavia, Italy), the first and still unique Italian centre providing protons and carbon-ion therapy for cancer treatment, robots have been exploited to pursue the implementation and clinical application of image guidance systems, as well as to support the protontherapy of ocular diseases. The design, implementation, commissioning and clinical application of these platforms will be presented and discussed.

▲ **Innovative thin silicon detectors for online beam monitoring in particle therapy applications.**

Abujami M. (1)(2), Galeone C. (2), Garbolino S. (1), Giordanengo S. (1), Mas Milian F. (1)(2)(3), Mazza G. (1), Mignone M. (1), Monaco V. (1)(2), Vignati A. (1)(2), Cirio R. (1)(2), Martì Villarreal O. A. (1)(2), Sacchi R. (1)(2)
(1) *National Institute for Nuclear Physics INFN, Turin division, Turin, Italy*
(2) *Università degli Studi di Torino, Physics Department, Turin, Italy*
(3) *Universidade Estadual de Santa Cruz, Ilheus, Brazil*

An innovative detector based on thin silicon UFSD detectors was developed and characterized by the medical physics group of University and INFN-Torino, on behalf of the MoVeIT project collaboration, for single ion discrimination and counting of a therapeutic particle beam. This detector aims at detecting each single beam particle and count their number up to 10^8 cm^2/s fluxes, with a pileup probability of $< 1\%$. In particular, the system was recently tested on the TIFPA proton beam (70–228 MeV). The result of this test was analysed, and the results will be presented and discussed.

▲ Therapeutic application of a mixture of $^{64/67}$Cu radioisotopes.

De Nardo L. (1)(2), Pupillo G. (3), Mou L. (3), Esposito J. (3), Rosato A. (4)(5), Melendez-Alafort L. (4)
(1) *Dipartimento di Fisica dell'Università di Padova, Padova, Italy*
(2) *INFN, Sezione di Padova, Padova, Italy*
(3) *INFN, Laboratori Nazionali di Legnaro, Legnaro Padova, Italy*
(4) *Veneto Institute of Oncology IOV-IRCCS, Padova, Italy*
(5) *DISCOG, Università di Padova, Padova, Italy*

Copper radioisotopes, such as ^{64}Cu and ^{67}Cu, could be useful tools for diagnosis and therapy of cancers, due to the increased accumulation of Cu^{2+} ions in the tumor site. While ^{64}Cu can be produced with high specific activity using low-energy biomedical cyclotrons and it is already commercially available, ^{67}Cu production is more challenging, due to the difficulties to obtain a high yield without the co-production of other Cu-isotopes, especially ^{64}Cu. Due to the favorable decay characteristics of both $^{64/67}$Cu radioisotopes, in this work the possibility of using a mixture of them for therapeutic purposes has been evaluated.

▲ Advances in Monte Carlo patient-specific internal dosimetry for ^{90}Y-TARE treatments.

Pistone D. (1)(2), Italiano A. (1)(2), Auditore L. (3), Campenní A. (3)(4), Baldari S. (3)(4), Amato E. (2)(3)
(1) *MIFT Department, University of Messina, Messina, Italy*
(2) *INFN Section of Catania, Catania, Italy*
(3) *BIOMORF Department, University of Messina, Messina, Italy*
(4) *Nuclear Medicine Unit, University Hospital "G. Martino", Messina, Italy*

Three-dimensional internal dosimetry (ID) is increasingly used in planning Trans-Arterial Radio-Embolization (TARE) treatments of liver tumors, with growing interest in the patient-specific Monte Carlo (MC) approach. Direct MC simulation is the gold standard for ID, but requires relatively long computational times. We present our recent studies aiming at speeding up MC ^{90}Y-TARE ID through the optimization of parameters such as CT resolution and production cuts on secondary particles. Using the GEANT4-based toolkit GATE, we carried out multiple simulations varying CT resampling and production cuts; we found combinations of parameters reducing simulation time up to 30–40% while maintaining high dosimetric accuracy. We moreover discuss ongoing studies focusing on further optimization of MC ^{90}Y-TARE ID by reducing background noise and dose artefacts in air-rich regions of patient's body. For this purpose, we developed filtering techniques of the input SPECT data. Comparing the results obtained with filtered and unfiltered data, non-negligible discrepancies in lungs doses emerge, with relative differences exceeding even 40% depending on the adopted filtering procedure.

▲ Dosimetric impact of intra-fraction motion during moderate hypo-fractionated prostate radiotherapy treatment: Population-based anisotropic margins for CTV-prostate.

di Franco F. (1)(2), Baudier T. (1)(2), Gassa F. (1), Sarrut D. (1)(2), Biston M.C. (1)(2)
(1) *Léon Bérard Cancer Center, Université de Lyon, Lyon F-69373, France*

([2]) *CREATiS, INSA, Université de Lyon, CNRS UMR5220, Inserm U1044, Lyon F-69622, France*

During radiotherapy, intra-fraction prostate movements impact dose distribution and target coverage. An accurate motion characterization may help determining the best compromise between increasing tumor control probability and normal tissues' sparing. The aim of this study was to investigate the dosimetric impact of intra-fractional motion during prostate radiation therapy providing population-based anisotropic margins for CTV-prostate based on volumetric coverage. A trans-perineal ultrasound probe was used to track prostate translations for 346 treatment sessions. Treatment plans were recomputed decreasing CTV-to-PTV margins with an auto-planning optimization algorithm and a voxel shifting method was used to move the CTV-prostate every second of treatment.

▲ **Dose computation with a GPU-based fast Monte Carlo for an IOeRT mobile electron linear accelerator.**

Franciosini G. ([1])([2]), Barone S. ([3]), Battistoni G. ([4]), De Maria P. ([5]), De Simoni M. ([1])([2]), Di Francesco M. ([3]), Di Martino F. ([6]), Felici G. ([3]), Fischetti M. ([2])([7]), Galante F. ([3]), Grasso L. ([3]), Marafini M. ([2])([8]), Muraro S. ([4]), Pacitti M. ([3]), Patera V. ([2])([7]), Sarti A. ([2])([7]), Schiavi A. ([2])([7]), Sciubba A. ([7])([9]), Toppi M. ([7])([9]), Traini G. ([2]), Trigilio A. ([1])([2])
([1]) *Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italia*
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([3]) *S.I.T. Sordina IORT Technologies SpA, Aprilia, Italia*
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([6]) *U.O. Fisica Sanitaria, Azienda Universitaria Ospedaliera Pisana, Pisa, Italia*
([7]) *Dipartimento di Scienze di Base e Applicate per l'Ingegneria, Sapienza Università di Roma, Italia*
([8]) *Museo Storico della Fisica e Centro Studi e Ricerche "E. Fermi", Roma, Italia*
([9]) *INFN, Istituto Nazionale di Fisica Nucleare, Sezione dei Laboratori di Frascati, Italia*

IORT is a technique that, after the surgical tumor removal, delivers a dose of ionizing radiation directly to the patient surgery bed. The dose is provided by an electron beam produced by a miniaturized LINAC accelerator with energy between 4 and 12 MeV. In this contribution we report the tests and simulations of a mobile electron linear accelerator NOVAC 11 (SIT, Aprilia, Italy). The experimental dosimetric characterization of the linear accelerator has been compared to a fast Monte Carlo simulation, using FRED (Fast paRticle thErapy Dose evaluator). The code FRED has been developed to allow a fast optimization of the Treatment Planning System in Particle Therapy, while keeping the dose release accuracy typical of a MC tool. This software has been written to run on GPU, so to reduce the simulation time by a factor of 103 compared to the standard MC tool. Currently, the code is already used as research tool at several research centers for proton beams while for carbon and electron beams is under development. The consistency between the measured and simulated quantities, such as Percentage Depth Dose and lateral profiles have been evaluated and are found to be in good agreement.

Aula Ada Lovelace **ore 09:30 – 13:00**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Battistoni G. (INFN, Sezione di Milano)

Relazioni su invito

▲ Innovative electron linear accelerators for FLASH radio therapy.

Palumbo L. ([1])([2]), Alesini D. ([3]), Bosco F. ([1])([2]), Carillo M. ([1])([2]), Faillace L. ([1])([3]), Ficcadenti L. ([2]), Giuliano L. ([1])([2]), Migliorati M. ([1])([2]), Mostacci A. ([1])([2]), De Arcangelis D. ([1])([2]), Spataro B. ([3])
([1]) *Università di Roma La Sapienza, Dipartimento Scienze di Base e Applicate per l'Ingegneria*
([2]) *INFN Sezione di Roma1*
([3]) *INFN Laboratori Nazionali di Frascati*
Flash therapy is a revolution in the cancer cure: it spares healthy tissue from the damage of the ionizing radiation maintaining the tumor control as efficient as in conventional radiotherapy. To allow the implementation of the revolutionary FLASH therapy concept into actual clinical use it is necessary to have linear accelerators able to deliver very high dose rate ($>$ 10E6 Gy/s) in very short time of irradiation ($<$ 100 ms). Recently, our group was involved in the design of the first electron linear accelerator dedicated to the Flash irradiation (S-band, energy of 7 MeV, peak current of 100 mA). The accelerator was built by Sordina Iort Technology S.p.A, and it is in operation at the Marie Curie Institute in Orsay (France). A first prototype of a novel C band (5.712 GHz) electron linear accelerator for FLASH therapy able to reach 10–12 MeV is being developed. In order to treat deep tumors, the energy should achieve the range of 70–100 MeV. We investigate the main issues in the design of a compact C band electron linac-VHEE, aiming to reach a high accelerating gradient and high peak current required for medical Flash radio therapy treatments.

▲ Hadrontherapy at CNAO: Present and future.

Pullia M., Facoetti A., Bressi E., Falbo L., Meliga P., Priano C., Savazzi S., Donetti M.
Fondazione CNAO, Pavia, Italy
CNAO is one of the four centres in Europe, and six worldwide, offering tumour treatments with both protons and carbon ions. By January 2021 about 3200 patients were treated at CNAO. The CNAO synchrotron provides carbon ion beams with energies up to 400 MeV/u and protons up to 227 MeV in 3 treatment rooms and one experimental room open also to external users. The beam distribution in all the lines is based on active scanning and the maximum field size is 200 mm $\times$ 200 mm. Experiments at CNAO can benefit from the presence of an equipped biological laboratory. The major ongoing upgrades of the facility are the following: 1) an additional ion source is under installation and additional ions will be made available in the experimental room within 2022; 2) a single room facility for protons with a gantry will be installed in a new building next to the present one; 3) an accelerator-based BNCT facility will also be installed; 4) the research area will be expanded as well as the biology labs and rooms for small-animal experiments will be made accessible. A carbon ion gantry will be a fundamental improvement for the facility and, for that reason, it is being designed to be installed at CNAO within 8–10 years.

▲ **La fisica applicata alle scienze della vita: L'esperienza dei Laboratori Nazionali del Sud.**

CUTTONE G.
INFN-Laboratori Nazionali del Sud, Catania

I Laboratori Nazionali del Sud (LNS) sono da oltre 30 anni fortemente impegnati nel campo delle applicazioni della fisica nucleare e degli acceleratori alle scienze della vita. Sono stati il primo centro clinico italiano di protonterapia (CATANA) realizzato in collaborazione con la Università degli Studi di Catania, l'azienda ospedaliera universitaria Policlinico di Catania e il Centro Siciliano di Fisica nucleare e struttura della materia. CATANA ha trattato con successo oltre 500 pazienti affetti da melanomi dell'occhio e altre forme tumorali della regione oculare. Attorno a CATANA è cresciuta ai LNS una ampia e significativa esperienza scientifica nel campo della fisica medica, della dosimetria, dei sistemi di avanzati di imaging e della radiobiologia svolta in collaborazione con le principali istituzioni accademiche e di ricerca italiane ed europee nel campo delle scienze della vita. Le ricerche portate avanti ai LNS continuano a generare conoscenza, strumenti e infrastrutture che sono di grande rilevanza nel campo della medicina, biologia, farmacologia e delle scienze omiche in generale. Negli ultimi anni stiamo anche contribuendo allo sviluppo e applicazione di Intelligenza Artificiale e machine learning con l'obiettivo di contribuire alla comprensione profonda di molte malattie e per realizzare una vera ed efficace medicina personalizzata. I programmi e le attività degli LNS in questo ambito saranno estensivamente presentati.

▲ **Prospettive nella ricerca su radiofarmaci innovativi con acceleratori.**

ESPOSITO J. ([1]), BOSCHI A. ([3]), CISTERNINO S. ([1])([2]), DUATTI A. ([3]), KEPPEL G. ([1]), MAGGIORE M. ([1]), MARTINI P. ([1])([3]), MOU L. ([1]), PUPILLO G. ([1]), SCIACCA G. ([1])([2])
([1]) *Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Legnaro, INFN-LNL*
([2]) *Università di Padova*
([3]) *Università di Ferrara*

Il notevole progresso della medicina nucleare (MN) nell'ultimo decennio si basa sullo sviluppo di una vasta (e diversificata) gamma di prodotti radiofarmaceutici sempre più efficaci. Quest'obiettivo si è raggiunto combinando l'impiego di nuove molecole, selettive per lo specifico target biologico, con le proprietà nucleari di nuovi radioisotopi, sia per diagnostica che terapia, fino alle applicazioni di frontiera della teranostica. In particolare, la disponibilità di nuovi radionuclidi, a volte difficili da produrre con reattori nucleari nelle quantità e purezze necessarie, è avvenuta grazie al recente sviluppo tecnologico degli acceleratori di particelle, in primis ciclotroni di alte prestazioni di bassa-media energia, anche per investigare canali di reazione a volte ancora inesplorati. In questo contributo sarà descritta anche la nuova infrastruttura di ricerca LARAMED —LAboratorio di RAdionuclidi per la MEDicina— in corso di realizzazione presso i Laboratori Nazionali di Legnaro (LNL) dell'INFN. LARAMED fa parte del progetto SPES, che utilizzerà il nuovo ciclotrone BEST 70p ad alte prestazioni (35–70 MeV, fino a 750 μA) per studi di frontiera di fisica nucleare con fasci radioattivi e per applicazioni.

▲ **Micro-pattern gas detector: Status and perspectives.**

IENGO P.
INFN, Sezione di Napoli e CERN, Geneva, Switzerland

In the last decades Micro-Pattern Gaseous Detectors (MPGD) stood out as the most promising gas detectors for the next generation of High Energy Physics experiments. Nowadays MPGD is a well-established technology adopted by many HEP experiments as well as for other applications as medical, dosimetry, imaging and neutron detectors. MPGD feature good position resolution, high rate capability and radiation tolerance, low material budget and industrial production capability, which makes them suited for a wide range of applications. Consolidated MPGD like GEM and Micromegas are used to equip large detector systems for the upgrade of LHC experiments, meanwhile R&D efforts are continuing in different directions: optical readout, time resolution below 100 ps, new materials, rate capability above 10MHz/cm^2, etc. The talk will review the recent development of MPGD with the focus on the most relevant applications. The current status of the technology will be discussed, including the many new devices featuring resistive material for spark suppression. The ongoing R&D, together with the perspectives and the possible future applications of MPGD will also be discussed.

▲ **Challenges of new detectors for high-energy physics experiments.**

D'Auria S.
Università degli studi di Milano, Dipartimento di Fisica e INFN, Sezione di Milano

This review of particle detectors for high-energy physics focuses on the technological challenges for the upgrade of existing experiments and on possible developments for the longer timescale of future experiments, with particular emphasis on tracking detectors.

▲ **La radiografia muonica: Dallo studio dei vulcani alle applicazioni in campo industriale ed archeologico.**

Saracino G.
Università di Napoli Federico II, INFN sezione di Napoli

La radiografia muonica utilizza i muoni di origine cosmica per lo studio della distribuzione di materia all'interno di corpi di grosse dimensioni. In particolare la tecnica per assorbimento misura l'attenuazione del flusso, dovuta all'interazione dei muoni con la materia attraversata, utilizzando un tracciatore di muoni che ne ricostruisce la direzione. Negli ultimi anni si è osservato un fiorire di attività che utilizzano tale tecnologia in diversi ambiti di applicazione. Ad esempio: in archeologia, per la ricerca di camere nascoste all'interno di piramidi o nel sottosuolo; in campo minerario per la ricerca di giacimenti; in campo industriale per lo studio della misura della densità all'interno di un altoforno; in geologia per la ricerca di cavità o per la determinazione della stratigrafia del terreno e per lo studio dei vulcani, dove diversi gruppi sono attivi in Italia, Giappone e Francia. Nella mia relazione, dopo aver introdotto i principi della radiografia muonica e le tecnologie più utilizzate per il tracciamento dei muoni, mi soffermerò su di una serie di esperimenti in corso in Italia e all'estero.

Aula Nella Mortara **ore 09:30 – 13:00**

Sezione VII
Didattica e storia della fisica
Presiede: Immè J. (Università di Catania)

Relazioni su invito

▲ **Apprendimento attivo nel laboratorio di fisica con Arduino e smartphone.**

Organtini G.
Sapienza Università di Roma

La disponibilità di strumentazione digitale come gli smartphone e le schede Arduino permette di cambiare radicalmente l'approccio al laboratorio di fisica nelle scuole e nelle università. Nelle prime, permette di trasformare il ruolo degli alunni da spettatori ad attori, nonché di superare i limiti tradizionali dovuti alla disponibilità di spazio, strumenti e tempo. Nelle università, consente di introdurre il laboratorio laddove tradizionalmente non previsto (spesso per mancanza di spazi idonei), come nei corsi di laurea di scienze o ingegneria, e di innovare l'insegnamento della fisica sperimentale nei corsi di laurea in fisica attraverso l'inclusione delle moderne tecnologie. La possibilità di realizzare esperimenti in casa o in aula permette di mitigare eventuali problemi di occupazione degli spazi e l'utilizzo di queste risorse rende più appetibili le esperienze da parte degli studenti, in un ambiente di apprendimento attivo e stimolante. Infine, queste tecnologie favoriscono lo sviluppo di competenze trasversali e sviluppano la creatività.

▲ **Approcci didattici allo studio della tensione superficiale.**

Termini G., Battaglia O.R., Agliolo Gallitto A., Fazio C.
Dipartimento di Fisica e Chimica - Emilio Segrè, Università degli Studi di Palermo

In questo contributo presenteremo la progettazione di una sequenza di insegnamento/ apprendimento sul concetto di tensione superficiale, da sperimentare con studenti di Scuola Secondaria di Secondo Grado. Essa nasce dalla considerazione, ben nota dalla letteratura scientifica, che un approccio tradizionale al concetto di tensione superficiale spesso si rivela poco efficace nel promuoverne l'apprendimento. La sperimentazione coinvolgerà attivamente uno specifico campione di studenti suddivisi in due gruppi (rispettivamente, di controllo e sperimentale). Il primo affronterà un approccio tradizionale alla tematica, basato sul modello macroscopico di tensione superficiale; il secondo sarà coinvolto in un approccio più innovativo alla tematica dei fenomeni di superficie, basato su un modello mesoscopico implementato in simulazioni Smooth Particle Hydrodynamics. Entrambi gli approcci si baseranno su metodologie di apprendimento attivo e si avvarranno di attività sperimentali durante le quali gli studenti potranno raccogliere e analizzare dati in prima persona.

▲ **Apprendimento attivo a distanza. Alcune considerazioni su opportunità, metodi e significatività dei risultati ottenuti a livelli di scolarità differenti.**

Giliberti M.
Università degli studi di Milano

Ciascuna disciplina ha il proprio modo di studiare il mondo, ma è collegata alle altre in una rete di connessioni sulla quale si deve strutturare la ricerca dell'approccio didattico più efficace affinché ciascun allievo possa esprimersi al meglio e sviluppare creatività e rigore. I concetti disciplinari sono astrazioni e il fisico non è un archeologo che scopre un'anfora sotto la sabbia: piuttosto la crea. Affinché questa creazione possa avvenire, però, l'apprendimento necessita di essere attivo. Si faranno esempi e considerazioni su alcuni approcci inquiry based sviluppati dal gruppo di didattica della fisica della Statale di Milano.

▲ Il contributo della multimedialità all'apprendimento attivo della fisica a distanza.

STEFANEL A.
Unità di Ricerca in Didattica della Fisica, Dipartimento di Scienze Matematiche, Informatiche e Fisiche, Università degli Studi di Udine

Promuovere apprendimento attivo della fisica in DAD è una sfida che coinvolge strategie per proporre le tematiche, le esercitazioni, il laboratorio sperimentale. Presso l'Università di Udine abbiamo progettato e sperimentato attività a distanza di apprendimento attivo della fisica rivolte alle scuole superiori e a studenti universitari. Integrano attività sincrone e asincrone, sviluppate valorizzando le potenzialità e le modalità comunicative degli ambienti di elearning per offrire e discutere le tematiche utilizzando ad esempio gli strumenti delle LIM per realizzare presentazioni dinamiche, proporre questionari con diverse modalità e ruolo (sessioni tipo clicker realizzate con app per smartphone; questionari implementati in form elettroniche al posto dei tutorial carta e penna, questionari di valutazione pre/post e in itinere), integrare attività sperimentali realizzate con quattro diverse modalità (RCL, RTL, uso di kit inviati agli studenti e autoprodotti anche con uso di smartphone). Se ne discutono le caratteristiche principali con esemplificazioni e documentazioni di esiti con gli studenti che ne facciano emergere il ruolo per l'apprendimento della fisica.

▲ Quando il laboratorio di fisica resta a casa: Strumenti e metodi per un apprendimento attivo a distanza.

ROSI T., ONORATO P., OSS S.
Dipartimento di Fisica, Università degli Studi di Trento, Italia

La didattica universitaria è stata messa a dura prova dalla pandemia Covid-19 e, nell'offrire corsi a distanza, una sfida cruciale è stata quella di proporre agli studenti un'esperienza di laboratorio, autentica e significativa, possibilmente collettiva, che consentisse un'analisi rigorosa garantendo un ambiente di apprendimento attivo. Per soddisfare questa esigenza alcuni corsi di laboratorio sono stati riprogettati sperimentando diverse soluzioni sia dal punto di vista della metodologia che degli strumenti utilizzati: sono stati ideati e realizzati Home-Kit forniti agli studenti, sono stati proposti esperimenti fatti in casa dagli studenti, sono stati creati esperimenti virtuali. Apriremo il sipario sulle criticità e i punti di forza di questa esperienza valutando le diverse soluzioni in termini di efficacia e soddisfazione degli studenti e il raggiungimento degli obiettivi di apprendimento.

▲ Apprendimento attivo a distanza: Un'esperienza di LRR mediata dal docente, per l'apprendimento della fisica del colore.

SAPIA P. (1), BOZZO G. (2)
(1) *Laboratorio di Fisica Applicata per le Nanotecnologie, i Beni Culturali e la Comunicazione della Scienza - Dipartimento di Biologia, Ecologia e Scienze della Terra, Università della Calabria.*
(2) *Liceo Scientifico "G.B Quadri", Vicenza*

La crisi pandemica ha sfidato l'efficacia della Didattica a Distanza, specie negli ambiti in cui le attività di laboratorio hanno un ruolo centrale. I laboratori virtuali sono un succedaneo del laboratorio reale, utile in emergenza, così come le esperienze di laboratorio reale con materiali di facile reperibilità, auto-allestite dai discenti a casa. Tuttavia il laboratorio reale strutturato rimane difficilmente sostituibile, specie nei setup didattici fondati su metodologie di apprendimento attivo basato sull'indagine. In questo contesto, e in risposta a specifiche richieste di formazione delle scuole del territorio, nell'a.s. 20/21 è stata progettata e realizzata un'iniziativa di laboratorio reale remoto (LRR) di carattere innovativo basato sull'esecuzione e documentazione video di esperimenti reali presso i laboratori universitari, con trasmissione dei dati ai discenti per l'elaborazione e interpretazione degli stessi. Il percorso di apprendimento è arricchito da elementi di interazione significativi, sul modello delle Interactive Lecture Demonstrations. Viene qui presentata un'esperienza contestualizzata sulla fisica del colore applicata allo studio conservativo di opere d'arte.

▲ **Scientific Literacy and transformative change for facing societal challenges.**

Tasquier G.
Alma Mater Studiorum - Università di Bologna, Dipartimento di Fisica e Astronomia, Bologna, Italia

To tackle the challenges of Anthropogenic climate change, society faces the need for rapid and deliberate transformation on a scale never attempted before. Science Education has the crucial role of struggling for a transition to a sustainable future. The main challenge is to foster scientific literacies for applying scientific knowledge to real-life challenges for developing critical decision making and action for change. In this endeavour, the H2020 project SEAS (*Science Education for Action and Engagement towards Sustainability*) is developing teaching/learning tools with the transformative potential to explore and link deeper dimensions of change such as practices, societal structures, values and worldviews through the lens of science.

Aula Plenarie **ore 14:30 – 15:25**

SEZIONE I
Fisica nucleare e subnucleare
Presiede: NANIA R. (INFN, Sezione di Bologna)

Relazione Generale

Recent progress in ab initio studies of light nuclei and few-nucleon reactions.

MARCUCCI L.E.
Dipartimento di Fisica, Università di Pisa e INFN, Sezione di Pisa

In this contribution, I will review the recent progress in *ab initio* studies of few-nucleon systems, in particular light nuclei and scattering states with A up to 6, using the so-called hyperspherical harmonics method. I will then present results obtained in selected applications, focusing on nuclear reactions of interest for astrophysics, and for the search of physics beyond the standard model.

Aula Plenarie **ore 15:30 – 16:25**

Sezione IV

Geofisica e fisica dell'ambiente

Presiede: Del Negro C. (INGV, Catania)

Relazione Generale

Polarized plate tectonics and earthquakes.

Doglioni C.
INGV, Roma

The combination of the secular cooling of a heterogeneous and stratified mantle, and the astronomical tuning are inferred as the main controlling factors of the Earth's geodynamics. The Earth's rotation and the tidal despinning generate a torque acting on the lithosphere, producing a net westerly directed rotation of the lithosphere with respect to the underlying mantle. These mechanisms generate asymmetric plate margins both along subduction and rift zones. Seismicity occurs at plate boundaries and during the interseismic stage, a dilatational band forms in the brittle upper crust. The stretching is recovered during the coseismic stage when the fault hanging wall falls releasing its gravitational energy on a normal fault. On the contrary, for a thrust fault, during the interseismic stage an over compressed band forms above the brittle-ductile transition, which is opposingly dilated during the earthquake, delivering elastic energy. In all tectonic settings, the epicentral area is elliptical and represents the surface projection of the crustal volume activated above the fault plane where seismic waves overlap the vertical coseismic motion of the hanging wall, hence producing the highest ground shaking.

Aula Plenarie **ore 17:00 – 18:30**

TAVOLA ROTONDA

Investire nelle donne: un'opportunità da sviluppare all'interno del Recovery Plan

Organizzata dal Comitato Pari Opportunità della SIF

Modera:
Agnese Pini, Direttrice de La Nazione

Partecipano:
Elena Bonetti, Ministra per le Pari Opportunità e la Famiglia
Stefania Brancaccio, Presidente Comitato Imprenditoria Femminile di Napoli
Daniela Farina, Direttrice dell'Istituto per la Scienza e Tecnologia dei Plasmi (ISTP) del CNR di Milano
Barbara Poggio, Prorettrice alle politiche di equità e diversità dell'Università di Trento
Antonella Polimeni, Rettrice dell'Università Sapienza Roma

L'argomento della Tavola Rotonda è di grande attualità poiché all'interno del Recovery Plan vi sono fondi specifici destinati alla parità di genere e alla coesione, e il loro opportuno indirizzo potrà contribuire a un cambiamento sostanziale della grave situazione generata dalla pandemia e che ha colpito in particolare le donne. È un tema che coinvolge il mondo della formazione, della ricerca, delle imprese, delle politiche sociali e il CPO-SIF qui propone una discussione tra le varie parti in un tavolo di eccellenza al femminile, per confrontarsi e ripartire investendo nelle donne.

Aula Chien Wu **ore 09:30 – 11:30**

Sessione Congiunta delle Sezioni
I - Fisica nucleare e subnucleare e III - Astrofisica
Presiede: Casini G. (INFN, Sezione di Firenze)

Relazioni su invito

▲ **Experimental Nuclear Astrophysics at n_TOF, ERNA and LUNA.**
Piatti D. ([3]), Amaducci S. ([1]), Buompane R. ([2])
([1]) *INFN Laboratori Nazionali del Sud*
([2]) *Università degli Studi della Campania "Luigi Vanvitelli" e INFN Sezione di Napoli*
([3]) *Università degli Studi di Padova e INFN, Department of Padova.*
Nuclear astrophysics studies reactions which shape the life and death of stars, and which are responsible for the synthesis of the chemical elements in the Universe. To improve our understanding of stellar evolution and isotopic abundances, indeed, a precise knowledge of nuclear reaction cross sections at astrophysical energies is fundamental. Three Italian groups are giving important contributions to nuclear astrophysics investigating nuclear reaction cross sections by direct measurements. In the talk a review of the most recent results, present activities and perspectives from n_TOF, ERNA and LUNA Collaborations will be presented.

▲ **Indirect methods and innovative techniques for Nuclear Astrophysics.**
Guardo G.L., Pidatella A.
INFN-Laboratori Nazionali del Sud, Catania, Italy
Physical phenomena occurring in the Universe, including evolution of stars and cataclysmic events are driven by nuclear reactions and decays. However, a satisfactory knowledge of the corresponding reaction rates in laboratory is prevented by the presence of Coulomb barrier penetration and electron screening effects. For overcoming problems in using extrapolation procedures, alternative methods —providing bare nucleus cross sections and stellar plasma-enhanced nuclear rates— are demanded. Within this interdisciplinary framework, we present the Asymptotic Normalization Coefficient (ANC) and the Trojan-Horse (THM) as indirect methods to determine low-energy reaction rates, and innovative experimental techniques accessible through the novel plasma trap-based facility named PANDORA, designed for exploring in-plasmas phenomena relevant for nuclear astrophysics. These methods unprecedentedly attempt providing experimental clarifications to nuclear cross sections, weak interaction rates, and atomic physics uncertainties, all of them impacting on several debated astrophysics issues ranging from primordial to stellar nucleosynthesis.

▲ **La misura dei nuclei nei raggi cosmici con AMS-02.**
Graziani M.
INFN e Università di Perugia
La misura della componente nucleare dei raggi cosmici (RC) è di fondamentale importanza per capire l'accelerazione e la propagazione dei RC stessi all'interno della galassia. In particolare, la misura del rapporto tra i flussi dei nuclei secondari e primari ci fornisce una stima della densità del mezzo interstallare e, di conseguenza, del coefficiente di diffusione nel modello di propagazione dei RC. Le recenti misure dell'esperimento Alpha Magnetic Spectrometer (AMS-02), un rivelatore per RC installato sulla Stazione Spaziale Internazionale

nel Maggio 2011, ci forniscono il più completo set di misure dei flussi dei RC, mettendo in discussione gli attuali modelli di propagazione degli stessi. È stato osservato un break nello spettro energetico sia nei nuclei primari che nei nuclei secondari e osservato, per la prima volta, che esistono almeno due classi distinte di flussi primari caratterizzate da una diversa dipendenza dalla rigidità. In questa relazione verranno discusse le misure nucleari effettuate da AMS-02 facendo anche il confronto con le misure degli esperimenti precedenti.

▲ **The relevance of nuclear reactions for Standard Solar Models construction.**
Villante F.
INFN, LNGS
The fundamental processes by which nuclear energy is generated in the Sun have been known for many years. However, continuous progress in areas such as neutrino experiments, stellar spectroscopy and helioseismic data and techniques requires ever more accurate and precise determination of nuclear reaction cross-sections, a fundamental physical input for solar models. In this work, we review the current status of (standard) solar models and present a detailed discussion on the relevance of nuclear reactions for detailed predictions of solar properties. The latter is of particular relevance in the context of the conundrum posed by the solar composition, the solar abundance problem, and in the light of the first ever direct detection of solar CN neutrinos recently obtained by the Borexino Collaboration.

▲ **Taking snapshots of our Sun with the Borexino experiment.**
Re A.C.
Dipartimento di Fisica "A. Pontremoli", Università degli Studi di Milano, Italia e Sezione INFN, Milano, Italia
Borexino is a liquid scintillator experiment designed and constructed for real-time detection of low-energy solar neutrinos. It is installed at the underground INFN Laboratori Nazionali del Gran Sasso (L'Aquila, Italy) and started taking data in May 2007. Besides being able to precisely measure all the solar neutrino fluxes belonging to the so-called pp-chain, the Borexino Collaboration recently published on "Nature" the first experimental evidence of the CNO (Carbon-Nitrogen-Oxygen) neutrinos produced in the Sun. While being a secondary mechanism of energy production in our star, the CNO cycle is the main nuclear engine in more massive stars: this result is therefore crucial for the precise modeling of solar physics and for astrophysics in general since it confirms the existence of this nuclear fusion process in our Universe. The details of the detector stabilization as well as the strategy adopted by the Borexino Collaboration for successfully isolating the spectral component of the CNO signal from the residual backgrounds will be presented.

Aula Chien Wu **ore 11:30 – 13:00**

Sezione I
Fisica nucleare e subnucleare
Presiede: Silvestris L. (INFN, Sezione di Bari)

Relazioni su invito

▲ **Hadronic structure at colliders.**
Bertone V.
IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France
In this contribution I will discuss the importance of an accurate knowledge of the hadronic structure for phenomenology at colliders. I will introduce and discuss the implications

of three different categories of distributions that embody information on the structure of hadrons and that emerge from factorisation of a selection of relevant processes in QCD. I will first consider the fundamental role of collinear parton-distribution and fragmentation functions. These distributions encode information on the longitudinal distribution of quarks and gluons inside hadrons (collectively called partons) and are necessary for the description of inclusive and semi-inclusive processes at large transverse momenta. Then I will move to consider transverse-momentum–dependent (TMD) distributions that contain information on the transverse-momentum distributions of partons and that are relevant to the description of semi-inclusive processes at small transverse momenta. Finally, I will briefly mention the importance of generalised parton distributions (GPDs) that carry information on the transverse spacial distribution of partons and that are important for the description of exclusive processes.

▲ Overview of the Jefferson Lab experimental program.

Marsicano L.

INFN - Sezione di Genova

Quantum chromodynamics (QCD) is the fundamental theory of the strong interaction, governing nuclear matter and all hadrons. Since its formulation, important steps have been made toward understanding how nuclear matter properties arise from the basic interactions of quarks and gluons. However, many questions remain to date unanswered. The mission of Jefferson Lab is to gain new fundamental understanding of QCD in all its manifestations, through a broad experimental program exploiting the CEBAF beam (Continuous Electron Beam Accelerator Facility). In 2017 Jefferson Lab completed a substantial upgrade, including the maximum beam energy increase to 12 GeV, the upgrade of the detector equipment in the existing experimental halls (Hall A, B, and C), and the construction of a fourth end station, Hall D. This upgrade allows to study the quark and gluon structure of hadrons in the valence region, deepen our understanding of strong interaction in the confinement regime to an unprecedented level and investigate how nuclear forces arise from basic interactions. This talk will give an overview of the experiments running at Jefferson Lab, reviewing recent results from this experimental program.

▲ Soft QCD studies at the LHC with ALICE.

Bianchi L.

Università e INFN di Torino, Italia

Studies on the production of light- and heavy-flavor hadrons are of prominent importance to characterize the partonic phase created in ultrarelativistic heavy-ion collisions and to investigate hadronization mechanisms at the LHC. Studies performed in p-Pb and pp collisions revealed unexpected features, qualitatively similar to what is observed in larger systems and, in the charm sector, not in line with the expectations from e^+e^- interactions. The ALICE experiment has exploited its excellent tracking and PID capabilities to perform an extensive study of hadron production in events characterized by very different multiplicities and multi-differential selections have been exploited to discriminate between soft and hard production processes. A critical discussion of the most recent results on light- and heavy-flavor hadron production will be proposed, together with a comparison to QCD-inspired and thermal phenomenological models. Emphasis will be given to the discussion of the impact of these studies on our understanding of soft-QCD processes.

▲ **Misure sulla produzione di adroni e jets a LHC con i rivelatori ATLAS e CMS.**

Giuli F. (1), Mariani V. (2)
(1) *Università di Roma Tor Vergata e INFN Sezione di Roma 2*
(2) *Università degli studi di Perugia e INFN Sezione di Perugia*

Le misure della produzione di jets in collisioni protone-protone a LHC sono cruciali per migliorare la nostra conoscenza della struttura interna del protone e sono anche rilevanti per ricerche di fisica oltre il Modello Standard. In questa comunicazione, verrà fornita una presentazione dei più recenti risultati riguardo studi di QCD e produzione adronica ottenuti dagli esperimenti CMS e ATLAS durante la presa dati di Run1 e Run2 di LHC. Verranno anche riportati studi sull'impatto di queste misure su parametri fondamentali della QCD come la determinazione di α_S o delle funzioni di probabilità partonica (PDFs).

Aula Cornelia Fabri **ore 09:30 – 13:00**

Sezione II
Fisica della materia
Presiede: Pulci O. (Università di Roma Tor Vergata)

Relazioni su invito

▲ **Atomistic simulations of molecules and of their photochemistry in the strong-coupling regime.**

Corni S. (1)(2)
(1) *Dipartimento di Scienze Chimiche and Padua Quantum Technologies Research Center, Università di Padova, Italia*
(2) *CNR Istituto Nanoscienze, Modena, Italia*

Electronic excitations in molecules can be strongly coupled to electromagnetic modes of resonant cavities. The properties of the resulting hybrid states (polaritons) are different than those of the original electronic states. In particular, the resulting photochemistry depends on the features of the excited molecular states, and can therefore be modified by entering the strong-coupling regime. As such, strong coupling is emerging as a new tool to manipulate the photochemistry (or rather the polaritonic chemistry) of molecules. To understand the underlying mechanisms, we are developing atomistic computational methodologies that extends to the strong-coupling regime well-established quantum chemistry approaches. In this talk, I will discuss such developments and present the results of the corresponding simulations. The picture appearing from these simulations is that of complicated mechanisms, where the realistic features of the studied molecules cannot be safely neglected.

▲ **Second sound driven by a modulated temperature field.**

Colombo L.
Department of Physics, University of Cagliari, Cittadella Universitaria, 09042 Monserrato, CA

Whenever heat is carried by temperature waves the phenomenon is referred to as "second sound"; this thermal transport regime is usually reported only at cryogenic temperatures and in just a few materials. In this talk I will instead provide evidence that second sound can in fact be observed at room temperature, both in bulk and low-dimensional systems. Molecular dynamics simulations are used to investigate room temperature second sound in germanium and one-dimensional cumulene, respectively driven out-of-equilibrium by a time-periodic thermal excitation and a space-periodic temperature field distributed along the chain backbone. The molecular dynamics simulations here presented convincingly explain recent laboratory evidence of second sound in germanium as observed by the frequency-domain optical reflectance pump-and-probe experiment, as well as they allow for a gedanken-experiment on cumulene inspired by real laser-induced transient thermal gratings measurements on bulk graphite. The theoretical foundation for the present simulative results is based on the hyperbolic Maxwell-Cattaneo-Vernotte heat equation, which is best suited to describe mesoscopic wavelike thermal transport.

▲ **Point defects in silicon for quantum technologies at room temperature**

Achilli S. (1), Le N. H. (2), Fratesi G. (1), Manini N. (1), Onida G. (1), Turchetti M. (3), Ferrari G. (4), Shinada T. (5), Tanii T. (6), Prati E. (7)
(1) *Dipartimento di Fisica, Università degli Studi di Milano*
(2) *Advanced Technology Institute and Department of Physics, University of Surrey*

(3) *Research Laboratory of Electronics, Massachusetts Institute of Technology*
(4) *Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano*
(5) *Center for Innovative Integrated Electronic Systems (CIES) , Tohoku University*
(6) *Faculty of Science and Engineering, Waseda University*
(7) *Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale della Ricerche*

Point defects in silicon have been envisioned as suitable systems for the realization of qubits and quantum simulators. The use of conventional dopants, as P, is limited to low temperatures due to their thermal ionization. Identifying new defects with deep states in the gap would allow operations up to room temperature. Furthermore, the control of their positioning, initialization and readout is crucial. We report about a new class of defects obtained by implanting Ge ions in silicon via high-resolution single-ion implantation technique. We demonstrate the formation of position-controlled Ge-vacancy centers (GeV) with deep states in the gap. By exploiting a multiscale theoretical approach we define a protocol for the quantum transfer of electrons through a 1D array of GeV defects. This analysis, performed in pair with experimental measurements of electrical conductivity, evidences a peculiar temperature activation of the quantum transport in GeV.

▲ **Fingerprints of dynamical correlation in electron spectroscopies.**

Gatti M. (1)(2)(3)
(1) *LSI, CNRS, Ecole Polytechnique, Palaiseau, France*
(2) *European Theoretical Spectroscopy Facility - ETSF*
(3) *Synchrotron SOLEIL, France*

One of the great challenges of condensed-matter physics is the description, understanding, and prediction of the effects of the Coulomb interaction on materials properties. In electronic spectra, the Coulomb interaction causes a renormalization of excitation energies and a transfer of spectral weight. Most importantly, it can lead to qualitatively new structures, such as satellites in photoemission. Being a genuine signature of dynamical correlation, they are absent in a non-interacting picture but can be understood in terms of the coupling between different elementary excitations. In this framework, a key physical ingredient is the dynamical screening of the Coulomb interaction, containing charge excitations such as plasmons and excitons. Building upon a detailed knowledge of dynamical screening, the cumulant expansion of the Green's function can efficiently explain plasmon and exciton satellites in the photoemission spectra of several materials, ranging from simple metals to correlated transition-metal oxides.

▲ **Recent developments in real-space quantum Monte Carlo.**

Filippi C.
MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands

Quantum Monte Carlo methods are first-principle electronic structure approaches that provide a stochastic solution to the Schrödinger equation and represent a powerful tool when conventional techniques are not reliable. While quantum Monte Carlo methods are routinely employed to predict accurate total energies of relatively large systems, their use is relatively uncommon when coming to excited states and has been further hampered by the lack of efficient and reliable schemes to obtain energy derivatives. Here, we will illustrate their performance as excited-state methods for prototypical photo-sensitive systems and discuss recent developments which allow the fast and accurate computation of structural properties in quantum Monte Carlo for ground and excited states.

▲ **Theoretical spectroscopy of graphene nanoribbons.**

RUINI A. (1)(2), PREZZI D. (2), MOLINARI E. (1)(2)
(1) *Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia, Italy*
(2) *Centro S3, Istituto Nanoscienze CNR-NANO, Modena, Italy*

Graphene-based nanostructures, such as graphene nanoribbons (GNRs), offer extraordinary versatility as next-generation semiconducting materials for nanoelectronics and optoelectronics due to their tunable properties, including charge-carrier mobility, optical absorption, and electronic bandgap, which are uniquely defined by their chemical structures. The bottom-up fabrication of GNRs has opened new opportunities to specifically tune their properties by precisely controlling their atomic structure. We adopt first-principles computational schemes —based on both density-functional theory and many-body perturbation theory— to aquire a comprehensive understanding of the electronic, optical and vibrational (Raman and IR) excitations in GNRs as a function of their width, edge shape, functionalization, distortion, and different reaction stage in their fabrication. Our results, often combined to experimental investigations, allow to fingerprint their precise structures, and to physically interpret and predict their spectral features.

▲ **Data mining the many-body problem.**

DALMONTE M., MENDES-SANTOS T., TURKESHI X., RODRIGUEZ A., FAZIO R., ANGELONE A.
ICTP and SISSA, Trieste

Many-body systems are typically characterised via low-order correlation functions, that are directly related to response functions. In this talk, I will show how it is possible to provide a characterisation of many-body systems via a direct and assumption-free data mining of one of the pillars of both classical and quantum statistical mechanics —the partition function. The core idea of this programme is the fact that, once sampled stochastically (such as in experiments or Monte Carlo simulations), partitions functions can be construed as very high dimensional manifolds. Such manifolds can be characterised via basic concepts, in particular, by their intrinsic dimension. I will discuss theoretical results for both classical and quantum many-body spin systems that illustrate how data structures undergo structural transitions whenever the underlying physical system does, and display universal (critical) behavior in both classical and quantum mechanical cases. I will conclude with remarks on the applicability of our theoretical framework to synthetic quantum systems, quantum computing architectures, and lattice gauge theories.

I lavori della prima parte della mattina si svolgeranno dalle 9:30 alle 11:30 nell'Aula Chien Wu in una Sessione Congiunta con la Sezione I - Fisica nucleare e subnucleare.
Per il programma si veda alla pagina 77.

Aula Margherita Hack **ore 11:30 – 13:00**

SEZIONE III
Astrofisica
Presiede: POZZI S. (Università di Milano Bicocca)

Relazioni su invito

▲ **Presente e futuro dei Laboratori Nazionali del Gran Sasso.**
GORLA P.
Laboratori Nazionali del Gran Sasso - INFN
I Laboratori Nazionali del Gran Sasso dell'INFN sono un centro di riferimento a livello internazionale per la fisica delle astroparticelle, grazie alla lunga lista di successi degli esperimenti attualmente in corso o in fase di conclusione, dalle misure sui neutrini solari di Borexino, alle misure sulla materia oscura di Xenon e CRESST, agli studi sulla massa di Majorana di GERDA e CUORE. Le sfide che pone oggi la ricerca, per migliorare la conoscenza dell'Universo e del mondo nucleare e subnucleare, aprono nuovi orizzonti, da affrontare con sempre maggior precisione sviluppando idee e progetti innovativi. Una nuova generazione di progetti ad alta sensibilità si prepara ad affrontare le sfide dell'Astrofisica Nucleare (LUNA-MV), dello studio della natura dei neutrini (CUPID e LEGEND) e della materia oscura (XENONnT, DarkSide, CRESST, ...). Attorno a questi progetti i LNGS stanno facendo da incubatore a innumerevoli idee e proposte, sviluppando rivelatori, tecniche e idee che faranno da apripista alle sfide scientifiche del futuro.

▲ **Il progetto XENON.**
DI GANGI P.
INFN Bologna
La ricerca diretta di materia oscura è oggi uno dei campi più attivi della fisica sperimentale che testa ipotesi di nuova fisica oltre il Modello Standard. I rivelatori a xeno liquido (LXe) hanno dimostrato la migliore sensibilità alle WIMP, la classe di particelle principali candidate a formare la materia oscura. Da oltre 15 anni il progetto XENON guida la ricerca diretta di materia oscura adoperando camere a proiezione temporale riempite con LXe, in grado di rivelare segnali sia di scintillazione che di ionizzazione. Sin dal prototipo XENON10, costruito nel 2005, ciascun rivelatore del progetto XENON ha ottenuto i migliori limiti sulle WIMP. L'esperimento XENON1T, il primo rivelatore di materia oscura nella scala delle tonnellate, ha prodotto i migliori risultati al mondo per WIMP di massa > 3 GeV/c^2, per un miglioramento complessivo di 3 ordini di grandezza della sensibilità dall'inizio del progetto XENON. Grazie al più basso livello di fondo mai raggiunto in rivelatori di materia oscura, XENON1T ha anche scoperto il processo più raro mai osservato direttamente e un possibile segnale di nuova fisica. Con l'upgrade XENONnT, attualmente operativo ai LNGS con una massa bersaglio di 6 tonnellate, la sensibilità sarà migliorata di un ulteriore ordine di grandezza.

▲ The LUNA-MV program.

BEST A. (1)(2)PER LA COLLABORAZIONE LUNA-MV
(1) *University of Naples Federico II*
(2) *INFN-Na*

INFN is setting up a modern accelerator facility for nuclear physics and nuclear astrophysics in the deep underground laboratory of LNGS in the context of the progetto premiale LUNA-MV. A 3.5 MV electrostatic accelerator will deliver intense proton, alpha and carbon beams into two beamlines, which can be operated with solid and windowless gas target stations. Together, the low background underground, the high-intensity beams and the extended energy coverage of the accelerator will drastically extend its experimental potential over current installations. The facility will allow measurements of nuclear reactions of crucial importance for a variety of astrophysical processes. In its proposal LUNA-MV, the LUNA Collaboration, active at LNGS for 30 years, is proposing the following measurements: ^{14}N(p,γ)^{15}O, which dominates the CNO cycle; ^{13}C(α,n)^{16}O and ^{22}Ne(α,n)^{25}Mg (the latter also scope of the ERC grant SHADES), the neutron sources of of the s process; and ^{12}C+^{12}C for late-stage stellar evolution. We will present a technical overview, an outline of the experimental program and future perspectives.

▲ DarkSide-20k on the way to the construction.

SUVOROV Y.
Dipartimento di Fisica, Università degli Studi di Napoli Federico II e INFN, Sezione di Napoli

The DarkSide project is based on the use of a double-fase liquid-argon TPC for the direct search of the WIMP dark matter. The goal is to build a 20 tonne fiducial mass TPC equipped with SiPM-based novel cryogenic photosensors (20 m^2 between top and bottom coverage) and run free of any instrumental background for an exposure of $>$ 100 ton$\times$yr at the Italian National Underground Laboratory (LNGS). To this end the TPC will be surrounded by an active veto based on a Gd-loaded acrylic shell and will be enclosed in the 700 t membrane cryostat filled with liquid argon. We expect to reach a WIMP-nucleon cross-section exclusion sensitivity of 10^{-47} cm^2 for a WIMP mass of 1 TeV/c^2 in a 5 yr run. This talk will be focused on the most recent developments and technical solutions adopted for the realisation of the experiment for which groundbreaking work is about to start later this year.

▲ The CUPID and LEGEND double-beta decay experiments.

VON STURM K. (1), FANTINI G. (2)(3)
(1) *INFN - Sezione di Padova, Italy*
(2) *Dipartimento di Fisica, Sapienza Università di Roma, Italy*
(3) *INFN - Sezione di Roma, Italy*

Neutrinoless $\beta\beta$ decay offers a unique probe for the Majorana nature hypothesis of neutrinos. The CUPID and LEGEND experiments aim to reveal this secret by pushing energy resolution and background suppression to unprecedented levels. Their goal is to cover the full parameter space of the inverted neutrino mass hierarchy for the two candidate isotopes ^{100}Mo and ^{76}Ge. CUPID is a tonne-scale array of Li_2MoO_4 scintillating bolometers that will be operated at $\sim$ 10 mK in the CUORE cryostat at LNGS. α events rejection with double readout of heat and light signals will bring the background below 10^{-4} cts/(keV·kg·yr). A $<$ 0.2% energy resolution ensures background free operation. The LEGEND Ge detectors have outstanding energy resolution ($\sim$ 0.1%) and excellent pulse shape discrimination power. Scintillation light from surrounding liquid argon is exploited as veto. GERDA demonstrated a background of $5.2 \cdot 10^{-4}$ cts/(keV·kg·yr) which will be improved. A 200 kg stage is being constructed at LNGS, followed by a 1 t stage using underground argon.

Aula Inge Lehmann **ore 09:30 – 13:00**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Marzocchi W. (Università di Napoli "Federico II')

Relazioni su invito

▲ **Warning before the shaking: From physical challenges to implementation of earthquake early warning systems.**

Colombelli S., Zollo A., Festa G., Caruso A., Elia L., Iaccarino A.G., Picozzi M.
Dipartimento di Fisica E. Pancini, Università degli studi di Napoli Federico II, Italia

When an earthquake happens, there are only few seconds between the rupture beginning and its devastating effect on population and buildings. Earthquake Early Warning Systems use source information inferred from the real-time recorded signals to alert distant sites before the arrival of the strongest ground shaking, for the prompt activation of emergency procedures. Open issues on the physical grounds and challenging tasks are behind the implementation of Earthquake Early Warning Systems. Here we will pass through the fascinating world of seismic ruptures and present the most recent methodological and technological achievements for the real-time prediction of quake shaking.

▲ **Lessons learned from coupled hydro-mechanical modeling of induced seismicity.**

Rinaldi A.P. (1)(2), Rutqvist J. (2), Wiemer S. (1)
(1) *Swiss Seismological Service, Swiss Federal Institute of Technology, Zurich, Switzerland*
(2) *Energy Geosciences Division, Lawrence Berkeley National Laboratory, Berkely, CA, USA*

Pressure changes caused by the direct injection/extraction of fluid at depth may produce variation in the state of stress, inducing seismicity and enhancing fluid circulation, and potentially have an impact on the sealing capabilities for storage projects. The importance of geomechanics including the potential for reactivating faults associated with large-scale underground operations has recently become more widely recognized. In this context, this contribution reviews and summarizes some recent modeling efforts, aimed at understanding the physical processes leading to induced seismicity. The simulations were conducted using simulators for coupled multiphase flow and geomechanical modeling. Several scenarios are investigated to study seismicity associated with various industrial applications (e.g. CO_2 storage, hydraulic fracturing for shale gas, geothermal exploitation, and gas production) at various scales. Results aims at discriminating the relative importance of several physical processes linked to the exploitation of deep underground resources.

▲ **Constraining families of dynamic models using geological, geodetic and strong ground motion data. Application to the Mw 6.5, October 30th, 2016, Norcia earthquake, Italy.**

Tinti E. (1)(2), Casarotti E. (2), Ulrich T. (3), Taufiqurrahman (3), Li D (3), Gabriel A.A. (3)
(1) *Università La Sapienza, Roma, Italia*
(2) *Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italia*

([3]) *Department of Earth and Environmental Sciences,Ludwig-Maximilians-Universität München, Munich, Germany*

The 2016 Central Italy seismic sequence is characterized by remarkable rupture complexity, including heterogeneous slip across multiple faults in an extensional regime. Geodetic and seismic data allow us to image intriguing details of the rupture kinematics for the main events of the sequence. Several kinematic models of the M6.5 October 30th, Norcia event, suggest multiple fault planes rupturing simultaneously, even if their mechanical viability is not guaranteed. Using 3D dynamic rupture and wave propagation simulations, we constrain "families" of spontaneous dynamic models informed by a kinematic rupture model of the event. These families differ in their parameterization of initial shear stress and strength. Models with heterogeneous dynamic parameters allow us to retrieve slip distributions similar to the target kinematic model and in agreement with seismic and geodetic observations. We discuss the consistency of the assumed static and dynamic friction coefficients with near fault rocks and their geological implications. Our approach permits to validate the viability of kinematic models and classify dynamic rupture scenarios that match observations and geological constraints.

▲ Epidemic-like description for foreshock hypothesis.

Petrillo G., Lippiello E.

Department of Mathematics and Physics, University of Campania L. Vanvitelli, Caserta, Italy

The ETAS model provides a good description of the post-seismic spatio-temporal clustering of seismicity and is also able to capture some features of the increase of seismic activity caused by foreshocks. Recent results, however, have shown that the number of foreshocks observed in instrumental catalogs is significantly much larger than the one predicted by the ETAS model. Here we show that it is possible to keep an epidemic description of post-seismic activity and, at the same time, to incorporate pre-seismic temporal clustering, related to foreshocks. Taking also into account the short-term incompleteness of instrumental catalogs, we present a model which achieves very good description of the southern California seismicity both on the aftershock and on the foreshock side. Our results indicate that the existence of a preparatory phase anticipating mainshocks represents the most plausible explanation for the occurrence of foreshocks.

▲ The era of high-resolution earthquake catalogs - What are we learning and where are the current limits?

Herrmann M., Marzocchi W.

Università degli Studi di Napoli 'Federico II'

With denser seismic networks and advanced data processing methods, observational capabilities for seismic monitoring continue to evolve; data quality is improving and the amount of recorded earthquakes is ever increasing, especially toward smaller magnitudes. This higher spatiotemporal resolution of earthquake catalogs gives us the opportunity to study seismicity in more detail. For instance, the abundance of smaller earthquakes helps us to identify previously invisible seismogenic structures, provides more clues of how earthquakes are triggered and interact, and reveals more precisely how earthquake sequences progress. High-resolution catalogs also improve the statistical representation of seismicity, allowing to better explore the variability of the magnitude-frequency distribution or the significance of foreshocks. Such new opportunities let us gain more insight into the underlying processes that drive earthquake occurrence and interaction. High-resolution catalogs can therefore help to forecast the evolution of seismicity, which supports decision making and reduces seismic risk during ongoing sequences.

▲ **Bayesian fusion: A novel approach to geophysical models integration.**
PIANA AGOSTINETTI N.
Dipartimento di Scienze dell'Ambiente e della Terra, Università di Milano-Bicocca
Defining a "complete, multi-physics model" of the Earth, i.e. its structures and its physical properties, is fundamental for advanced geophysical modelling. Here I present a novel approach, called "Bayesian fusion", where models obtained from different sources and with different levels of information are integrated in a statistical way, to define a single pool of coherent information about the Earth's interior. The novel approach solves the long-standing issue of the integration of single models of complementary physical properties. Integrating single models that (a) exploit observables displaying different depth- resolutions, (b) are based on data recorded during different surveys, and (c) are obtained using different geophysical tools, is not a trivial problem. I will show how a statistical approach to model integration can be used to obtain a coherent "weighting" of the different single models within the final "complete model" solution. Moreover, the Bayesian fusion approach also furnishes estimated of the uncertainties on the investigated parameters coherent with the input information given (i.e. the single properties models).

Aula Ida Ortalli **ore 09:30 – 13:00**

Sezione V
Biofisica e fisica medica
Presiede: Ravazzani P. (IEIIT-CNR, Torino)

Relazioni su invito

▲ **Reti neuronali ed elettroceutica.**
Tecchio F.
ISTC-CNR, Roma
Ascoltando con tecniche non invasive (elettro- e magneto-encefalografia ed elettromiografia) l'organizzazione del nostro corpo-cervello emerge un principio di funzionamento delle reti neuronali fatto di feedback, sincronia, plasticità, lo chiamerò FeeSyCy. Il principio che governa il funzionamento di ogni rete di neuroni appare pienamente nell'azione. Mettiamo di prendere la mela che ho davanti: i miei neuroni di pianificazione mandano un messaggio ai miei muscoli e contemporaneamente ne mandano una copia ai neuroni che ricevono informazioni dal mondo: quel che il nostro cervello sente è feedback: se i neuroni che mandano e quelli che ricevono si sintonizzano bene, io, con la mia mano, procedo come stavo facendo, altrimenti: mi correggo, mi adatto plasticamente. FeeSyCy, il principio di funzionamento del nostro sistema nervoso, ci insegna che siamo fatti apposta per ridurre la distanza col nostro obiettivo, nella sinergia coi sistemi ormonale e immunitario. I molti errori nella scelta dell'obiettivo, o traumi a cui non ci siamo adattati, generano disfunzioni del sistema nervoso che contrastiamo con l'elettroceutica, la cura con segnali elettrici, di cui vedremo insieme un esempio.

▲ **Combined cognitive training and non-invasive brain stimulation to counteract cognitive decline.**
Assecondi S.
Center for Mind/Brain Sciences - CIMeC, University of Trento, Rovereto, TN, Italy
Physiological cognitive decline can heavily compromise the quality of life of healthy ageing individuals. In this talk, I will describe a combined approach that exploits plasticity to counteract cognitive decline. Plasticity is the brain's ability to adapt to an increasing demand for resources, when facing a challenging environment, and we now know that the brain is capable of plasticity up to a very old age. The combination of non-invasive brain stimulation (tDCS) and cognitive training regimes has shown potential to modulate brain plasticity. My research focuses on working memory, a core cognitive function fundamental to carry out everyday activities, that allows us to store and manipulate information. In particular, I will present results in both young adults and the elderly, showing that these combined interventions are beneficial to individuals with specific cognitive profiles. I will then present how these interventions in healthy adults can be used in clinical populations. Finally, I will briefly describe some of the work we are doing to make this technology more accessible.

▲ **A multi-state Markov model predicting progression from mild cognitive impairment to Alzheimer's disease using MRI-based cortical features.**
Ficiarà E. (1), Crespi V. (2), Guiot C. (1), D'Agata F. (1), Pizzagalli F. (1)(3)
(1) *Department of Neurosciences, University of Turin, Italy*
(2) *Information Sciences Institute - ISI, AI Division, University of Southern California, CA,*

USA
(3) *Imaging Genetics Center, Mark and Mary Stevens Neuroimaging and Informatics Institute, Keck School of Medicine of USC, Marina del Rey, CA, USA*
Magnetic resonance imaging (MRI) has a potential for early diagnosis of risk for Alzheimer's disease (AD). Cognitive performance in healthy elderly people and in mild cognitive impairment (MCI) patients has been associated with cortical gyrification and thickness suggesting that sulcal shape descriptors may help predict AD-to-MCI conversion. We analyzed 400 patients from the Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset, applying a multi-state continuous Markov model to monitor their progression to the AD condition. Our preliminary results indicate that MRI-based cortical features, including sulcal morphometry, are well correlated to conversion from MCI to AD.

▲ Target identification in functional neurosurgery: A preliminary assessment of the variability of the Ventral Intermediate Nucleus through MR structural connectivity analysis from Human Connectome Project.

Collura G. (1), Borgese R. F. (1), Calamia M. (2), Midiri M. (2), Gagliardo C. (2), Marrale M. (1)
(1) *Department of Physics and Chemistry, University of Palermo*
(2) *Department of Biomedicine, Neuroscience and Advanced Diagnostics University of Palermo, Palermo, Italy*
Since the introduction of trans-cranial MR-guided Focused UltraSound surgery (tcMRgFUS), brain therapeutical lesioning (functional neurosurgery) is experiencing a new era. TcMRgfus is indeed is a non-invasive technique able to accurately and precisely induce lesions in brain for treatment of neurologic disorders, such as Essential Tremors (ET). The most common target for ET is the Ventral Intermediate Nucleus (VIM) that is not visible with traditional MR sequences. The aim of the work is to improve and speed up the VIM identification by using probabilistic tractography analysis. In particular using 100 healthy individuals from the Human Connectome Project, we have quantified target variability across this population and measured the discrepancy with atlas-defined targets. This work demonstrates significant individual anatomical variability of the VIM that atlas-based approaches fail to capture. Probabilistic tractography analysis methods seem sensitive to individual anatomical variability; these findings may form the basis for translational tools to improve THE efficacy of functional neurosurgery procedures such as tcMRgFUS.

▲ X-ray phase contrast tomography for pre-clinical studies of neurodegenerative diseases.

Palermo F. (1), Pieroni N. (1)(2), Maugeri L. (1), Begani Provinciali G. (1), Sanna A. (1), Bukreeva I. (1), Fratini M. (1), Massimi L. (1), Uccelli A. (3)(4), Kerlero de Rosbo N. (3), Cedola A. (1)
(1) *TomaLab, Institute of Nanotechnology, CNR, Rome, Italy*
(2) *Dipartimento di Morfogenesi e Ingegneria Tissutale, Sapienza Università di Roma, Rome, Italy*
(3) *DINOGMI, University of Genoa, Genoa, Italy*
(4) *Ospedale Policlinico San Martino IRCCS, Genoa, Italy*
Research in neurodegenerative diseases strongly relies on pre-clinical studies of experimental models, to disclose physiological and pathological phenomena or to test and quantify the impact of new drugs and therapeutic treatments. Recent studies suggest that the pathogenesis of neurodegenerative diseases involves other anatomical regions besides the central nervous system. We will show that X-ray phase contrast tomography (XPCT) is an excellent 3D imaging tool to investigate the complex structure of different organs and tissues —healthy

and pathological. XPCT reproduces all the morphological features visible in histological sections of comparable spatial resolution, with the further decisive advantage of imaging the samples from the organ as a whole down to the single cell, preserving tissue chemistry and structure. The ability of XPCT of generating such a highly resolved 3D multiscale image allows studying disease-related alterations in the context of and in relation to their surrounding environment, that is especially important for the study of neurodegenerative diseases.

▲ **New analysis software for β-γ coincidence technique to be applied for activity measurements of short-lived radionuclides used in nuclear medicine.**

Abubaker F. (1)(2), Tortorici F. (1)(2), Pepe F. (3), Capogni M. (4), Sutera C. (1)(2), Bellini V. (2), Corbo M. (3), De Felice P. (4)
(1) *University of Catania, Department of Physics, Italy*
(2) *INFN, Sezione di Catania, Italy*
(3) *CAEN S.p.A, via Vetraia 11, I-55049 Viareggio, LU, Italy*
(4) *ENEA, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti - INMRI, C.R Casaccia, Rome, Italy*

A new analysis software (SWA) for the β-γ coincidence technique was developed within a collaboration among the different Institutions in the affiliations. The SWA allowed to analyze data recorded by a detector based on a Triple-to-Double-Coincidence-Ratio (TDCR) device, as β-channel, and a NaI(Tl) device, as γ-channel, and equipped with a CAEN DT5720 Digitizer. The list-mode data file, containing information, namely the charge and time of both signals from the three PMTs of the TDCR and the NaI(Tl), was analyzed by the SWA and compared with an ENEA-INMRI software using a data set concerning a F-18 source measured by the detector above.

▲ **Tears as possible source of biomarkers for amyotrophic lateral sclerosis: A micro-FTIR spectroscopy study.**

Ami D. (1), Duse A. (2), Mereghetti P. (3), Cozza F. (4), Ambrosio F. (1), Ponzini E. (2), Grandori R. (1), Lunetta C. (4), Tavazzi S. (2), Pezzoli F. (2), Natalello A. (1)
(1) *Department of Biotechnology and Biosciences, University of Milano-Bicocca, Milano, Italy*
(2) *Department of Materials Science, University of Milano-Bicocca, Milano, Italy*
(3) *Bioinformatics Consultant, Arquata Scrivia, Italy*
(4) *NEuroMuscular Omnicentre - NEMO, Serena Onlus Foundation, Milano, Italy*

Amyotrophic lateral sclerosis (ALS) is a complex neurodegenerative disease, whose understanding could take advantage of a multi-disciplinary research to obtain new insights on the molecular mechanisms that underlie the pathology and to find new diagnostic markers. In fact, to date, ALS diagnosis is based on the symptoms and signs observed by a physician, along with clinical tests to exclude other mimicking pathologies. In this work, Fourier transform infrared (FTIR) microspectroscopy has been employed to explore tears as possible source of ALS biomarkers. In particular, in conjunction with multivariate analysis, this vibrational approach made it possible to discriminate between tears from healthy controls (HCs) and ALS patients, with high sensitivity and specificity. Additionally, the investigation of tears allowed to disclose specific ALS hallmarks related to lipid changes as well as an enrichment in β-sheet structures in comparison with HCs. Our findings show that vibrational spectroscopy is a new potential ALS diagnostic approach and indicate that tears are a reliable and non-invasive source of ALS biomarkers.

Aula Ada Lovelace **ore 09:30 – 13:00**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Pirri F. (Center for Sustainable Future Technologies, IIT, Torino)

Relazioni su invito

▲ **Nuovi sviluppi nella microscopia olografica digitale e le sue prospettive di applicazione.**
Ferraro P.
CNR, Istituto di Scienze Applicate e Sistemi Intelligenti, Pozzuoli, NA
Recentemente la microscopia di tipo olografico in modalità digitale si è sviluppata fino al punto da far intravedere significative possibilità applicative in diversi campi che vanno dalla medicina fino al monitoraggio ambientale. La presente relazione sarà l'occasione per illustrare e discutere in modo critico i risultati di diverse sperimentazioni in campo medico, in particolare in ambito ematologico e oncologico, per prospettive d'impiego nella citometria in flusso in configurazione microfluidica per piattaforme di tipo *Lab on Chip*. Ad esempio, di specifico rilievo sono le concrete possibilità di impiego per la ricerca e identificazione di cellule tumorali circolanti nel sangue. Questo consentirebbe di giungere allo sviluppo di una metodica completamente innovativa di "biopsia liquida" basata esclusivamente sulla identificazione di bio-marcatori morfologici che evitano l'impiego di coloranti utilizzati per marcare in modo selettivo diverse strutture subcellulari. Si illustreranno inoltre i recenti progressi per questa microscopia a contrasto di fase quantitativo ottenuti in modo congiunto a metodiche di intelligenza artificiale sia allo scopo di rendere automatica l'analisi degli ologrammi che per il potenziamento delle pratiche diagnostiche in campo clinico.

▲ **Microscopia Raman coerente per applicazioni biomediche.**
Cerullo G., Polli D., De la Cadena A., Vernuccio F.
Dipartimento di Fisica, Politecnico di Milano, Piazza L. da Vinci 32, 20133 Milano
La microscopia Raman coerente (coherent Raman scattering, CRS) è una tecnica ottica non lineare che permette l'identificazione chimica delle molecole sulla base del loro spettro vibrazionale intrinseco e trova applicazione all'imaging ad alta velocità di cellule e tessuti in assenza di marcatori. In questa relazione presenteremo diversi approcci innovativi alla microscopia CRS a larga banda, nelle modalità sia di Stimulated Raman Scattering (SRS) che di Coherent Anti-Stokes Raman Scattering (CARS). Un sistema CARS a larga banda, accoppiato a una rete neurale convoluzionale per la rimozione del background non risonante, consente di ottenere spettri Raman di tessuti con tempi di acquisizione di alcuni millisecondi. Un sistema SRS accoppiato con un amplificatore lock-in multicanale e un sistema di rivelazione bilanciato consente la misura di 32 frequenze in parallelo con tempi di acquisizione di soli 40 microsecondi per pixel. Mostreremo applicazioni di questo sistema a campioni istologici per l'identificazione e la diagnosi dei tumori.

▲ **Large-area functional and structural linear and nonlinear brain imaging.**
Pavone F.S.
LENS Università di Firenze
High-resolution microscopy methods based on nonlinear optical technique find numerous applications in brain imaging. Functional or structural information can be gained with different

implementations. In this work large-area reconstructions are obtained using a mesoscale light sheet system for structural analysis and a light sheet two-photon microscope for functional information. The mesoscale methodology developed allows analyzing the cytoarchitecture of the human brain in three dimensions at high resolution. Functional imaging has been used to investigate the whole organ, like zebrafish larval brain activity, using standard scanning or light sheet two-photon illumination. Both modalities are capable to sample the whole brain with single-cell resolution, with light sheet imaging being capable to perform high-rate volumetric imaging allowing to map in real time whole-brain calcium dynamics not affected by undesired visual stimulation artefacts, as occurring in one-photon excitation fluorescence microscopy. Large-area nonlinear imaging allows, in general, extended measurements of the neuronal activity in normal conditions, under pathological modeling of epilepsy and during visual stimulation.

▲ **Machine learning e intelligenza artificiale per l'analisi di segnali e immagini in fisica applicata.**

Bellotti R.
Dipartimento di Fisica, Università di Bari e INFN

La eccezionale disponibilità delle risorse di calcolo e di strumenti software pronti all'uso, quali ad esempio gli algoritmi di classificazione basati sul *deep learning*, proposti dalle multinazionali dell'ICT, hanno riacceso l'interesse e l'utilizzo di tali strumenti in molte comunità scientifiche, tra cui quelle della fisica applicata. In questa relazione verranno descritti alcuni strumenti di analisi dei segnali e immagini allo stato dell'arte e in particolare le tecniche note come "Explainable Artificial Intelligence" (XAI), che coniugano la velocità di elaborazione dei dati tipiche delle reti neurali con la relativa trasparenza ed intellegibilità nella interpretazione dei risultati ottenuti e la *Network Analysis*, che permette di evidenziare comportamenti cosiddetti "emergenti" nei sistemi complessi. Verranno mostrati svariati esempi di applicazione di tali tecniche in contesti di ricerca multidisciplinare e in cui le metodologie proprie della fisica sono utilizzate per studiare e comprendere sistemi biologici, economici e sociali.

▲ **Remote-sensing measurements of growth and gas exchange rates of photosynthetic bacteria under non-terrestrial conditions.**

Poletto L. ([1]), Battistuzzi M. ([2]), Cocola L. ([1]), Salasnich B. ([3]), Alei E. ([3]), Claudi R. ([3]), La Rocca N. ([2])
([1]) *CNR, Institute for Photonics and Nanotechnologies, Padova, Italy*
([2]) *Department of Biology, University of Padova, Padova, Italy*
([3]) *INAF, Astronomical Observatory of Padova, Padova, Italy*

Photosynthetic bacteria have played a fundamental role in Earth's history by enabling the rise of atmospheric oxygen. Similarly, they may play a key role in the modification of non-terrestrial atmospheres of planets in the habitable zone of stars. To understand how a non-terrestrial atmosphere can be modified by photosynthetic bacteria, simulation chambers play a pivotal role. It is here presented a system consisting of: 1) a LED-based star light simulator; 2) an atmosphere simulator chamber where cultures of photosynthetic bacteria can be exposed to different and controlled gas compositions and where the internal gas evolution is constantly monitored; 3) a reflectivity detection system to measure the normalized difference vegetation indexes. The setup allows to monitor bacteria growth and gas exchange performances under selected conditions of illumination, temperature and atmospheres, simulating non-terrestrial environments in non-solar–type stars, in particular M dwarfs. Experimental data obtained through exposing photosynthetic organisms show that cyanobacteria use far-red light for oxygenic photosynthesis, suggesting the possibility of exotic photosynthesis.

▲ A compact QCL-based quartz-enhanced photoacoustic sensor system for ammonia, methane and nitrous oxide detection.

PATIMISCO P. (1), DELLO RUSSO S. (1), KNIAZEVA E. (1), MENDUNI G. (2), SUKHINETS A. (1), SAMPAOLO A. (2), GIGLIO M. (2), PROVOLO G. (3), DINUCCIO E. (4), SPAGNOLO V. (2)
(1) *Università degli Studi di Bari*
(2) *Politecnico di Bari*
(3) *Università degli Studi di Milano*
(4) *Università degli Studi di Torino*

Simultaneous detection of ammonia, nitrous oxide and methane is an important topic in many applications, such as agriculture, environmental monitoring and breath analysis. The main advantage in employing Quartz-Enhanced Photoacoustic Spectroscopy (QEPAS) sensors is their capability to target gas species with high selectivity and detection sensitivity in extremely small volumes, reaching very high sensitivity levels. Here we report on the realization of a sensor system composed of two QEPAS modules mounted in series so that the same gas sample goes through them. Each module is composed by a gas cell containing a custom QTF with a couple of micro-resonator tubes in on-beam configuration and a QCL laser. The first laser targets two adjacent but not superimposed spectral lines of CH_4 and N_2O centered at 1275.04 cm^{-1} and 1275.49 cm^{-1}, respectively, while the second laser operates at 1103.44 cm^{-1} for NH_3 detection. At 100 ms lock-in integration time, detection limits of 23.7 ppb, 7.7 ppb and 2.4 ppb were obtained for CH_4, N_2O and NH_3, respectively, demonstrating the possibility to perform fast and accurate monitoring of these gas species starting from natural abundance concentrations.

▲ Raman and luminescence spectral imaging of paper natural degradation.

BOTTI S., BONFIGLI F., NIGRO V., RUFOLONI A., VANNOZZI A.
ENEA, FSN Department, Frascati, Italy

In this work we report a study, based on Raman and luminescence microscopy of differently degraded samples of paper, dated from 1880 to 2021. A structural evolution of the paper with ageing years has been detected through variations of the Raman and fluorescence spectra features. Raman and fluorescence maps were built contrasting spectral parameters point by point, with multi-scale spatial resolution, ranging from areas of 1 mm^2 down to the single fiber. The lack of surface compactness, consequent to the ageing, was studied with atomic force and confocal laser microscope. Quantification of the effect was evaluated through surface roughness parameter and was correlated with sample age and spectral marker values. The application of our method, which involves the use of non-destructive techniques, is of particular interest in the case of precious and ancient samples either for a better understanding of the degradation processes of historical samples or to choose the most appropriate restoration treatment.

Aula Nella Mortara **ore 09:30 – 13:00**

Sezione VII
Didattica e storia della fisica
Presiede: Gariboldi L. (Università di Milano)

Relazioni su invito

▲ **The two hemispheres of Dante's cosmos.**
Bersanelli M.
Dipartimento di Fisica, Università degli Studi di Milano
The structure of the cosmos in Dante's Commedia foreshadows a curved spatial geometry where the astronomical and angelic worlds are represented by symmetric hemispheres of what we would call, in modern terms, a 3-spherical space. We outline such unique cosmic vision and comment on a new element that supports Dante's intuition of a spherical space, namely, the temporal image described at the beginning of Paradiso XXIX (1-9). Finally, we briefly comment on the remarkable analogies, as well as on the qualitative differences, of Dante's cosmic geometry with the space-time structure of contemporary cosmology.

▲ **G.B. Riccioli, a Jesuit guide to 17th century astronomy.**
Gambaro I.
DAFIST Università di Genova
Considered one of the main opponents to the heliocentric systems G.B. Riccioli (1598-1671), astronomer, geographer and theologian of the Society of Jesus, in his Almagestum novum (Bononiae 1651) intended to harmonize tradition with new astronomical discoveries. The two volumes in folio collected all the astronomical knowledge available at the time about Sun, Earth, Moon, lunar and solar eclipses, fixed stars, planets, comets, new stars, cosmological models, trigonometry and optics, astronomical instruments, time measurements, parallax evaluation, etc. The book was widely disseminated thanks to its encyclopaedic intent and the selenography included therein. In this vast thoroughgoing synthesis the Earth's motions or rest were extensively discussed by the author, whose aim was to prove the immobility of the Earth at the centre of the world. However, Riccioli's cosmological model, a variant of the Tychonic system, was not very successful and neither were his proofs against the Earth's motions, considered nothing more than paralogisms by many of his Jesuit confrères. The salient features and contradictory aspects of this controversial figure will be outlined.

▲ **From Kepler's Supernova to the naked-eye GRB 080319B.**
Della Valle M.
INAF-Capodimonte Observatory, Salita Moiariello 16, 80131, Napoli, Italy
In my talk, I will briefly comment on the role that supernovae visible to the naked eye, namely SN 1604, SN 1987A, and GRB 080319B, have played in understanding the final stages of stellar evolution.

▲ **150 anni fa, la Società degli Spettroscopisti Italiani.**
Chinnici I.
INAF, Osservatorio Astronomico di Palermo
Il talk presenterà le circostanze storiche ed i personaggi che nel 1871 portarono alla fondazione della Società degli Spettroscopisti Italiani, la prima società scientifica dedicata all'astrofisica.

Era un tempo nel quale l'Italia primeggiava nel campo della spettroscopia astronomica, grazie ad una serie di studi pionieristici sull'analisi spettrale dei corpi celesti. Diversamente dalle società accademiche, la Società nacque attorno ad un progetto scientifico ben definito, riguardante lo studio del sole, che tuttavia non riuscì a svolgersi come previsto. Nonostante il parziale fallimento del progetto originario, la Società conseguì un notevole successo, soprattutto all'estero, grazie alla pubblicazione delle sue Memorie, antesignane delle moderne riviste di astrofisica.

▲ Galilei e il Sole: La nascita dell'imaging astronomico e la descrizione del moto delle macchie solari.

Straulino S. (1), Molesini G. (2), Righini A. (3)

(1) *Dipartimento di Fisica e Astronomia, Università degli studi di Firenze*
(2) *Già Istituto Nazionale di Ottica CNR, Firenze*
(3) *Già Dipartimento di Fisica e Astronomia, Università degli studi di Firenze*

L'avvento del cannocchiale portò un rapido e improvviso sviluppo nelle possibilità di osservare gli oggetti celesti. Ben presto lo strumento fu usato non solo per l'osservazione visuale ma anche, con qualche aggiustamento, per la proiezione di un'immagine su uno schermo. In questa modalità fu utilizzato da Galilei e da alcuni suoi collaboratori per proiettare l'immagine del disco solare su carta, con dimensioni adeguate per le osservazioni delle macchie. Abbiamo una serie preziosa di disegni del Sole con macchie, "vedute & osservate dal sig. Galileo Galilei nel mese di Giugno, e parte di Luglio 1612, giorno per giorno". Dall'analisi di questi disegni, Galilei ha potuto dimostrare che non si tratta di pianetini in orbita intorno al Sole, come qualcuno all'epoca sosteneva per non ammettere la "corruttibilità" dei corpi celesti, ma di macchie contigue alla superficie solare, che si spostano di giorno in giorno perché il Sole ruota. Nei disegni galileiani è possibile tracciare gli spostamenti delle macchie solari: a tal fine proponiamo una attività didattica significativa, utilizzabile sia per la scuola primaria, in maniera semplificata, che per la scuola secondaria.

▲ Il modello della Ricostruzione Educativa per la progettazione di sequenze didattiche. Esempi in ambito astrofisico.

Colantonio A.

Scuola di Scienze e Tecnologie, Dipartimento di Fisica, Università di Camerino, Italia e INAF-Osservatorio Astronomico di Capodimonte, Italia

Il modello della Ricostruzione Educativa è un utile riferimento per la progettazione didattica a livello internazionale, in quanto permette di sviluppare sequenze didattiche basate su idee chiave rilevanti dal punto di vista disciplinare ed epistemologico, e connette efficacemente la pratica scolastica e la ricerca in didattica mediante un processo iterativo costituito da tre fasi: 1) l'analisi del contenuto disciplinare; 2) l'analisi della letteratura sulle idee degli studenti e degli insegnanti sul contenuto scelto; 3) la progettazione e validazione dei materiali didattici. In questa relazione, dopo l'inquadramento teorico, saranno presentati esempi di sequenze didattiche progettate in ambito astrofisico (struttura ed evoluzione delle stelle, origine ed espansione dell'Universo) per affrontare argomenti curricolari di fisica sia di base che avanzati. Sarà, infine, discussa la validazione delle sequenze avvenuta nell'ambito del Piano Lauree Scientifiche.

▲ **Il pensiero sistemico e i cittadini di domani.**

Zanella S.
Facoltà di Scienze della Formazione, Libera Università di Bolzano, Italia

Per formare dei cittadini che siano in grado di essere parte attiva del sistema sociale in cui vivono, è necessario insegnare loro, fin dai primi anni scolastici, a ragionare per sistemi. È essenziale che lo studio delle scienze non sia fatto in modo mnemonico e sconnesso ma che lo studente sia guidato a cercare collegamenti negli argomenti proposti e sia aiutato a comprendere per poter apprendere a lungo termine. Lavorare sulla competenza dello studente significa quindi bilanciare le sue conoscenze e la sua capacità di muoversi tra i sistemi. Questo significa insegnare ai cittadini del futuro ad avere un pensiero sistemico.

Aula Plenarie **ore 09:30 – 13:00**

SEZIONE GIOVANI

In collaborazione con l'AISF – Associazione Italiana Studenti di Fisica

Presiede: DE DOMENICO F. (Università di Pavia)

Relazioni su invito

▲ **Dalla fisica alla BCE, passando per i cambiamenti climatici.**

PARISI L.
European Central Bank, Directorate General Macroprudential Policy and Financial Stability, Stress Test Modelling Division

Vorrei cogliere l'occasione di questo evento per concentrarmi su tre aspetti principali. In primo luogo quali *steps* ho seguito durante il mio percorso di crescita personale, educativo e professionale, e che sono stati fondamentali per approdare in Banca Centrale Europea. In secondo luogo, quali competenze e quali strumenti ho appreso durante il percorso di Laurea in Fisica e di Dottorato in *Economics and Management*, e che mi sono stati di grande aiuto in ambito professionale. Infine, vorrei focalizzare l'ultima parte dell'intervento sugli aspetti specifici del mio lavoro in termini di processo e contenuti: in generale, che tipo di lavoro tipicamente si svolge in Banca Centrale, e più in particolare, che tipo di lavoro svolgiamo io e il mio team circa l'identificazione e la quantificazione degli impatti dei cambiamenti climatici sul sistema finanziario ed economico. Molti non sanno che i cambiamenti climatici non solo rappresentano una minaccia per le condizioni di vita e abitabilità in molte parti del nostro pianeta, ma costituiscono anche una costosa minaccia per le nostre imprese, banche e società: e questo è proprio ciò di cui mi occupo coi miei collaboratori!

▲ **Measuring the gravitational constant with atom interferometry for fundamental physics test.**

ROSI G.
INFN, Sezione di Firenze

Starting from the original experiment performed by Henry Cavendish more than two centuries ago, the precision determination of the gravitational constant G remains a challenging endeavor. It has been measured about a dozen times over the last 50 years, but the results have varied much more than what would be expected from random and systematic errors. Likely, this is due to the fact that, so far, all the past experiments have relied on macroscopic classical instruments, which could all be governed by uncontrolled mechanical influences. On the other hand, a recent controversial study about correlations between the measured values of G and the variations of the length of day seems to suggest that some other not well-understood effects could be present. The MEGANTE experiment will address all these issues by carrying out precision G determinations making use of original experimental strategies based on quantum sensors. Unprecedented accuracy levels will be achieved using cold atoms in free-fall to probe the gravitational field, surpassing thus the state-of-the-art measurements based on torsion balance and simple pendulum. In parallel, MEGANTE will provide results that go far beyond the pure metrological interest. Indeed, owing to the lack of a full understanding of gravity, several theoretical models predict new physics phenomena such as violations of the inverse square law or a dependency of the G value on the local density of the matter.

▲ **The CosmicAntiNuclei project: From the proposal to the starting blocks.**
Bellini F.
Università di Bologna
The CosmicAntiNuclei project aims at shedding light on the production mechanisms of light nuclei and antinuclei in high-energy interactions. Based on precision measurements of rare antihelium production in proton-proton, proton-nucleus and nucleus-nucleus collisions with the ALICE detector at the LHC Run 3, the project will target comprehensively the modelling of light antimatter cluster formation. This is a necessary ingredient to predict the expected signal and background rates for dark matter antinuclei searches in space-borne experiments. The five-year project is funded by a Starting Grant of the European Research Council. After presenting the physics motivation and objective of the project, I will review its genesis, from the early ideas to the submission of the proposal, from the selection process to the start of the project activities in July 2021.

▲ **Technology transfer: How to bring laboratory research to the market.**
Meinardi F.
Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca
Turning academic research into a product for real-world applications is a difficult but very rewarding challenge that requires both scientific skills and entrepreneurial spirit. This contribution will review the steps taken to transform a proof of concept about the manipulation of nanomaterials to give them unconventional properties, into a transparent photovoltaic device that can be integrated without any aesthetic impact in energy-sustainable buildings. This is exactly the story of the spin-off Glass to Power which, starting from some innovative ideas and patents, has recently arrived to install its first prototypes and is now ready for entering the market of the building integrated photovoltaics (BIPV).

Aula Plenarie **ore 14:30 – 15:25**

Sezione II

Fisica della materia

Presiede: Paris M. (Università di Milano)

Relazione Generale

Coherent light and sound interactions.

Stiller B.

Max Planck Institute for the Science of Light, Erlangen, Germany

Despite their different nature, light waves and acoustic vibrations can couple efficiently through the effects of electrostriction, photo-elastic effect and radiation pressure. These phenomena enable the coherent creation and annihilation of sound waves as well as manipulation of optical signals. A particular interesting optoacoustic interaction in optical fibers and waveguides is stimulated Brillouin scattering (SBS) —a nonlinear optical process that couples the optical modes to longitudinal acoustic waves. SBS has a wide range of applications from passive mode-locking, narrow-linewidth lasers, agile radiofrequency filters, distributed sensing to versatile signal processing. The latter includes calculus operations and the storage of light information. By using traveling acoustic waves, we have recently shown proof-of-principle experiments of a Brillouin-based light memory via sound waves. It allows for the coherent storage of optical signals for several nanoseconds, simultaneous storage at multiple wavelengths, cascading of the process, as well as nonreciprocal processing with a GHz bandwidth. We also experimentally demonstrated the coherent reinforcement of acoustic waves which extends the storage time by a factor 4 that was previously fundamentally limited to the acoustic lifetime of about 10 ns. I will give an overview on these recent discoveries as well as optoacoustics in more exotic optical fibers such as CS_2-filled capillaries and twisted multi-core photonic crystal fibers.

Aula Plenarie **ore 15:30 – 16:25**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiedono: Boscolo M. (INFN, Laboratori Nazionali di Frascati)
Scamarcio G. (Università di Bari)

Relazione Generale

Dentro le opere d'arte: Tecniche neutroniche applicate ai beni culturali.

Senesi R.
Dipartimento di Fisica, Università degli Studi di Roma Tor Vergata, Centro NAST, Roma

Le indagini neutroniche sui beni culturali sono una delle applicazioni della scienza nucleare, con l'emergere di tecniche non invasive in grado di fornire evidenza sui metodi di fabbricazione, su attribuzione e provenienza, composizione atomica e molecolare di oggetti di interesse storico e artistico. Fin dai primi sviluppi della scienza nucleare, fu evidente che i neutroni liberati dalle reazioni penetrano in profondità nei materiali e, una volta posti in equilibrio termico, hanno lunghezze d'onda paragonabili alle distanze interatomiche. L'interazione dei neutroni di diverse energie e lunghezze d'onda con i materiali rende i fasci di neutroni una sonda penetrante, non invasiva e non distruttiva. Negli ultimi anni sono state potenziate le tecniche neutroniche di maggiore impatto per l'indagine dei beni culturali quali l'imaging, la diffrazione, l'attivazione, e allo stesso tempo in questo settore è stato introdotto l'uso di metodi quali la spettroscopia vibrazionale con neutroni, e l'attivazione risolta in tempo di volo, che hanno mostrato un elevato potenziale. I campi esplorati vanno dall'origine degli inchiostri usati per la scrittura, allo studio delle ossa combuste, dei materiali da costruzione, degli oggetti preistorici. Questa relazione esamina alcuni risultati recenti, e discute le opportunità di sviluppo presso infrastrutture globali, presso sorgenti compatte e infrastrutture su scala regionale nel contesto italiano e internazionale.

Aula Plenarie **ore 17:00 – 18:00**

TAVOLA ROTONDA

Physics and the green revolution

Introduce: Angela Bracco, Presidente Società Italiana di Fisica

Partecipano:
Giorgio Graditi, Direttore del Dipartimento Tecnologie Energetiche e Fonti Rinnovabili di ENEA
Rosario Corrado Spinella, Direttore del Dipartimento di Scienze Fisiche e Tecnologiche della Materia (DSFTM) del CNR
Antonio Zoccoli, Presidente dell'Istituto Nazionale di Fisica Nucleare

C'è molto fermento su come e quanto la nostra Comunità Scientifica potrà sviluppare, in termini di progettualità, sui temi di interesse per la transizione ecologica. Le Scienze Fisiche potranno certamente dare un impulso notevole all'innovazione dei processi produttivi contribuendo significativamente alla riduzione delle emissioni di gas serra.

Aula Chien Wu **ore 09:30 – 13:00**

SEZIONE I
Fisica nucleare e subnucleare
Presiede: ANTONIOLI P. (INFN, Sezione di Bologna)

Relazioni su invito

▲ Verso una strategia europea su R&D dei rivelatori per il futuro della fisica delle particelle.

COLALEO A.
Università degli Studi di Bari e INFN-Bari

Nel 2020 l'aggiornamento della strategia europea per la fisica delle particelle ha fornito delle linee guida sulla ricerca scientifica fondamentale a breve e a lungo termine. È stato evidenziato l'obiettivo di mantenere un ruolo leader dell'Europa nella ricerca della fisica delle particelle e nelle tecnologie innovative. Si richiede che gli istituti nazionali, laboratori e università mantengano una forte attenzione allo sviluppo di rivelatori, alle infrastrutture associate, allo sfruttamento delle sinergie con altri campi di ricerca e con l'industria, a beneficio della società in generale. Negli ultimi mesi, organizzata da ECFA, è stata messa a punto una roadmap per identificare un portafoglio di R&D sui rivelatori, al fine di migliorare il programma di ricerca, favorendo l'innovazione e la collaborazione con l'industria. In questa presentazione si illustra il processo in corso con particolare attenzione a R&D sui rivelatori gassosi, liquidi, calorimetria, particle identification e tecnologie emergenti.

▲ Rivelatori al silicio per misure di tempo.

DE CILLADI L. [1][2], TORNAGO M. [1][2]
[1] *Dipartimento di Fisica, Università degli Studi di Torino, Italia*
[2] *Istituto Nazionale di Fisica Nucleare, Sezione di Torino, Italia*

Negli esperimenti agli acceleratori del futuro, caratterizzati da alta densità di collisioni, l'informazione temporale sarà un requisito fondamentale per l'identificazione di particelle e la separazione delle tracce di singoli eventi. Risoluzioni temporali di decine di picosecondi possono essere raggiunte grazie a rivelatori al silicio innovativi, quali Ultra-Fast Silicon Detectors (UFSD), Monolithic Active Pixel Sensors (MAPS) basati su tecnologie CMOS e SiGe, e sensori 3D ibridi. Questi sensori trovano applicazione in progetti in cui siano previsti sistemi di tracciamento 4D e per specifiche misure di tempo di volo, e verranno utilizzati in ATLAS e CMS e nel futuro esperimento ALICE3.

▲ I tracciatori al silicio nella fisica delle particelle elementari.

ROBUTTI E.
INFN Genova

Da alcuni anni i rivelatori al silicio si sono imposti come strumenti di straordinaria precisione, affidabilità e versatilità nella realizzazione di tracciatori per gli esperimenti di fisica delle particelle. Il disegno e la realizzazione si sono evoluti in direzioni multiple, tali da soddisfare le esigenze dettate da condizioni sperimentali molto diverse tra loro. Sarà presentata una panoramica sulle tecnologie attualmente in uso, evidenziandone le prestazioni, e su quelle oggetto degli ambiziosi programmi in fase di sviluppo per affrontare le sfide degli esperimenti di prossima generazione.

▲ The Silicon-Photomultiplier: Key features and applications.

Collazuol G.
Dipartimento di Fisica ed Astronomia Università di Padova e INFN Sezione di Padova

The Silicon Photomultiplier (SiPM) is a solid-state device capable of sensing and quantifying with high accuracy light signals down to the single-photon level. Featuring large internal gain with negligible fluctuations, high intrinsic timing resolution, low-voltage operation, insensitivity to magnetic fields, high degree of radio-purity, mechanical robustness and excellent uniformity of response, the SiPM is a very attractive alternative to Vacuum and Hybrid Photomultiplier Tube devices. The review talk summarizes the present status of SiPM development by illustrating its main physics aspects. Perspectives are discussed by analyzing key technology aspects, including a comparison between digital and analog versions of the device, and by selecting the most interesting and challenging application examples.

▲ Silicon detectors in nuclear physics: Challenging resolution and particle identification.

Piantelli S. (1), La Cognata M. (2)(1)
(1) *INFN, Sezione di Firenze, Sesto F.no, FI*
(2) *INFN-LNS, Catania*

Silicon detectors have been playing a key role in nuclear physics experiments for many years, thanks to properties such as the large amount of charge carriers formed following the passage of ionising radiations. They have been adapted to many applications thanks to their flexibility. High-resolution position sensitivity was achieved by segmentation, reaching micrometer pitch. The possibility to stack them into multilayer systems made it possible to carry out particle identification exploiting the dependence of the energy loss on charge and mass of the impinging particles. The use of digital electronics and the development of high-homogeneity doping procedures (such as neutron transmutation) allow to identify particles by means of pulse shape analysis technique, leading to lower detection thresholds. In this presentation we will review the main applications of silicon detectors, focusing in particular on the most recent developments on particle identification, following the recent work by Badala *et al.*, submitted to *Rivista del Nuovo Cimento*. Some hints concerning solid state detectors with more radiation hardness than silicon, such as SiC, will also be presented.

▲ Sviluppo e produzione dei rivelatori di radiazioni: esperienze e prospettive per un filiera italiana.

Paternoster G.
Fondazione Bruno Kessler, Trento, Italy

La maggior parte dei moderni strumenti e grandi esperimenti di fisica contengono una complessa rete di sensori a stato solido, tipicamente in silicio. Il percorso, che dal concepimento di un nuovo sensore porta alla sua produzione, è un processo complesso che coinvolge diverse professionalità, che spaziano dalla ricerca di base, alle nuove micro e nano tecnologie, e alla necessità di governare anche la produzione in volumi. FBK dai primi anni 2000 è entrata in questo ciclo virtuoso grazie alla collaborazione strategica con INFN, e negli anni più recenti con INAF. La complementarietà delle competenze in gioco ha consentito l'affermarsi di un modello di collaborazione equilibrato capace anche, quando necessario, di allargare la filiera ad altre realtà industriali di diversa dimensione. Grazie anche a questo, l'Italia ricopre oggi un ruolo di primaria importanza a livello internazionale nel campo. In questo contributo si presenteranno le ultime rilevanti esperienze di ricerca, sviluppo e produzione di rivelatori in silicio per esperimenti di fisica, e si discuterà delle prospettive future della tecnologia e dell'industria dei rivelatori in silicio in Italia.

Aula Cornelia Fabri **ore 09:30 – 13:00**

Sezione II
Fisica della materia
Presiede: Palma M. (Università di Palermo)

Relazioni su invito

▲ **Device-independent certification of quantum protocols.**

Agresti I. (1), Poderini D. (1), Mancusi M. (1), Carvacho G. (1), Polacchi B. (1), Suprano S. (1), Polino E. (1), Guerini L. (2), Aolita L. (3), Cavalcanti D. (4), Bowles J. (4), Chaves R. (5), Supic I. (6), Sciarrino F. (1)
(1) *La Sapienza, University of Rome, Italy*
(2) *International Center of Theoretical Physics, Sao Paulo, Brazil*
(3) *Universidade Federal do Rio de Janeiro, Brazil*
(4) *Institute of Photonic Sciences, Barcelona, Spain*
(5) *International Institute of Physics, Natal, Brazil*
(6) *Université de Genéve, Switzerland*

The design of new technologies based on quantum effects, within the last years, has impacted a great variety of fields. For this reason, it is crucial to be endowed with techniques to distinguish devices that display a quantum resource-based functioning from those that do not. To tackle this non-trivial task, it is convenient to rely only on input/output statistics, without the need of a perfect knowledge of the inner functioning of the device, since this may be hard to verify or unknown to the user. This approach, called device-independent, is typically based on the quantum violation of Bell inequalities. However, it is pivotal to take a step further and study different processes, especially in view of the realization of large quantum communication networks. In such a context, this talk deals with the design and implementation on photonic platforms of device-independent protocols for alternative venues, with respect to Bell's one. At first, we consider the so-called instrumental process, featuring an unknown state shared by two parties, linked by a classical channel. Then, we study basic quantum networks' instances, equipped with two independent quantum state sources.

▲ **Exploiting quantum frequency correlations: The metrology of ghost spectrometry.**

Gianani I. (1), Chiuri A. (2), Cimini V. (1)(3), De Dominicis L. (2), Genoni M. (4), Barbieri M. (1)(5)
(1) *Università degli Studi Roma Tre, Roma, Italy*
(2) *ENEA - Centro Ricerche Frascati, Frascati, Italy*
(3) *Sapienza Università di Roma, Roma, Italy*
(4) *Università degli Studi di Milano, Milano, Italy*
(5) *Istituto Nazionale di Ottica-CNR, Firenze, Italy*

Encoding information in the time-frequency domain demonstrates its potential for quantum information processing. It offers a novel scheme for communications with large alphabets, computing with large quantum systems, and new approaches to metrology. Frequency correlations are a versatile tool that can be exploited to enable the spectral analysis of objects where a direct measurements would not be feasible, through the so-called ghost spectrometry. The advantages that are brought forward by this approach are numerous, however they

come at the cost of performing a complete state characterisation in the spectral domain, a task already demanding in the classical regime. In this talk we will explore these two aspects, discussing the challenges posed by the characterisation of time-frequency states on the one hand, and the metrological advantage achievable in ghost spectrometry through the use of quantum frequency correlations on the other. We will explore the comparison between a quantum and a classical ghost spectrometer, discussing the estimation of the transmittivity of a bandpass filter performed with frequency-entangled photon pairs.

▲ **Metrology for Quantum Communication: Results and perspectives of the EURAMET European Metrology Network for Quantum Technologies.**

Degiovanni I. P. (1)(2), Gramegna M. (1)(2)
(1) *INRIM, Istituto Nazionale di Ricerca Metologica, Turin, Italy*
(2) *European Metrology Network for Quantum Technologies - EMN-Q*

A group of European National Metrology Institutes (NMIs) have recently created a European Metrology Network for Quantum Technologies (EMN-Q) under the auspices of EURAMET. The objective of the EMN-Q is to co-ordinate the activities of the European NMIs to ensure their efficient support for European competitiveness in quantum technologies. A special focus of the EMN-Q will be to develop new measurement capabilities and dedicated services to serve the rapidly-growing needs of industry and research institutions in this field. In this talk, I will provide a short overview of the EMN-Q organization. Afterwards, I will focus on Quantum Key Distribution (QKD) and how the EMN-Q has started to answer to the metrology needs of the QKD community. Specifically, European NMIs have already carried on activities for assessing QKD and its components, so that we better understand how QKD components, and new types of QKD which are in principle more robust to attacks, perform in an adversarial environment. A transformation of these results into a reliable, efficient and market-oriented metrological approach is necessary for maintaining the leading role of Europe in the quantum communication field.

▲ **Non-Gaussian continuous variables quantum networks.**

Parigi V.
Laboratoire Kastler Brossel, Sorbonne Université

Large multipartite Continuous Variables (CV) quantum states are easy to characterize as far as the measurement statistics of quadratures is Gaussian. Although they are essential resources for CV quantum technologies, non-Gaussian statistics is required for reaching a quantum computational advantage. Non-Gaussianity can be induced via local operations. When the number of involved optical mode and non-Gaussian operations are large enough, these systems are hard to benchmark in theory, to test experimentally, and they can even be hard to sample. I will speak about the experimental challenges on producing such states, theoretical benchmarks based on complex network theory and machine learning technique for the experimental detection of Wigner negativity.

▲ **Continuous variables entanglement in OAM beams.**

Porzio A.
CNR - SPIN, Napoli

In the last decades or so orbital angular momentum (OAM) has gained attention as an extra degree of freedom (d.o.f.) for classical as well as quantum communication purposes. Indeed, it allows accessing high-dimensional Hilbert spaces and this has proven to enhance both information transmission and security in communications in radically different contexts. The possibility of tailoring the spatial profile in co-propagating beams paves the way to spatial multiplexing, in classical as well as quantum communication regimes, if the detection stage is able to discriminate different OAM in a reconfigurable manner. Here we illustrate the manipulation and detection strategies that led to the first direct detection of CV entanglement among OAM carrying beams. Both manipulation and detection make use of q-plates: a liquid crystal device able to convert ordinary polarised Gaussian beams into OAM beams. We also discuss the peculiarities of a balanced homodyne receiver used in the experiment and designed to discriminate between OAM modes. In particular, we describe its sensitivity to the analysed misalignments.

▲ Quantum decay at short, intermediate, and long times: Observation in integrated photonics.

Pepe F.V. ([1])([2]), Crespi A. ([3])([4]), Facchi P. ([1])([2]), Sciarrino F. ([5]), Mataloni P. ([4])([5]), Nakazato H. ([6]), Pascazio S. ([1])([2]), Osellame R. ([3])([4])
([1]) *Università degli Studi di Bari, Dipartimento Interateneo di Fisica, Bari, Italy*
([2]) *INFN - Sezione di Bari, Bari, Italy*
([3]) *Politecnico di Milano, Dipartimento di Fisica, Milano, Italy*
([4]) *Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Milano, Italy*
([5]) *Sapienza Università di Roma, Dipartimento di Fisica, Roma, Italy*
([6]) *Waseda University, Department of Physics, Tokyo, Japan*

The decay of an unstable system is usually described by an exponential law. However, quantum mechanics generally predicts deviations from the exponential: the quantum survival probability is characterized by an initial regime of quadratic decrease, while at large times it must follow, in a very wide range of physical systems, a power law with possible superimposed oscillations. The latter regime is particularly elusive, as its onset commonly occurs when the survival probability is heavily depleted. We describe a hopping model on a semi-infinite array, in which we analyze the quantum decay of an initial state in which only the first site is populated. We show that the model parameters can be tuned in order to enhance the relevance of the power-law decay regime. We report the experimental observation of the decay dynamics in arrays of parallel single-mode optical waveguides, fabricated by femtosecond laser direct inscription, in which the quantum temporal evolution is mapped into the longitudinal propagation coordinate. We finally comment on the features of state propagation in the array, highlighting the behavior of wavefronts and the relation with the Lieb-Robinson bound.

▲ Nonlinear and quantum optics in confined photonic systems.

Gerace D.
Dipartimento di Fisica, Università di Pavia

I will review our recent efforts to enhance optical nonlinearities of conventional semiconductors materials by exploiting the electromagnetic radiation confinement in nanostructured photonic media, such as photonic crystal cavities. In particular, I will focus on enhanced harmonic generation from passive dielectric materials, such as silicon or III-nitrides, and discuss the role of peculiar solutions of Maxwell equations such as bound states in the continuum which has allowed to demonstrate doubly resonant second harmonic generation in a GaN photonic crystal cavity for the first time. Finally, I will show the perspectives of these results in view of quantum optical applications, such as the generation of quantum states of electromagnetic radiation exploiting only material nonlinearities.

Aula Margherita Hack **ore 09:30 – 13:00**

SEZIONE III
Astrofisica
Presiede: CARUSO R. (Università di Catania)

Relazioni su invito

▲ **Raggi cosmici carichi, introduzione e misure da terra.**
BUSCEMI M.
INFN - Sezione di Catania
In questo contributo sono analizzate le principali proprietà della componente carica dei raggi cosmici nella regione energetica che va da 10^{14} eV fino alle più alte energie. In questo range energetico, i raggi cosmici possono essere studiati solo indirettamente, sfruttando gli sciami di particelle prodotti dalla loro interazione con l'atmosfera. Dopo una breve introduzione sugli sciami e le tecniche di misura, sono descritte le strumentazioni impiegate nella rilevazione dei raggi cosmici da terra ed è presentata una selezione dei più recenti risultati scientifici ottenuti da alcuni esperimenti. Infine vengono mostrate le prospettive future nel campo della fisica dei raggi cosmici.

▲ **Futuro prossimo e remoto nella rivelazione diretta dei Raggi Cosmici nello Spazio.**
DURANTI M.
INFN - Sezione di Perugia
L'esperienza acquisita con la corrente generazione di esperimenti per la rivelazione diretta di Raggi Cosmici nello Spazio (AMS-02, PAMELA, Fermi-LAT, DAMPE, CALET, ...) sta guidando il disegno della prossima generazione di rivelatori, sia da lanciare ed operare nello spazio nell'immediato futuro (HERD sulla Stazione Spaziale Cinese), sia da progettare e eventualmente costruire per il lancio e l'operazione nello Spazio nella seconda metà del secondo (ALADIno e AMS-100 nel Punto Lagrangiano Terra-Sole L2). Le idee alla base degli apparati, il loro disegno e le tecnologie che si pensa di utilizzare, verranno discussi brevemente.

▲ **Gamma-ray astronomy: An introduction and ground-based measurements.**
BONNOLI G.
Instituto de Astrofisica de Andalucia - Granada, Spain e Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Italy
The field of gamma-ray astronomy merges fruitfully approaches and techniques at the crossroads of astronomy and particle physics. It has undergone astonishing developments and refinements in the last three decades, moving steadily from the initial stage of a territory populated of ambitious experiments towards a landscape of proper observatories. This evolution is still in progress and will bring current and future instruments to play a crucial role in contributing, together with a wealth of information coming from other bands of the electromagnetic spectrum and other messengers, to tackle long-standing, important open topics at the intersection of astrophysics, particle physics, cosmology and fundamental physics. Both satellite-borne and ground-based gamma-ray detectors join these endeavours, with the latter extending their sensitivity to the highest energies and providing remarkably large collection areas. After a brief general introduction to the field, I will focus on ground-based detectors and their operating principles. Thereafter I will review the status and future perspectives of these instruments, with glimpses to the multi-wavelength and multi-messenger context.

▲ Constraints on the antistar fraction in the Solar System neighborhood from the 10-year Fermi-LAT gamma-ray source catalog.

Tibaldo L., Dupourqué S., von Ballmoos P.
IRAP - Université de Toulouse, CNRS, UPS, CNES

It is generally taken for granted that the Universe does not contain antimatter domains. Recently, the possible detection of anti-helium by AMS-02 challenged this idea and reopened the debate on the existence of nearby reservoirs of antimatter, most plausibly in antistars. As antimatter domains surrounded by normal matter would produce a gamma-ray signal from baryon-antibaryon annihilation, we use the 10-years Fermi-LAT gamma-ray source catalog to set constraints on the abundance of antistars in our local galactic environment. We identify 14 antistar candidates not associated with any object belonging to established gamma-ray source classes and featuring spectra compatible with baryon-antibaryon annihilation. We evaluate the sensitivity of the LAT to antistars and set upper limits on the local antistar fraction. For antistars with properties similar to those of disk-population stars we derive constraints that are 20 times stronger than those previously available. For a primordial population of antistars in the galactic halo, gamma-ray data combined with microlensing observations constrain the density of antistars to less than 10^{-5}–10^{-2} pc^{-3} depending on their masses.

▲ La missione LIMADOU sul satellite cinese CSES: Risultati e obiettivi futuri.

Mergè M.
INFN Roma2

La missione CSES-LIMADOU è frutto di una collaborazione internazionale tra Cina e Italia, dedicata a monitorare le perturbazioni originate da emissioni elettromagnetiche e particellari nella ionosfera, magnetosfera e nelle fasce di Van Allen, e a investigare possibili correlazioni con eventi sismici tramite una costellazione di satelliti LEO. La collaborazione italiana, denominata LIMADOU, ha contribuito a realizzare il rivelatore High Energy Particle Detector (HEPD-01) a bordo del satellite CSES-01, sulla base di una pluridecennale esperienza nella realizzazione di rivelatori spaziali di particelle cariche e raggi gamma dell'Istituto Nazionale di Fisica Nucleare (INFN). Il rivelatore HEPD, grazie all'ampio range energetico per protoni, elettroni e nuclei leggeri, permette —oltre allo studio di particelle intrappolate nelle fasce di Van Allen— di estendere il campo di interesse anche ad eventi solari (Space Weather) e alla fisica dei raggi cosmici galattici. Il satellite CSES-01 è stato lanciato il 2 febbraio del 2018 dal Jiuquan Satellite Launch Center e ha concluso le operazioni di commissioning nell'agosto dello stesso anno. Da allora sono stati raccolti i dati dei payload del satellite presso lo Space Science Data Center dell'Agenzia Spaziale Italiana dove sono stati distribuiti a tutti i gruppi di ricerca afferenti. In questo talk verranno presentati lo stato della missione, dei payload, i principali risultati della missione e gli obiettivi futuri, che comprendono il lancio del secondo satellite CSES-02 previsto al momento per l'inizio del 2023.

▲ Nuove prospettive per l'astronomia X nello spazio.

Manfreda A.
Istituto Nazionale di Fisica Nucleare, Pisa, Italia

Nel prossimo decennio, nuove tecniche di misura per il timing e la polarimetria dei fotoni renderanno possibile lo studio della materia in condizioni estreme di densità e magnetismo, tramite l'osservazione dallo spazio di sistemi come buchi neri, pulsar e magnetar. In particolare, già alla fine di quest'anno, la missione NASA IXPE (Imaging X-Ray Polarimetry Explorer), porterà in orbita tre rivelatori a gas di nuova concezione, i Gas Pixel Detector, inventati e realizzati in Italia, consentendo per la prima volta la misura della polarizzazione di decine di sorgenti nella banda degli X soffici. Al tempo stesso, è allo studio la prossima generazione di questa tecnologia per la missione multistrumento eXTP (enhanced X-ray Timing and Polarimetry), attualmente in fase avanzata di progettazione. A bordo di eXTP, quattro telescopi dedicati alla polarimetria si affiancheranno, assieme a strumenti dedicati alla spettroscopia e al monitoraggio a largo campo del cielo, al LAD (Large Area Detector), un rilevatore che, combinando un'elevatissima area efficace con un'eccellente risoluzione temporale, consentirà misure di timing con una sensibilità senza precedenti.

▲ **Polarized emission from strongly magnetized sources.**

Taverna R., Turolla R., Zane S., Suleimanov V., Potekhin A., Gonzalez Caniulef D.
Dipartimento di Fisica e Astronomia - Università degli Studi di Padova

Anomalous X-ray pulsars (AXPs) and Soft gamma repeaters (SGRs) form together a single class of astrophysical sources which are commonly associated to magnetars, *i.e.*, neutron stars endowed with ultra-strong magnetic fields. New-generation X-ray polarimeters, like IXPE (a NASA SMEX mission) and eXTP (Chinese Academy of Science) to be flown soon, will play a key role in assessing the nature of these sources by directly probing the star magnetic field. In fact, in the highly magnetized environment radiation is expected to be strongly polarized and such a measure will be easily within the reach of IXPE and eXTP. Polarization measurements will eventually confirm the presence of ultra-strong magnetic fields, probing the magnetar scenario. In this talk I will discuss theoretical expectations, within the magnetar scenario, for the polarization signature of AXPs and SGRs and present numerical simulations for the detector response of the polarimeters currently under construction. I will also show how these sources can be used to test vacuum birefringence, a QED effect predicted by Heisemberg and Euler in the Thirties and not experimentally verified as yet.

▲ **The NUSES space mission.**

Di Santo M. on behalf of the NUSES Collaboration
Gran Sasso Science Institute, 67100, L'Aquila e INFN Laboratori Nazionali del Gran Sasso, Italia

NUSES is a new space mission project promoted by the Gran Sasso Science Institute (GSSI), with Thales Alenia Space and several INFN groups. The mission is intended as a pathfinder to test new technologies and observational approaches for the study of low- and high-energy cosmic radiation. Two scientific payloads will be hosted onboard the satellite. The first one, called Terzina, will test a new approach for the detection and study of very high-energy cosmic rays and astrophysical neutrinos, through the observation of Cherenkov light emitted in the atmosphere. The second payload, called Zirè, will detect low-energy electrons, protons and nuclei to monitor and study particle fluxes and their short-time perturbations induced by solar and terrestrial phenomena. A low-energy gamma-ray detector will also be hosted by Zirè for the study of stable and transient astrophysical sources. Novel detector solutions will be adopted and tested in space environment. As an example all the light signal readout will be done by using arrays of silicon photomultiplier and dedicated electronics.

Aula Inge Lehmann **ore 09:30 – 13:00**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Bonadonna C. (University of Geneva, Switzerland)

Relazioni su invito

▲ **The European Ground Motion Service: Characteristics and products.**

Solari L. (1)(2), Andersen H.S. (2)
(1) *Centre Tecnològic de Telecomunicacions de Catalunya, Geomatics Division, Av. Gauss, 7,E-08860 Castelldefels, Spain*
(2) *European Environment Agency, Kongens Nytorv 6, 1050 Copenhagen, Denmark*

Multi-temporal satellite interferometry (MTInSAR) can provide precise measurements of ground motion, including natural and anthropogenic phenomena such as landslide, subsidence and volcanic activity. MTInSAR is the technique applied to process C-band Sentinel-1 images in the framework of the European Ground Motion Service (EGMS), the newest addition to the Copernicus Land Monitoring Service. The EGMS will provide free and open interferometric products covering the Copernicus Participating States. Three products are foreseen: basic (L2a), LOS velocity maps in ascending and descending orbits, calibrated (L2b), L2a calibrated with a geodetic reference network and ortho (L3), components of motion anchored to the reference geodetic network. The baseline delivery is expected Q1 2022 with subsequent annual updates.

▲ **Investigation of natural hazard events and support to disaster risk reduction using Italian radar satellites.**

Tapete D.
Agenzia Spaziale Italiana - ASI

COSMO-SkyMed is the Italian Space Agency (ASI)'s excellence Earth Observation space asset using X-band high resolution Synthetic Aperture Radar (SAR) sensors. Short revisit time up to 1 day, spatial resolution up to 1 m, interferometric capabilities and the ever-growing image catalogue are among the key properties making this constellation suitable to both investigation of natural hazard events and long-term environmental monitoring. The present paper will showcase scientific research experiences in the framework of the Committee on Earth Observation Satellites (CEOS), where COSMO-SkyMed was exploited to observe the recovery phase after a catastrophic hurricane and detect otherwise-unknown floods.

▲ **Combining Hyperspectral and thermal data acquired by satellites and drones on geothermal active areas.**

Buongiorno M.F., Silvestri M., Musacchio M., Rabuffi F., Romaniello V., Marotta E., Caputo T., Bellucci Sessa E., Belviso P., Avvisati G.
Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

The study of thermal and spectral characteristics of natural surfaces is very important to understand both the geophysical phenomena and their interaction with environment. Combining hyperspectral and thermal data acquired at different scales using remote sensing techniques and sensors (proximal, drones, airplane, satellites) permits to acquire different information on active geothermal areas as the variation of temperatures in the daytime and nighttime, spectral emissivity and reflectance of exposed surfaces and possibly detect gas species from fumaroles emissions. Moreover it is possible to study the effect of the presence of the hot fluids and gas that circulated in soils on vegetation.

▲ Investigating active volcanism from infrared satellite imagery: The role of multi-temporal, multi-spectral and multi-mission approaches in the Open Data era.

Pergola N. (1), Falconieri A. (1), Genzano N. (2), Marchese F. (1), Mazzeo G. (1), Tramutoli V. (2)
(1) *Istituto di Metodologie per l'Analisi Ambientale, Consiglio Nazionale delle Ricerche*
(2) *Scuola di Ingegneria, Università degli Studi della Basilicata*

Every year about 50-70 active volcanoes erupt on average, posing a serious threat at both local and global scale. Systems capable of guaranteeing a continuous and efficient monitoring of the aforementioned phenomena are then fundamental to survey and mitigate volcanic risk. Several studies have shown the significant contribution satellite systems may provide for investigating and monitoring active volcanoes, also in well-monitored areas. Here, different original approaches based on multi-temporal, multi-spectral and multi-mission techniques proposed to investigate volcano thermal features from space are presented, discussing main advantages and possible drawbacks. The algorithms rationale and physical background are described, together with some recent results achieved on different volcanoes worldwide. Finally, the possible added-value coming from integrating different sensors and techniques, complementing temporal and spatial resolutions in the Open Data era, is discussed.

▲ Assessing impacts of groundwater resource exploitation on urban landscapes in Mexico with space geodesy.

Cigna F.
Institute of Atmospheric Sciences and Climate, National Research Council, Rome, Italy

Exploitation of groundwater resources in excess of natural recharge may cause aquifer depletion, land subsidence and cascading effects and impacts, e.g. ground faulting and fissuring, damage to infrastructure (housing, transport and utility networks) and increase in flood risk. These are very common in central Mexico, induce significant economic loss, and are key concerns for local inhabitants, authorities and stakeholders. Space geodesy, through long-term satellite InSAR surveys and GNSS/GPS monitoring, is exploited in this work to estimate magnitude, extent and evolution of such impacts in several major cities, and assess risk for urban landscapes, infrastructure and population.

▲ Total Variometric Approach, a new tool for tsunami genesis estimation.

Crespi M. (1), Ravanelli M. (1), Occhipinti G. (2)
(1) *Sapienza University of Rome*
(2) *Université de Paris - Institut de Physique du Globe de Paris*

The Total Variometric Approach (TVA) methodology was conceived to contribute to the fully understanding of the physics and detectability of tsunami genesis by GNSS ionospheric monitoring and to support tsunami warning systems. TVA is based on the joint application of VADASE (Variometric Approach for Displacements Analysis Standalone Engine) and VARION (Variometric Approach for Real-time Ionosphere ObservatioN) and allows for the simultaneous estimation of ground shaking, coseismic displacements and ionospheric total electron content (TEC) disturbances, using the same real-time GNSS data stream. In particular, the high spatial resolution of the GNSS-TEC observations enables to map the earthquake source extent in real time: this feature represents the key point in the tsunami genesis estimation. TVA can also rely on the ionospheric information coming from geostationary satellites, ship-based GNSS receivers and dual-frequency smartphones. The TVA methodology are in the process of being applied into the GNSS network of the IPGP Observatoire Volcanologique et Sismologique de Guadeloupe in the Caribbean to create the first TVA-based pilot system.

▲ **Seismic strain accumulation and release in the Apennines.**

D'Agostino N.
Istituto Nazionale di Geofisica e Vulcanologia, Roma

Tectonic strain is released episodically by earthquakes and by aseismic fault slip, implying a sort of budget that must be balanced over some time period. What could control such a budget? Over what time interval is the budget due? In this presentation I will describe this balance and discuss its implications using geodetic measurements of tectonic deformation and the record of historical earthquakes from the Apennines. Suggestions that tectonic strain along a 400 km section is nearly balanced by earthquakes come from comparisons of seismologically and historically observed earthquake with rates of strain accumulation estimated from geodetic data. Within the considered section the "balance" yields an average recurrence interval of 30-75 years for events with magnitude larger than 6.5 without requiring a future earthquake larger than those observed historically. A minimum estimate of unreleased tectonic strain in the last 500 years, allows events larger than 6.9 and 6.5 to be released in 35 and 10% of the central-southern Apennines, respectively. Are these regions overdue for actual large earthquakes? What is the probability of observing a given amount of unreleased strain?

Aula Ida Ortalli **ore 09:30 – 13:00**

SEZIONE V
Biofisica e fisica medica
Presiede: TORRICELLI A. (Politecnico di Milano)

Relazioni su invito

▲ **Interazione delle onde elettromagnetiche con i sistemi biologi: Valutazione dei livelli di esposizione in nuovi scenari espositivi.**

RAVAZZANI P., PARAZZINI M., TOGNOLA G.
Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni, IEIIT - Consiglio Nazionale delle Ricerche, Torino

La conoscenza dei livelli delle grandezze elettromagnetiche dovute all'esposizione delle persone alle onde elettromagnetiche è da sempre uno aspetto cruciale nella valutazione del possibile loro impatto sulla salute. Questo per quanto concerne sia la diffusione di tali onde nell'ambiente, sia la dose assorbita da organi e sistemi specifici (dosimetria). Questi studi assumono sempre più importanza, tenendo conto dell'introduzione di nuovi scenari espositivi legati a tecnologie emergenti, quali il 5G, la più recente generazione per le telecomunicazioni, e i sistemi wireless già installati nelle auto di nuova concezione che permettono il "dialogo" fra le auto, con le infrastrutture delle strade, e per la gestione di funzionalità di controllo avanzate all'interno dei veicoli stessi. In questo contributo verranno presentati i risultati relativi all'applicazione di tecniche di bioelettromagnetismo computazionale per la stima dei livelli delle grandezze elettromagnetiche in modelli di sistemi ed organi umani, generate sia da sistemi 5G che da sistemi wireless installati a bordo di autovetture.

▲ **Particle tracking in the FOOT experiment.**

ZARRELLA R. FOR THE FOOT COLLABORATION
Department of Physics and Astronomy, University of Bologna, INFN - Section of Bologna, Italy

FOOT (FragmentatiOn Of Target) is an applied nuclear physics experiment aiming to perform high-precision cross-section measurements for nuclear fragmentation processes for particle therapy applications and radioprotection in long-term space missions. The apparatus is currently under development and will consist of three main regions: an upstream region, dedicated to primary beam characterization, a silicon magnetic spectrometer, which performs particle tracking, and a downstream region, dedicated to fragment identification. A Kalman filter based tracking algorithm is developed in order to reconstruct the fragments trajectory and measure their momentum. It is tested on FLUKA Monte Carlo simulations in order to evaluate its performances in terms of particle identification efficiency and momentum resolution. The results show that the algorithm can fulfill our experimental requirements, providing momentum measurements with an accuracy of about 4% and efficiencies close to 1 on all fragments heavier than ^{4}He. The MC results with different algorithm tuning will be presented, together with the first application on acquired data.

▲ **Internal Bremsstrahlung: A process to be considered for a realistic study of exposure to high-energy beta emitters.**

AUDITORE L. (1), AMATO E (1)(2), JUGET F. (3), ITALIANO A. (2)(3), PISTONE D. (3)(4), NEDJADI Y. (3), GNESIN S. (3)
(1) *Section of Radiological Sciences, Department of Biomedical and Dental Sciences and Morphofunctional Imaging, University of Messina, Italy*

([2]) *INFN, National Institute for Nuclear Physics, Section of Catania, Italy*
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([4]) *MIFT Department, University of Messina, Italy*

A process usually neglected in the Beta decay is the Internal Bremsstrahlung (IB), a weak continuous energy electromagnetic radiation associated with Beta emission. Despite this phenomenon is not kept into account in the conventional estimate of the absorbed dose due to the exposure to beta emitter radionuclides, we recently found that such contribution appears worthy of consideration. We implemented different models for the IB spectral distribution in Monte Carlo (MC) codes to simulate the absorbed dose whether or not the IB photon emission is present. Then, at the Institute of Radiation Physics (IRA) in Lausanne, we carried out radiometric measurements aimed at identifying the most proper spectral distribution, by comparing MC simulations with experimental results for high-energy beta emitters such as ^{90}Y and ^{32}P. These studies show that the inclusion of IB photons allows achieving a reasonable agreement with measurements, indicating the most reliable model to adopt for the IB spectral distribution, and also confirming the need to include this process in MC simulations.

▲ Denoising and dose reduction techniques for positron emission tomography.

Presotto L. ([1]), De Bernardi E. ([2]), Bettinardi V. ([1])
([1]) *Servizio di Medicina Nucleare, IRCCS Ospedale San Raffaele, Milano, Italia*
([2]) *Dipartimento di Medicina e Chirurgia, Università di Milano Bicocca, Monza, Italia*

In positron emission tomography (PET) image quality (IQ) and quantitative accuracy (QA) are constrained by the number of events that can be collected at clinical scan durations/radiation activity. Recent technological improvements are represented by better detector hardware (timing and energy resolution), reconstruction algorithms, and artificial intelligence based image denoising algorithms. All of this can be exploited to minimize radiation dose given to the patient while maintaining or improving IQ and QA. In this talk, we will review the novel developments in hardware and software PET technologies as well as the deep learning strategies for image denoising and dose reduction.

▲ A new biology-based mathematical model for radiation cell survival.

Nicotra A. ([1])([2]), Russo G. ([3])([4]), Strolin S. ([5]), Strigari L. ([5]), Borasi G. ([6])
([1]) *Physics and Astronomy Department, University of Catania, Italy*
([2]) *Sicilian Center for Nuclear Physics and Structure of Matter - CSFNSM, Catania, Italy*
([3]) *Institute of Molecular Bioimaging and Physiology, National Research Council - IBFM-CNR, Cefalù, Italy*
([4]) *National Laboratory of South, National Institute for Nuclear Physics - LNS-INFN, Catania, Italy*
([5]) *Medical Physics Department, IRCCS Azienda Ospedaliera Universitaria di Bologna, Italy*
([6]) *Department of Medicine and Surgery, University of Milano Bicocca, Milano, Italy*

Cornerstone of modern radiobiology is the linear-quadratic model. It assumes that the cell survival level is determined by two exogenous radiation killing phenomena. Conversely, several radiobiological experiments demonstrate that the main processes following the radiation absorption are direct killing (exogenous process) and counteracting internal recovery (endogenous process). The new model, applied to a dataset of forty-two experimental high-quality survival curves by adopting several statistical indexes, overcomes the linear-quadratic experimental drawbacks in both low and high dose ranges. It favourably compares with a dozen of previously proposed models and allows to reconstruct the radiobiology building on an energetically correct basis.

▲ Lung cancer induction risk comparison between standard and hypo fractionated treatments for breast cancer.

D'Anna A. (1), Bonanno E. (3)(4), Borzì G. (3), Cavalli N. (3), Gueli A. M. (1)(2)(4), Marino C. (3)(4), Stella G. (1)(3)(4)
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(4) *Medical Physics Specialty School, Department of Physics and Astronomy "Ettore Majorana" and Department of Medical, Surgical Sciences and Advanced Technologies "G. F. Ingrassia", University of Catania, Italy*
Breast treatments using high therapeutic doses may be associated with an excess risk for second cancer induction in adjacent critical organs related to some parameters. These are the patient's age at the time of exposure (agee) and attained age (agea), slope of the dose-response relationship at low doses, A-bomb survivors data, and other regional dependent statistical data as free cancer risk time interval of 5 years, and probability of a healthy to survive from agee to agea. The aim of this study was to estimate the patient-specific Lifetime Attributable Risk (LAR) for developing secondary malignancies to the ipsilateral lung from Standard Fractionated (SF), 2 Gy $\times$ 25 fractions, and HypoFractionated (HF), 2.66 Gy $\times$ 16 fractions, 3D-CRT treatment plans from H-ICC institute. The study group included 58 females, with agee between 30 and 70 years, irradiated for breast cancer with 6 MV photons. Risk quantities values have been determined implementing a script (C#) for Eclipse^{TM} software. The differences between the LARs attributable to different fractioned treatments were statistically significant ($P = 0.037$) with a lower mean risk for HF.

▲ Optimization of ^{68}Ga-PSMA-PET/CT acquisition parameters in patients with local and metastatic prostate cancer.

Richiusa S. (1), Sabini M. G. (2), Scopelliti F. (3), Gueli A. M. (1), Cosentino S. (4), Ippolito M. (4)
(1) *Medical Physics Specialty School, Department of Physics and Astronomy and Department of Medical, Surgical Sciences and Advanced Technologies, Università di Catania*
(2) *Medical Physics Unit, Cannizzaro Hospital, Catania, Italy and INFN, Laboratori Nazionali del Sud Catania*
(3) *Radiopharmacy Laboratory Nuclear Medicine Department, Cannizzaro Hospital, Catania*
(4) *Nuclear Medicine Department, Cannizzaro Hospital, Catania*
Radionuclide imaging techniques such as PET/CT, based on ^{11}C or choline ^{18}F, allow the diagnosis of prostate cancer (PCa). However, their use is limited in patients with prostate specific antigen (PSA) levels < 2 ng/ml. To address this limitation, new tracers have been developed that allow for more specific detection of PCa with PET, such as prostate-specific membrane antigen (PSMA, a membrane glycoprotein). The aim of this study is to evaluate the role of variations in the acquisition time of the PET images and the semi-quantitative parameters SUV_{max}/SUV_{mean}, in order to improve the imaging protocols of ^{68}Ga-PSMA PET/CT to obtain optimal image quality and quantitative diagnostic accuracy, without any appreciable loss, in patients with local and metastatic prostate cancer.

Aula Ada Lovelace **ore 09:30 – 13:00**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Palumbo L. (Sapienza Università di Roma)

Relazioni su invito

▲ **I Laboratori Nazionali di Frascati: Da Dafne a Eupraxia.**
Bossi F.
Laboratori Nazionali di Frascati dell'INFN
Nei loro quasi settant'anni di storia, i Laboratori Nazionali di Frascati hanno costituito la punta di diamante della fisica fondamentale con gli acceleratori in Italia. Attualmente i LNF operano il collisore elettrone-positrone Dafne, detentore del record mondiale di luminosità a basse energie, e Sparc, una facility per lo studio della accelerazione al plasma. Quest'ultima è la palestra per testare le tecniche fondamentali per il nuovo grande progetto europeo, Eupraxia, la prima *user facility* che produce fasci di fotoni prodotti da plasma acceleration.

▲ **New research opportunities at FERMI.**
Masciovecchio C.
Elettra Sincrotrone Trieste
FELs have opened unprecedented opportunities in science providing an extremely powerful tool to study processes at the atomic and molecular level and paved the the way to investigations of the fundamental properties of matter with an unprecedented temporal resolution. We will discuss the impact of FELs in studies of fast phenomena in material science and chemistry obtained combining scattering and spectroscopic approaches and exploiting electronic resonances.

▲ **Elettra 2.0: The Italian 4th-generation synchrotron radiation facility.**
Karantzoulis E.
Elettra Sincrotrone, Trieste
Elettra has been operating for users for 28 years; to stay competitive for world-class photon science in the future a complete upgrade of the storage ring is underway. Although a first version of the conceptual design was available since 2017 additional user requests forced us to upgrade the original lattice to the S6BA-E (six bend enhanced achromat) and the technical design report was produced in June 2021. The S6BA-E lattice reduces by about 50 times the present emittance and increases the brightness by almost three orders of magnitude. At the same time studies to produce short pulses using deflecting cavities are ongoing and, if installed, will give short photon pulses of 1–2 ps fwhm. The new machine will serve 31 beam lines. Three new micro-spot beamlines that the present machine cannot support will be installed. All three require a flux of 10^{14} ph/s at the source and are: the μXRD at 14 keV with a 10×10 μm spot size at the end station, the μSAX at 13 keV with a spot size of 10×10 μm and the μXRF at 15 keV that requires a spot of 1×1 μm to be served by in-vacuum undulators. Also, a coherent diffraction imaging beam line using a short undulator will be installed. Additionally, 2 super-bends at 6 T will be installed to serve the Hard X-ray Imaging beamlines cluster (evolution of the Syrmep BL) requiring a flux at the source of at least 10^{13} ph/sec at 50 keV.

▲ The research infrastructure STAR at the University of Calabria.

Barberi R.
Università della Calabria

Since 1972 University of Calabria is structuring a strong research system also installing cutting-edge laboratories in areas of fundamental research and key enabling technologies. Physics is contributing with a relevant effort, involving also other hard sciences and engineering, towards solutions in fields like technological platforms for biomedical applications, cultural heritage and energy. The 2007–2013 PON program has allowed to start building STAR, the Southern Europe Thomson Back-Scattering Source for Applied Research, an advanced source of X-rays. STAR was then included in the National Program for Research Infrastructures 2014–2020 among the 18 strategic Italian infrastructures, for its potential international projection. At present, STAR is being upgraded through the PIR_000008 STAR_2 project program within the framework of the PON "Research and Innovation" 2014–2020. During 2021 two important contractual agreements with INFN and the Trieste synchrotron, together with the donation of CNISM to University of Calabria, relating to part of the instrumentation installed with the first phase of the project, have defined the final design of this research infrastructure, which will be completed by the end of next year. STAR is conceived as a facility open to external users and it is organized in three progressive levels: the X-ray source, with two beam lines up to 350 keV photon energy, six highly specialized laboratories for matter physics and technology, a network of university departmental laboratories. Altogether, this defines a technological pole of strategic interest for the Italian scientific community, open to European and International collaborations.

▲ Challenges and perspectives for Target Systems of high-intensity and -energy machines.

Calviani M.
CERN

The present contribution will highlight the challenges faced by beam-intercepting devices, and specifically Target Systems, in high-intensity and -energy machines. It will detail the material and production techniques R&D that are required to face the ever-increased operational demands of high-energy physics machines, coupled with high reliability. These will include operational feedback as well as specific in-beam testing of components and integral systems. Specific focus will be provided on Target Systems components, required to produce secondary particles for different applications. Examples of facilities under operation and under design will be provided, including perspectives for new facilities and projects.

▲ SRF cavities activites at INFN LASA.

Sertore D.
INFN Milano - LASA, Segrate, Italy

Since the early 1990s, with the involvement on the LEP2 SRF cavity production and on the setting up of the TESLA project, INFN LASA have been working on the development of superconducting RF cavities for advance accelerators in the framework of international collaborations. In this context, the experience of the group grew and covered the different aspects of this scientific challenge including design, fabrication, surface treatments and cold testing. In this presentation, I will sketch our main contributions to a few major projects such as TESLA, Trasco/ADS, European-XFEL, ESS and PIP-II.

▲ **Storage rings and gravitational waves.**

FRANCHETTI G. (1)(2), ZANETTI M. (3), ZIMMERMANN F. (4)
(1) *GSI Helmholtzzentrum für Schwerionenforschung GmbH*
(2) *Institute of Applied Physics, Goethe Universität Frankfurt am Main*
(3) *Dipartimento di Fisica, Università di Padova*
(4) *CERN*

Particle accelerators have paved the way for extraordinary discoveries in physics by colliding energetic particles among themself or with a target. In storage rings, investigations are instead carried out inside the machine by measuring revolution times and other properties of stored particles. Mass spectroscopy and frontier investigations as for g-2 and EDM are significant fields of research. Recently at a workshop organized by the ARIES-APEC, the possibility of using storage rings for detecting gravitational waves was addressed. This presentation will review the main ideas, controversial discussions, and perspectives emerged from the lively discussions.

Aula Nella Mortara **ore 09:30 – 13:00**

Sezione VII

Didattica e storia della fisica

Presiede: Giliberti M. (Università di Milano)

Relazioni su invito

▲ **Sperimentazioni con studenti e insegnanti sulle tecnologie quantistiche nell'ambito della Quantum Flagship: Il contributo di Pavia.**

Malgieri M., Sutrini C., Zuccarini G., Macchiavello C.
Dipartimento di Fisica, Università di Pavia

Il progetto Quantum Flagship costituisce una delle iniziative più innovative dell'Unione Europea nel campo della ricerca, e porta con sè la richiesta di un significativo cambiamento nella didattica della meccanica quantistica, anche a livello di scuola secondaria. Per rendere possibile tale innovazione, il punto di partenza è operare una ricostruzione didattica dei contenuti riguardanti la computazione e la comunicazione quantistica, che includa il chiarimento, finalizzato all'elementarizzazione, dei principi fisici coinvolti. In questa relazione documenteremo i passi in questa direzione intrapresi congiuntamente dal gruppo di ricerca in didattica della fisica e da quello sulle tecnologie quantistiche dell'Università di Pavia, discutendo anche le prime iniziative didattiche per insegnanti e studenti, e alcuni risultati ottenuti.

▲ **The Second Quantum Revolution at school: Teaching Quantum Physics in the context of Quantum Technologies.**

Bondani M. (1), Chiofalo M.L. (2), Ercolessi E. (3), Levrini O. (3), Macchiavello C. (4), Malgieri M. (4), Michelini M. (5), Mishina O. (6), Onorato P. (7), Pallotta F. (8), Santi L. (5), Satanassi S. (3), Stefanel A. (5), Sutrini C. (4), Testa I. (9), Zuccarini G. (4)
(1) *Istituto di Fotonica e Nanotecnologie - CNR-IFN, Como, Italia*
(2) *Dipartimento di Fisica, Università di Pisa, Italia*
(3) *Dipartimento di Fisica e Astronomia, Università di Bologna, Italia*
(4) *Dipartimento di Fisica, Università di Pavia, Italia*
(5) *Unità di Ricerca in Didattica della Fisica, Università di Udine, Italia*
(6) *Centro DEMOCRITOS - Istituto Officina dei Materiali CNR-IOM c/o SISSA, Trieste, Italia*
(7) *Dipartimento di Fisica, Università di Trento, Italia*
(8) *Dipartimento di Scienza e Alta Tecnologia - Università dell'Insubria, Como, Italia*
(9) *Dipartimento di Fisica, Università Federico II, Napoli, Italia*

Stimulated by the European project "QTEdu CSA", active within the Flagship "Quantum Technologies", we have designed and implemented a PCTO course (March-May 2021, online). The course has been attended by about 250 high school students from all over Italy. The activity is the result of the joint efforts of the communities of researchers active in the fields of Quantum Technologies and Physical Education. Our goal was to answer the research question: How to exploit the context of the Second Quantum Revolution to introduce the basic concepts of Quantum Physics in high schools? We present some preliminary results of the educational experiment.

▲ Opening a window on the nature of science: The universal meaning of the quantum of action - a didactic proposal.

MONTI F.
Dipartimento di Informatica, Università di Verona

I will present a didactic strategy suitable at University level that allows highlighting some distinctive traits of the Nature of Science by introducing the universal and foundational meaning of the quantum of action in the context of an inter-related treatment of Thermodynamics and Quantum Theory complementary to the theory of black-body radiation. The proposed approach relies on the ideal gas kinetic theory and on the Boltzmann definition of entropy and is centered on the calculation of the absolute entropy for an ideal monoatomic gas, offering strong interdisciplinary connections with the History of Science as well as with Mathematics and Chemistry. The presentation will be given in Italian.

▲ COLLABORA: Un percorso biennale per migliorare l'uso del laboratorio nell'insegnamento della fisica.

CARLI M., PANTANO O.
Dipartimento di Fisica e Astronomia, Università degli Studi di Padova, Italia

Il progetto COLLABORA - A Community Of Learners on LABORAtory work è un percorso di formazione per insegnanti in servizio volto a migliorare l'uso del laboratorio nell'insegnamento della fisica. Il percorso, basato sulla comunità di apprendimento e sulla ricerca-azione, è iniziato nel 2018 con un programma di 13 incontri mensili e ha coinvolto 15 insegnanti da 11 scuole del Veneto. A partire dai risultati del primo anno e dai bisogni formativi emergenti, il percorso è continuato per un ulteriore anno introducendo elementi di supporto alla progettazione e attività di micro-teaching e peer observation. Il gruppo ha continuato a lavorare durante il lockdown del 2020, sperimentando alcune proposte didattiche in modalità a distanza. In questo contributo descriviamo il percorso biennale, la sua valutazione al termine dei due anni e il suo impatto sulle pratiche didattiche degli insegnanti e sulla loro autoefficacia nell'uso del laboratorio.

▲ Molecular Simulation, a new computational frontier of theoretical physics: A historical reconstruction.

CICCOTTI G., BATTIMELLI G.
Dipartimento di Fisica, Università di Roma "La Sapienza"

Computational power has developed at unbelievable speed, increasing in a little more than 70 years eighteen orders of magnitude, and making possible the technological revolution which characterizes our present times. Not so known, instead, is the fact that this advancement has brought along a deep change in the foundations of Theoretical Physics, specifically to the part dealing with large aggregates of molecules in Statistical Mechanics and Molecular Simulation. This presentation will introduce the new approach, its epistemological meaning and reconstruct, historically, the transformation induced in theoretical physics.

▲ John Wheeler: Dalla geometrodinamica a law without law.

FURLAN S.
Max-Planck-Institut für Wissenschaftsgeschichte, Berlino, Germania e Geneva Symmetry Group, Università di Ginevra, Svizzera

Al giorno d'oggi John A. Wheeler è ben noto per l'estro creativo nel coniare (o almeno adottare) espressioni che continuano a risuonare nell'orecchio dei fisici e non solo: quantum foam, black hole, law without law, it from bit. Decisamente meno noto, anzi inesplorato, risulta il contesto di idee, influenze, speculazioni e aspettative che le hanno viste sorgere, e il modo in cui nella visione di Wheeler si sono gradualmente interconnesse. Scopo di questo intervento è illustrare, grazie ai lavori di Wheeler medesimo e ad inedito materiale d'archivio, alcune delle tappe e dei tratti salienti che, tra gli anni Sessanta e Settanta, caratterizzarono il percorso che lo condusse dall'interrogarsi sulle implicazioni dei buchi neri fino a propugnare una nuova visione delle leggi fisiche, law without law. Nel mentre, inoltre, Wheeler si confrontò (ulteriore aspetto inesplorato) con le proposte di altre distinte figure, quali Ilya Prigogine e Manfred Eigen, che lasciarono una traccia nella nuova concezione che cercava di sviluppare. Tutto questo è il preambolo all'ultima fase visionaria di Wheeler, riassunta sotto l'etichetta dell'it from bit.

▲ **Spontaneous symmetry breaking and the long course of an analogy: Concepts and languages of physics meet.**

Gaudenzi R.
Max-Planck-Institute for the History of Science, Berlin

Most of the historical accounts on the concept of spontaneous symmetry breaking trace to the 1960 its beginning point, and ascribe its genesis to the analogy between superconductivity and the vacuum of the universe by Yoichiro Nambu and Giovanni Jona. While that brilliant analogy certainly marks the beginning of the history of the concept literally intende that is, what can be drawn from the written (published) sources it is hardly more than a little fraction of a larger whole, the docking of a ship after a sea odyssey, as it were. This odyssey begins in fact ten years earlier, at the onset of 1950 Nambu's notebook bears witness to this with Nambu's reconsideration, under the light of new quantum electrodynamics, of the analogy between the vacuum and the degenerate Fermi gas which Dirac had in turn drawn twenty years earlier. The adventure of thought that unfolded from the 1950 through to the superconducting-vacuum analogy, and how this tied in with the cultural and material context of Japanese physics and prepared that final step, will be the subject of this talk.

Aula Plenarie **ore 14.30 – 15.25**

SEZIONE VII
Didattica e storia della fisica
Presiedono: FAZIO C. (Università di Palermo)
LA RANA A. (Università di Verona)

Relazione Generale

Physics education and the history of physics: Lessons for today's physicists from the life and achievements of Enrico Fermi.

SCHWARTZ D.
Independent scholar

Many physicists would argue that a knowledge of the history of physics is irrelevant to becoming a fine physicist. On the contrary, I argue that a knowledge of the history of physics can be quite valuable in the education of a professional physicist. The life and work of Enrico Fermi is a case in point. In studying Fermi's life and his contributions to physics, a professional physicist can gain insight into 1) the way in which Fermi solved specific problems, which can be instructive to physicists as they try to solve their own specific problems; 2) the mistakes that Fermi made along the way, also instructive to physicists who want to avoid such mistakes; 3) the way certain ideas of major importance to modern physics had their origins in Fermi's own work, giving physicists today some perspective on the ideas and tools that they use in their everyday work; and finally, 4) the way that Fermi's breakthroughs and discoveries reflected the challenges that the field faced in the 1920s–1950s. A knowledge of the problems and ideas that drove research during Fermi's time provide an historical-scientific context for professional physicists today in understanding where the current challenges come from, and how to approach them.

Aula Plenarie **ore 15.30 – 16.25**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiedono: Boscolo M. (INFN, Laboratori Nazionali di Frascati)
Scamarcio G. (Università di Bari)

Relazione Generale

Magneti superconduttori ad alto campo per la frontiera delle alte energie e per l'innovazione tecnologica.

Rossi L.
Università degli Studi di Milano, Dipartimento di Fisica e INFN, Sezione di Milano, LASA

La superconduttività ha un ruolo chiave per gli acceleratori e rivelatori della fisica delle alte energie, spingendo l'aumento dell'energia della luminosità dei collisori. I magneti superconduttori ad alto campo, dal Tevatron fino ai 10000 magneti superconduttori nel tunnel LHC, hanno permesso la scoperta del bosone di Higgs. La grande sfida è ora superare gli 8 tesla di LHC e aprire la strada per conquistare la regione dei 12–16 tesla per magneti da acceleratore, prima per High Luminosity LHC e poi per il collisore da 100 km FCC, per esplorare la fisica oltre il Modello Standard. Il rinnovato interesse per il Muon Collider è pure una motivazione per magneti ad alto campo, come il solenoide da 50 T per la generazione dei muoni, con forte carico termico e campo di radiazione. I magneti superconduttori, e le tecnologie associate, stanno entrando in modo promettente anche nel settore medico per terapia con ioni (gantry o altri sistemi). Pure il settore dell'"imaging" (NMR e MRI) richiede magneti ad alto campo con sviluppi comuni. Infine, verrà presentata una tecnologia mutuata dai magneti per HiLumi LHC: una linea superconduttrice che potrebbe diventare il paradigma per una trasmissione di energia a quasi zero-emissione.

Sezione I
Fisica nucleare e subnucleare

Comunicazioni

A study of differential Higgs-plus-jet distributions in hybrid high-energy/collinear factorization.

Celiberto F.G. (1)(2)(3), Fucilla M. (4)(5), Ivanov D.Yu. (6)(7), Mohammed M.M.A. (4)(5), Papa A. (4)(5)
(1) *ECT*, I-38123 Villazzano, Trento, Italy*
(2) *Fondazione Bruno Kessler, FBK, I-38123 Povo, Trento, Italy*
(3) *INFN-TIFPA, I-38123 Povo, Trento, Italy*
(4) *Dipartimento di Fisica, Università della Calabria, I-87036 Arcavacata di Rende, Cosenza, Italy*
(5) *Istituto Nazionale di Fisica Nucleare, Gruppo collegato di Cosenza, I-87036 Arcavacata di Rende, Cosenza, Italy*
(6) *Sobolev Institute of Mathematics, 630090 Novosibirsk, Russia*
(7) *Novosibirsk State University, 630090 Novosibirsk, Russia*

We investigate the inclusive production of a Higgs boson plus a jet, featuring large transverse momenta and widely separated in rapidity. This reaction, that can be studied at the LHC as well as at new-generation colliding machines, represents a novel probe channel for the manifestation of the Balitsky-Fadin-Kuraev-Lipatov (BFKL) dynamics. We build up a hybrid factorization that encodes genuine high-energy effects inside the standard collinear structure of the cross section. We bring evidence that high-energy resummed distributions, differential in rapidity and transverse momentum, exhibit a solid stability under higher-order corrections, thus offering us a faultless chance to gauge the feasibility of precision calculations of these observables at high energies. We come out with the message that future, exhaustive analyses of the inclusive Higgs boson production, would benefit from the inclusion of high-energy effects in a multilateral formalism where distinct resummations are concurrently embodied. We propose these studies with the aim of inspiring synergies with other Communities, and pursuing the goal of widening common horizons in the exploration of the Higgs physics sector.

Testing ab initio calculations in ^{20}O via lifetime measurements.

Zanon I. (1)(2), Clément E. (3), Goasduff A. (1)(4), Ciemała M. (5)
(1) *INFN, Laboratori Nazionali di Legnaro, Legnaro, PD*
(2) *Dipartimento di Fisica e Scienze della Terra, Università di Ferrara*
(3) *GANIL, CEA/DRF - CNRS/IN2P3, Caen, France*
(4) *Faculty of Physics, University of Warsaw, Warsaw, Poland*
(5) *IFJ PAN, Krakow, Poland*

The ^{20}O nucleus represents an interesting case of study. In this nucleus, the spectroscopic properties of the 2^+_2 and 3^+_1 states are influenced by the contribution of the three-body forces. Hence, lifetime measurements of these states can provide meaningful information on the role of three-body forces in this nucleus. An experiment aimed at measuring the lifetime of 2^+_2 and 3^+_1 states of ^{20}O using the Doppler Shift Attenuation method was performed at GANIL, using the AGATA array coupled to the MUGAST array and the VAMOS spectrometer. The lifetimes of the states were extracted by comparing the experimental data with Monte Carlo simulations. In this contribution, the measured lifetimes and the theoretical interpretation will be presented.

Asymptotic normalization coefficients method with mirror nuclei in the context of the ^{26}Al problem: The ^{26}Si(p, γ)^{27}P case.

D'Agata G. (1), Kilic A.I. (1), Burjan V. (1), Mrazek J. (1), Glagolev V. (1), Kroha V. (1), Guardo G.L. (2)(1), La Cognata M. (2), Lamia L. (2)(3)(4), Palmerini S. (5)(6), Pizzone R.G. (2), Rapisarda G.G. (2), Romano S. (2)(3)(4), Sergi M.L. (2)(3), Spartà R. (2)(3), Spitaleri C. (2), Siváček I. (1)(7), Tumino A. (2)(8)
(1) *Nuclear Physics Institute of the Czech Academy of Sciences, Řež, Czech Republic*
(2) *INFN, Laboratori Nazionali del Sud, Catania*
(3) *Dipartimento di Fisica e Astronomia E. Majorana, Università degli Studi di Catania, Catania*
(4) *Centro Siciliano di Fisica Nucleare e Struttura della Materia CSFNSM, Catania*
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The presence of ^{26}Al in the interstellar medium represents a tracer for recent nucleosynthesis in our galaxy: it is produced via the ^{24}Mg(p, γ)^{25}Al(β^+)^{25}Mg(p, γ)^{26}Al reaction chain, but its abundance is diminished by the ^{25}Al(p, γ)^{26}Si(β^+)^{26}Al$^{\mathrm{m}}$ reaction chain. Also, ^{26}Si can be also burned by the ^{26}Si(p, γ)^{27}P reaction. To better understand the ratio between ^{26}Al and ^{26}Al$^{\mathrm{m}}$, an indirect measurement of the ^{26}Si(p, γ)^{27}P has been performed using the Asymptotic Normalization Coefficient method in its application for mirror nuclei: the ^{26}Mg(d, p)^{27}Mg reaction has been studied to gain information on the ^{26}Si(p, γ)^{27}P reaction. Experimental results and its implication on the reaction rate will be shown.

Studio della reazione ^{20}Ne(p, γ)^{21}Na a LUNA.

Masha E.
Università degli studi di Milano e INFN, Sezione di Milano, Milano

Il ciclo neon-sodio gioca un ruolo fondamentale nella sintesi degli elementi dal ^{20}Ne al ^{27}Al nelle stelle AGB, RGB, nelle novae e nelle esplosioni di supernove di tipo Ia. La reazione ^{20}Ne(p, γ)^{21}Na ($Q_{\mathrm{value}} = 2431.68$ keV) è la reazione più lenta dell'intero ciclo e attualmente governa la sua incertezza. A LUNA, ai Laboratori Nazionali del Gran Sasso, è in corso la misura della risonanza a $E_{\mathrm{R}} = 366$ keV e lo studio della cattura diretta a energie inferiori a 400 keV dove non esistono dati sperimentali. Nella presentazione verrà descritto il setup sperimentale e verranno mostrati i risultati preliminari della misura della risonanza a $E_{\mathrm{R}} = 366$ keV.

Studio della reazione ^{3}He(n, p)^{3}H alle energie di interesse astrofisico attraverso il metodo indiretto del Trojan Horse.

Spampinato C. (1)(2)(3), Pizzone R.G. (1), Spartà R. (1)(2), Couder M. (4), Wanpeng Tan (4), Boccioli L. (5), Burjan V. (6), Chae K.Y. (7), D'Agata G. (6), Guardo G.L. (1), La Cognata M. (1), Lamia L. (1)(2)(3), Lattuada D. (1), Mrazek J. (6), Palmerini S. (5), Romano S. (1)(2)(3), Spitaleri C. (1)(2), Tumino A. (1)(8), Wiescher M. (4)
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Fra le reazioni di interesse astrofisico incluse nel network di reazioni della Big Bang Nucleosynthesis, la reazione ^{3}He(n, p)^{3}H gioca un ruolo importante poiché influenza l'abbondanza finale di ^{7}Li. Il metodo indiretto del Trojan Horse (THM) è stato applicato alla reazione ^{3}He(d, pt)H in modo da ottenere la sezione d'urto $\sigma(E)$ nell'intervallo energetico di interesse (finestra di Gamow). In questa comunicazione saranno esposti il metodo sperimentale usato, l'apparato utilizzato, le procedure di calibrazione dei rivelatori ed alcuni risultati sull'andamento della sezione d'urto confrontata con i dati presenti in letteratura.

Studio preliminare di processi $\beta\beta$ in ^{106}Cd usando un cristallo scintillatore arricchito di ^{106}CdWO$_4$ in coincidenza/anticoincidenza con due CdWO$_4$.

Leoncini A. ([4])([5]), Belli P. ([1])([2])([1]), Bernabei R. ([1])([2]), Brudanin V.B. ([3]), Cappella F. ([4])([5]), Caracciolo V. ([1])([2])([6]), Cerulli R. ([1])([2]), Danevich F. A. ([7]), Incicchitti A. ([4])([5]), Kasperovych D.V. ([7]), Kobychev V.V. ([7])([1]), Merlo V. ([1])([2]), Polischuk O.G. ([7])([1]), Tretyak V.I. ([7])([1])
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In questa analisi preliminare il decadimento doppio beta del ^{106}Cd è stato studiato utilizzando un cristallo scintillatore ^{106}CdWO$_4$ arricchito in ^{106}Cd al 66% operante in coincidenza/anticoincidenza con due cristalli scintillatori CdWO$_4$ composti da cadmio naturale. La geometria di questi ultimi permette di coprire larga parte dell'angolo solido intorno al cristallo arricchito. La misura è stata realizzata nell'apparato DAMA/R&D ai Laboratori Nazionali del Gran Sasso. Sono state effettuate simulazioni Monte Carlo al fine di studiare il fondo e le contaminazioni presenti nei vari materiali dell'apparato sperimentale e le caratteristiche del segnale atteso. Nuovi limiti preliminari sul tempo di dimezzamento sono stati fissati su vari canali di decadimento doppio beta del ^{106}Cd a livello di $\lim T_{1/2} \sim 10^{20}$–$10^{22}$ anni. Essi sono stati ottenuti attraverso l'analisi dei dati accumulati per 467 giorni, studiando in particolare gli eventi in coincidenza e/o anticoincidenza nei tre rivelatori. La sensibilità preliminarmente ottenuta sul $T_{1/2}$ del processo $2\nu\epsilon\beta^+$ è prossima alle previsioni teoriche: $T_{1/2} \sim 10^{21}$–10^{22} anni.

Silicon drift detectors for high precision kaonic atoms spectroscopy at DAΦNE.

Sgaramella F., Curceanu C. per la Collaborazione SIDDHARTA-2
INFN, Laboratori Nazionali di Frascati, RM

The SIDDHARTA-2 experiment is going to perform the first high precision X-ray spectroscopy of the kaonic deuterium $2p \to 1s$ transition at the DAΦNE collider of the INFN-LNF, to investigate the low-energy QCD in the strangeness sector. To achieve this goal, a new technology of Silicon Drift Detectors has been developed by the SIDDHARTA-2 Collaboration, able to operate even in the high background environment of the DAΦNE collider. The contribution will present the optimization of the SDDs and the performances of the detectors under different background conditions during the DAΦNE commissioning phase, in preparation for the SIDDHARTA-2 data taking campaign.

Femtoscopic analysis of K^0_S-p pairs in proton-proton collisions at $\sqrt{s} = 13$ TeV with ALICE.

Urioni M.
Università di Brescia

The precise knowledge of the strong interaction between kaons and nucleons is a key element to describe the interaction between hadrons in the non-perturbative regime of QCD. Moreover, the knowledge of this interaction plays an important role in the study of the equation of state of dense baryonic matter, and hence has important implications for the modeling of neutron stars. We present the first femtoscopy measurement of momentum correlations of $K^0_S p$ and $K^0_S \overline{p}$ pairs in pp collisions at $\sqrt{s} = 13$ TeV measured by the ALICE experiment at the LHC. In this study, the strong scattering parameters of $K^0_S p$ and $K^0_S \overline{p}$ pairs are extracted through the Lednický-Lyuboshitz model. This model links the experimental momentum correlation to the strong final state interaction parameters. The extracted scattering parameters indicate that the strong interaction between $K^0_S p(\overline{p})$ is attractive, contrary to K^+p and K^-p. This indicates that in the $K^0_S p(\overline{p})$ there are no resonances below threshold which are responsible of the repulsive strong interaction between K^-p.

The REDTOP experiment: An eta/eta' factory to explore Physics Beyond the Standard Model.

Gatto C. per la Collaborazione REDTOP
INFN

The η and η' mesons are almost unique in the particle universe since they are Goldstone bosons and the dynamics of their decay are strongly constrained. The integrated eta meson samples collected in earlier experiments have been about $\sim 10^9$ events, dominated by the WASA at Cosy experiment, limiting considerably the search for such rare decays. A new experiment, REDTOP, is being proposed, with the intent of collecting more than 10^{13} eta/year (10^{11} eta'/year) for studying of rare η decays. Such statistics are sufficient for investigating several symmetry violations, and for searches of new particles beyond the Standard Model. With tagged-eta experiment the fully constrained kinematic of the process will allow for searches of light dark matter with a “Missing 4-momentum technique” which, at present, cannot be exploited by any other existing or proposed experiment. The physics program and the detector for REDTOP will be discussed during the presentation.

Could there still be new physics hidden in the Fermi constant?

Manzari C.A.
University of Zurich

The Fermi constant (GF) represents a key fundamental parameter of the Standard Model (SM), due to its extremely precise measurement from the muon lifetime. The best alternative extractions of (GF) proceed via the global electroweak (EW) fit or from superallowed β decays in combination with the Cabibbo angle measured in K, τ, or D decays and both variants display some tension with GF from muon decay, albeit in opposite directions, reflecting the known tensions within the EW fit and the hints for the apparent violation of CKM unitarity, respectively. In this talk, I investigate how physics beyond the SM (BSM) could bring these three determinations of GF into agreement using SM effective field theory and discuss the importance of improving the precision of the alternative independent determinations of GF to strengthen the constraining power on BSM effects commenting on future perspectives.

b- and c-jet identification with Deep Learning techniques at LHCb.

GIAMBASTIANI L.
Uni. Padova e INFN Padova

LHCb is an experiment that covers the forward region of pp collisions, that has already demonstrated its capabilities in performing b- and c-jet measurements. Several efforts have been done in the LHCb Collaboration to enhance the performance of b- and c-jet identification algorithms. A promising path is the usage of Machine Learning (ML), which is becoming popular thanks to simple implementations and excellent performance. This presentation shows one new ML-based b- and c-jet identification algorithm in comparison with the baseline algorithm. The sensitivity improvements in some of the key measurements of the experiment are evaluated when using this new method.

Constraining dimension-six EFT operators with VBS and diboson measurements at the LHC.

BOLDRINI G. ([1]), BRAMBILLA D. ([1]), COVARELLI R. ([2]), OLIVI L. ([2]), VAGNERINI A. ([2]), BRIVIO I. ([3]), DEL TATTO V. ([1]), BRUSA R. ([1]), GOVONI P. ([1]), CETORELLI F. ([1]), MASSIRONI A. ([1]), TARABINI A. ([1]), XIAO J. ([4]), ORTONA G. ([2]), PIZZATI G. ([1]), VERNAZZA E. ([1])
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Despite the unprecedented amount of data collected by the LHC, significant signs of physics beyond the Standard Model are yet to be observed. This study presents a first sensitivity estimate of the combination of Vector Boson Scattering (VBS) and Diboson processes to constrain dimension-six Effective Field Theory operators. Processes of interest $\mathrm{W}^{\pm}\mathrm{W}^{\pm}+2\mathrm{j}$, $\mathrm{W}^{\pm}\mathrm{W}^{\mp}+2\mathrm{j}$, $\mathrm{W}^{\pm}\mathrm{Z}+2\mathrm{j}, \mathrm{ZZ}+2\mathrm{j}$, $\mathrm{W}^{\pm}\mathrm{W}^{\mp}+0\mathrm{j}$, with fully leptonic or semi-leptonic final state, have been combined with their respective QCD-induced backgrounds. A set of 15 operators has been constrained exploiting the linear interference and the pure BSM term, paving the way for a global fit with LHC data.

Search for CP violation in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$.

MACCOLINI S.
Uni. Bologna e INFN Bologna

The existence of CP violation has been recently proved by the LHCb experiment in neutral charm meson decays measuring the CP-violating difference $\Delta ACP = ACP(KK) - ACP(\pi\pi)$. A measurement of the single $ACP(KK)$ and $ACP(\pi\pi)$ is presented making use of $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays promptly produced in proton-proton collisions and reconstructed in data recorded by the LHCb experiment at a centre-of-mass energy of 13 TeV, corresponding to 6/fb of integrated luminosity. The flavour of the meson is determined by the charge of the pion in $D^{*+} \to D^0\pi^+$ decays. High-yield samples of Cabibbo-favoured D^{*+}, D^+ and D_s^+ decays are used to subtract nuisance asymmetries due to production and detection effects.

Proposta di misura della sezione d'urto di cattura neutronica del $^{137}\mathrm{Er}(\mathrm{n},\gamma)$ in zona termica presso la facility sperimentale GELINA.

GUGLIELMELLI A. ([1]), MASSIMI C. ([2])([3]), ROCCHI F. ([1]), CASTELLUCCIO D.M. ([1]), PER LA COLLABORAZIONE N_TOF
([1])

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Sin dal 2000 si studia la possibilità di utilizzare l'erbio miscelato direttamente in tutto il combustibile dei reattori nucleari PWR (Er-Super High Burnup). Studi di S&U evidenziano che la sezione d'urto di cattura del ^{137}Er in zona termica è una dei maggiori contributori all'incertezza associata alla criticità dei sistemi Er-SHB. Nonostante ciò, i dati in letteratura e le validazioni delle facility critiche sperimentali evidenziano inconsistenze sulla reale incertezza da associare alla sezione d'urto di cattura del ^{137}Er. In questa comunicazione vengono presentate le motivazioni per proporre una rivalutazione della sezione d'urto di cattura neutronica del ^{137}Er presso la facility sperimentale GELINA.

Search for the electroweak production of a W+W pair plus two jets in the leptonic channel with the full Run 2 dataset.

Benaglia A. ([2]), Cetorelli F. ([1]), Ciulli V. ([3]), De Guio F. ([1]), Ghezzi A. ([1]), Govoni P. ([1]), Lenzi P. ([3]), Lizzo M. ([3]), Malberti M. ([2]), Massironi A. ([2]), Pinolini B.S. ([1]), Viliani L. ([3])
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The scattering of two opposite-sign W bosons has not been observed yet. At the LHC this measure is of the utmost importance since it has the potential to significantly enhance the sensitivity in constraining the EWSB sector. The full Run2 CMS dataset has been analysed considering the fully leptonic final state, characterised by the presence of two jets, two opposite-charged leptons and MET. One key of this project is the investigation of a Deep Neural Network to increase the signal discrimination power. Particular attention has been dedicated to the determination of the optimal network, in terms of performances and reliability.

Osservazione dello stato esotico Zcs presso l'esperimento BESIII.

Scodeggio M.
INFN - Sezione di Ferrara e Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Ferrara, Italia
A partire dal 2003, è stato identificato nella regione energetica del charmonio un nuovo gruppo di stati esotici, noti come XYZ. Questi stati, incompatibili col modello quark-antiquark, sono possibili candidati per tetraquark, molecole mesoniche ed ibridi. L'esperimento BESIII, installato presso BEPCII ad IHEP, opera nella regione energetica tra 2.0 e 4.9 GeV ed è uno degli attori principali nello studio degli stati XYZ. Sebbene attese dalla simmetria di sapore $SU(3)$, al 2020 non erano ancora state identificate le controparti "strane" delle Z, chiamate Zcs. In questo contributo verrà introdotta l'osservazione da parte di BESIII del primo candidato tetraquark con stranezza.

BFKL approach in high-energy physics.

Fucilla M.
Università della Calabria e INFN-gruppo collegato di Cosenza
The Balistky-Fadin-Kuraev-Lipatov (BFKL) approach is an established tool in the treatment of the high-energy behaviour of the Quantum Chromodynamics (QCD). The BFKL equation became famous owing to the prediction of the rapidity growth of the $\gamma^* p$ cross section at increasing energy, but the region of applicability is much wider, in fact, the approach even finds applications in different theories such as $\mathcal{N} = 4$ Super Yang-Mills and Supergravity.

There are also many formal connections of this approach with different sectors of high-energy physics (such as that of integrable systems). In this talk, after a brief general overview on the approach, I will focus on recent developments regarding hadronic structure and semi-hard processes and on the possibility of testing the approach at modern colliders.

Measurement of the charm-mixing parameter y_{CP} with D^0 mesons from semileptonic B decays at LHCb.

VILLA A.
Dipartimento di fisica, Università di Bologna, Italia e INFN sezione di Bologna, Italia

A measurement of y_{CP} with $D^0 \to K^+K^-$, $D^0 \to \pi^+\pi^-$ and $D^0 \to K^-\pi^+$ decays is presented, where D^0 mesons are selected from semimuonic B-meson decays at LHCb. The full Run 2 dataset of pp collisions at $\sqrt{s} = 13$ TeV is used, corresponding to an integrated luminosity of 6 fb^{-1}. The increased data sample size with respect to the previous LHCb measurement results in an improvement of a factor 2 in statistical precision, allowing to reach a precision below the per-mille level for the first time.

Spin-isospin excitations studied by mirror beta decay and charge exchange reactions.

ORRIGO S.E.A.
Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Valencia, Spain

A systematic study of proton-rich nuclei has been carried out by decay spectroscopy experiments with implanted radioactive ion beams at GANIL and RIKEN. Beta decay has a direct access to the absolute values of the Fermi B(F) and Gamow-Teller B(GT) transition strengths. The comparison with complementary charge exchange reactions, such as the (^{3}He,t) reaction performed on the mirror stable targets at RCNP Osaka, allows the investigation of fundamental questions related to the role of the isospin in atomic nuclei, such as isospin symmetry in mirror nuclei. An overview of the most important results obtained will be presented.

Sviluppo di un tracciatore per il polarimetro di alta precisione dell'esperimento JEDI.

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L'esperimento JEDI si occupa della misura del momento di dipolo elettrico (EDM) di particelle cariche in un anello di accumulazione, tale grandezza è una sonda sensibilissima per la fisica BSM. In presenza di un EDM, un campo elettrico radiale è applicato ad un fascio di particelle longitudinalmente polarizzato, ciò causa una precessione dello spin nel piano verticale. La presentazione sarà dedicata allo sviluppo del tracciatore a scintillatori plastici (SITH) da accoppiare al nuovo polarimetro dell'esperimento. Nella presentazione saranno mostrati gli sviluppi delle simulazioni e le analisi di queste, confrontate con i risultati di un test su fascio di un prototipo.

Determination of the double Higgs cross section and trilinear Higgs coupling sensitivities at muon collider.

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Muon collisions at multi-TeV center of mass energies are ideal for studying Higgs boson properties: the double (triple) Higgs boson production rate will be sufficiently high to directly measure the parameters of trilinear (quadrilinear) self-couplings, enabling the precise determination of Higgs potential. In this contribution the expected sensitivity of an experiment at muon collider at $\sqrt{s} = 3$ TeV on double Higgs production cross section and on the trilinear self-coupling is evaluated. Signal ($\mu^+\mu^- \to HH\nu\bar{\nu}$, where $H \to b\bar{b}$) and physics backgrounds processes are fully simulated and reconstructed taking into account the effects of the beam-induced background.

The LHCspin project: A polarized fixed target for LHC.

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A polarized fixed-target experiment at LHC will open the way for a broad and unique physics program. The kinematic coverage will allow to study the negative-rapidity region in the CM, corresponding to the poorly explored high x-Bjorken domain for the target proton. Furthermore, the use of a transversely polarized H or D gas will allow precision measurements of spin-asymmetries in Drell-Yan and in inclusive production of quarkonia, opening the way to the measurement of the unknown gluon PDFs, such as the gluon Sivers function. The status of the project, the R&D for the implementation of the setup at the LHCb experiment, as well as the physics case, are discussed.

Identification of electrons from B meson decays in CMS.

BELVEDERE A.
Sapienza Università di Roma and INFN Roma1

The standard electron reconstruction in CMS targets electrons with transverse momentum (pT) above 5 GeV. Dedicated algorithms are therefore needed to reconstruct and select electrons produced in B meson decays, which have typical transverse momenta below this value. In this presentation a new algorithm to identify low pT electrons exploiting machine learning techniques is presented, its optimization is discussed and the algorithm performances in data and in simulation are shown.

Measurement of Spin-Coherence Time (SCT) from simulations of the prototype EDM Storage Ring.

SHANKAR R. ([1])([2]), VITZ M. ([3])
([1]) *INFN Ferrara*
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The JEDI experiment is dedicated to the measurement of the electric dipole moment (EDM) of the proton and the deuteron in a storage ring, as a very sensitive probe for BSM physics. The method requires the use of polarized beams. In the presence of a non-zero EDM a radial electric field applied to a longitudinally polarized beam causes the precession of the spin in the vertical plane. The measurement of an EDM at the aimed sensitivity requires the design of a pure electrostatic ring with a high Spin-Coherence Time (SCT) of the stored particles. The presentation will show the results of the simulations of beam and spin dynamics performed with the code BMAD for a dedicated prototype storage ring.

Electroweak Physics at LHCb.

Zuliani D.
Uni. Padova e INFN Padova

The LHCb experiment offers a phase space which is complementary with respect to ATLAS and CMS. Thanks to its forward acceptance and its precise vertex reconstruction, studying electroweak physics at LHCb can provide precise measurements of Standard Model parameters, like the W boson mass, and unique constraints to Parton Distribution Functions. In this presentation the latest measurements on W and Z bosons production performed during LHCb Run II data taking are presented. Finally, some insights on undergoing work on double boson production, particularly WW production, and future prospects for electroweak physics at LHCb and its upgrades are also presented.

Quantum machine learning for jet tagging at LHCb.

Nicotra D.
Dipartimento di Fisica e Astronomia "Galileo Galilei", Università degli Studi di Padova, Padova, Italia e INFN Sezione di Padova, Padova, Italia

At the LHCb experiment, it is mandatory to identify jets produced by b and $\bar{b}$ quarks, since it is fundamental in several Physics studies, *e.g.*, the measurement of the b-$\bar{b}$ production asymmetry, which could be sensitive to New Physics channels. Being a classification problem, Machine Learning (ML) techniques, such as Deep Neural Networks (DNN), have been used to solve this problem. Here we present a new approach based on a Quantum ML algorithm trained on official LHCb simulated data that performs the same task. Performance comparisons with other classical algorithms are also presented.

Search for tetraquark resonances with the CMS detector.

Fantini L.
Dipartimento di Fisica, Sapienza, Università di Roma e INFN Roma

A search for narrow resonances in the four leptons final state (two muons and two electrons) is performed for masses below 25 GeV using a sample of proton-proton collisions at $\sqrt{s} = 13$ TeV with the CMS detector at the CERN LHC, corresponding to an integrated luminosity of about 135 fb^{-1}. Such a resonance could indicate the existence of a tetraquark that is a bound state of two b quarks and two anti-b quarks or two c quarks and two anti-c quarks. The tetraquark search is performed near the $J/\Psi J/\Psi$ and near the $\Upsilon\Upsilon$ mass thresholds. One of the key ingredient of this search is the exploitation of low-energy electrons (below 5 GeV) for which dedicated energy corrections and identification strategy have been recently developed at CMS.

Search for Heavy Neutral Leptons with the CMS detector.

Pannozzo D.
Sapienza Università di Roma e INFN Roma

A search for Heavy Neutral Leptons (HNL) produced in B decays is presented. The search is performed on a sample of 10 billion unbiased B decays collected with the CMS detector. The analysis searches for HNLs with mass in the 1–5 GeV range decaying to $N \to e^{\pm}\pi^{\mp}$, so a signal would appear as a resonant mass peak over a smooth background. The vast majority of the electrons produced in these decays have transverse momentum below 5 GeV; therefore, dedicated algorithms are studied and are employed as the standard CMS electron reconstruction is optimized for higher transverse momenta.

Study of M4 stretched-configurations decay in ^{14}N and ^{16}O.

Ziliani S. (1)(2), Cieplicka-Oryńczak N. (3), Leoni S. (1)(2), Fornal B. (3), Benzoni G. (2), Boiano C. (2), Bottoni S. (1)(2), Bracco A. (1)(2), Brambilla S. (2), Camera

F. (1)(2), Ciemała M. (3), Clisu C. (4), Crespi F.C.L. (1)(2), Dhanmeher K. (3), Florea N. (4), Gamba E. (1)(2), Grebosz J. (3), Harakeh M.N. (5), Jaganathen Y. (3), Kmiecik M. (3), Krzysiek M. (3), Łukasik J. (3), Maj A. (3), Marginean N. (4), Marginean R. (4), Matea I. (6), Matejska-Minda M. (3), Mazurek K. (3), Million B. (2), Parol W. (3), Pawłowski P. (3), Porzio C. (1)(2), Sferrazza M. (7), Sowicki B. (3), Stan L. (4), Wasilewska B. (3), Wieland O. (2), Ziebliński M. (3)
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Stretched states are one of the simplest known nuclear excitations, whose configuration is dominated by a single particle-hole component. However, the wave function does not necessarily reflect their simplicity and this can be verified by studying their decays. Such investigations have been carried out only very recently at the Cyclotron Center Bronowice (CCB) of the Institute of Nuclear Physics in Kraków: a first experiment was realised in 2019 to investigate ^{13}C and to benchmark recent *ab initio* Gamow Shell Model calculations. We will report on a second experiment at CCB in which ^{14}N and ^{16}O M4 stretched states were studied using proton inelastic scattering.

Study and modeling of fuel burnup in the TRIGA Mark II reactor.

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In this master thesis work, a new simulation model has been developed for studying the fuel burnup of the TRIGA Mark II reactor at the University of Pavia. The reactor model exploits the Monte Carlo code Serpent2, which provides several useful features for simulating both the neutron transport and the fuel evolution. Generally speaking, the analysis of a specific TRIGA reactor allows to develop a burnup simulation tool that can be used for studying many other research reactors, once their main features and historical data are provided. The Serpent simulation model of the TRIGA Mark II relies on a benchmark analysis of its first experimental criticality configurations, either at low power (10 W) and full power (250 kW). Starting from the full power model and a fresh fuel condition, the fuel burnup is performed for the first 48 years of operation of the reactor. The reliability of the model is checked comparing Serpent results with those obtained in a past reactor model, both looking at the nuclides temporal evolution and the reactivity values for each reactor core reconfiguration.

Studio dei decadimenti $\Lambda_b \to D^0 p K^-$ in preparazione della misura dell'angolo gamma della matrice CKM a LHCb.

Mancuso C.
Uni. Milano e INFN Milano

Sarà presentato uno studio del decadimento $\Lambda_b \to D^0 p K^-$ dove il mesone D^0 viene ricostruito negli stati finali K^+K^- e $\pi^+\pi^-$, autostati di CP, utilizzando l'intero campione di dati raccolto dall'esperimento LHCb durante il Run1 e Run2 di LHC. Tali decadimenti sono potenzialmente sensibili alla violazione di CP e all'angolo gamma della matrice CKM attraverso l'interferenza delle ampiezze mediate dagli elementi Vub e Vcb. Questo studio potrebbe consentire in futuro di osservare la violazione di CP e misurare per la prima volta l'angolo gamma in decadimenti di barioni.

Prospettive per la misura di momenti di dipolo di barioni Lambda a LHCb.
Tonani G.
Uni. Milano e INFN Milano
Sarà presentato uno studio della polarizzazione dei barioni Lambda prodotti nei decadimenti $\Xi_c^0 \to \Lambda K^- \pi^+$ utilizzando i dati raccolti dall'esperimento LHCb. Si prevede una significativa polarizzazione longitudinale dovuta alla violazione di parità nel decadimento debole del barione con charm, ingrediente chiave per un programma di misure dei momenti di dipolo elettromagnetici dei barioni Lambda. Saranno inoltre presentate le prospettive per tali misure a LHCb nei prossimi anni.

Novel technique for measurement of mixing and CP violation in Charm at LHCb.
Shields E.B.
Uni. Milano Bicocca e INFN Milano Bicocca
We present a novel method for measuring the mixing parameter in Charm decays, yCP, in the D0 $\to K_S$ KK channel. Such a measurement could be used as evidence of CP violation in mixing if discrepancies were found between y and yCP. The method will be discussed including dominant systematic uncertainties arising from its application at LHCb and expected sensitivities. Further we will then discuss potential sensitivities in the future runs of the LHCb detector as well as techniques being developed to bring potentially very low systematic uncertainties in the future, in order to take full advantage of the statistical gain of LHCb Run III and beyond.

Misura della polarizzazione longitudinale del mesone D* in decadimenti di B0 $\to$ D* tau nu a LHCb.
Fazzini D.
Uni. Milano Bicocca e INFN Milano Bicocca
I decadimenti B0 $\to$ D* tau nu B0, dove il leptone tau decade adronicamente in tre pioni carichi, rappresentano dei perfetti candidati per la verifica del Modello Standard e delle sue possibili estensioni di Nuova Fisica. In particolare, la misura della polarizzazione longitudinale del mesone D* in questi decadimenti può fornire informazioni complementari a quelle di altre misurazioni, individuando elementi di Nuova Fisica anche laddove queste ultime forniscano risultati in accordo con il Modello Standard. LHCb sta eseguendo per la prima volta tale misura utilizzando i dati raccolti nel periodo 2011–2016, corrispondenti ad una luminosità integrata di 5.1/fb, ottenendo risultati competitivi con quelli attualmente disponibili.

Simultaneous measurement of R(D) and R(D*) at the LHCb experiment.
Meloni S.
Uni. Milano Bicocca e INFN Milano Bicocca
The Lepton Flavour Universality (LFU) hypothesis of the Standard Model is being tested in semileptonic decays of b-mesons with tau and mu leptons in the final state. The combination of previous measurements in this channel shows an interesting tension at the level of 3.2 sigma with respect to the Standard Model predictions, in the R(D*) and R(D) observables. The LHCb experiment contributed to this combination with measurements of R(D*). In the talk I will summarize the state of the art for LFU analyses in b $\to$ clnu decays and the status and prospects of a simultaneous measurement of R(D) and R(D*) at the LHCb experiment.

Search for violation in the charmless decay $B^0 \to p\bar{p}K^+\pi^-$ using triple product asymmetries at LHCb.

Bartolini M.
Uni. Genova e INFN Genova

CP violation has been established in K, B and D meson decays. However, it is yet to be confirmed in heavy baryon decays and also in B decays with half-spin particles in the final state, where sizable asymmetries are predicted as well. In particular, baryonic B-meson decays mediated dominantly through internal W emission are believed to be promising processes. A search for CP violation in the charmless baryonic meson decay $B^0 \to p\bar{p}K^+\pi^-$ using triple product correlations is reported. The analysis uses the data collected by LHCb from 2011 to 2018 corresponding to an integrated luminosity of 9/fb collected during Run 1 and Run 2.

The LHCb RICH detector upgrade: Improvements and performance.

Okamura S.
Uni. Ferrara e INFN Ferrara

LHCb is one of the main experiments running at the CERN Large Hadron Collider (LHC) and is specialized in heavy-flavour physics. One of its key detector components is the Ring-Imaging Cherenkov (RICH) system which has the crucial task of identifying charged particles over a wide momentum range. During the Long Shutdown 2 of the LHC (2019–2021), the RICH detector is undergoing a significant upgrade by installing new photodetectors, electronics and modified optics and mechanics. This will allow to handle higher luminosity and 40 MHz continuous data taking, expected for Run 3. The current status of the RICH upgrade will be reviewed starting from a summary of the major changes to presentation of the expected improvements in detector performance.

First observation of time-dependent CP violation in the decays of B_s^0 meson.

Manuzzi D.
Uni. Bologna and INFN Bologna

Charmless charged two-body B_s^0 decays are of great interest to search for physics beyond the Standard Model. New particles may appear as virtual contributions inside the loop diagrams governing such decays, leading to discrepancies between the measured CP violation observables and their Standard Model predictions. We present the first observation of time-dependent CP violation in the decays of B_s^0 mesons performed by the LHCb Collaboration analysing a sample of $B_s^0 \to K^+K^-$ decays. A preview of the updated analysis, exploiting the whole data sample currently available, is also shown.

Simulating the LHCb detector with Generative Adversarial Networks.

Barbetti M.
Uni. Firenze e INFN Firenze

During Run 2, the simulation of physics events at LHCb has taken about 80% of the distributed computing resources available to the experiment, with the majority of the computational cost ($\sim$90%) spent by Geant4. In Run 3, in order to match the expected increase of collected data, larger simulated samples and a strategy to speed-up their production will be necessary. Replacing the detailed simulation of the radiation-matter interactions with a parametrization of the detector response may drastically reduce the cost of large simulated samples. Machine Learning techniques, and in particular Generative Adversarial Networks (GANs), have proved to be a promising class of algorithms to model the response of the Tracking, RICH, Calorimeter and Muon systems at LHCb. On the other hand, GAN training requires tuning a large set of hyperparameters which cannot be carried out in reasonable time without the concurrent usage of multiple GPUs, possibly relying on cloud computing. The status of the development and future perspectives will be presented.

Study of the measurement of the ratio R(D_s^*) at LHCb.

Paolucci L.
Uni. Roma e INFN LNF

The semileptonic b-hadron decays with a heavy lepton are sensitive to new couplings. The B-Factories and LHCb have previously performed various measurements of the ratio R(D). A global average of these measurements shows a discrepancy with the Standard Model expectations, which is above 3 sigma. In this presentation, the status of the analysis of R(D_s), exploiting the huge amount of B_s mesons collected by LHCb, is presented. The study of B_s mesons provides a crucial cross-check of the existing measures, all based on B^+ and B^0. The treatment of some of the most important backgrounds to these decays will be discussed in detail.

Spectroscopy of the excited D_s mesons.

Debernardis F.
Uni. Bari e INFN Bari

The discoveries of the $D_{s0}^*(2317)$ and $D_{s1}(2460)$ mesons challenge our understanding of quantum chromodynamics. After almost 20 years the nature of these hadrons is still subject of debate and many models have been proposed to explain their unexpected masses: standard charm strange mesons, DK molecules and tetraquarks. The LHCb experiment has studied the production of excited D_s meson in prompt proton-proton collisions and from b-hadron decays. Precise measurement of their properties and observation of new D_s states have been reported. The latest results on the spectroscopy of the charmed-strange mesons and the prospect to investigate their nature will be presented.

Uso di fotoni per calibrazione di sensori a micro strip di silicio.

Peverini F. per la Collaborazione FOOT
Dipartimento di Fisica e Geologia, Università degli studi di Perugia, Italia e INFN Sezione di Perugia

In questo lavoro viene presentato un nuovo metodo di calibrazione per sensori a micro strip di silicio, che utilizza sorgenti di fotoni monocromatici, alternativo alla calibrazione standard con particelle cariche. Il differente tipo di interazione dei fotoni con le micro strip permette il loro completo assorbimento nel sensore; questo consente di ricostruire con maggior accuratezza il segnale rilasciato e consente una miglior stima del coefficiente di calibrazione. L'ostacolo di questa analisi è l'impossibilità di utilizzare un trigger esterno per acquisire. Per superare tale difficoltà è stato sviluppato un algoritmo che, tramite metodo Monte Carlo, simula il processo di acquisizione random e restituisce la distribuzione della carica generata in funzione di due parametri che caratterizzano in maniera univoca il segnale dovuto ai gamma. In questo modo è stato possibile confrontare quantitativamente i risultati simulati con quelli sperimentali, in modo da ottenere una stima per i valori dei parametri del segnale. Con l'utilizzo di differenti sorgenti è stata tracciata una retta di calibrazione. I risultati ottenuti confermano il funzionamento di questo nuovo approccio.

A 10^{-3} monitoring drift chamber for MEG II experiment.

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The MEG II experiment searches for the lepton flavor violating decay $\mu \to e + \gamma$. The reconstruction of the positron trajectory is performed by a drift chamber, operated with a mixture of He and $i - C_4H_{10}$. For a continuous monitoring of the quality of gas, we plan to install a small drift chamber, that allows to give a prompt response about drift velocity variations at the 10^{-3} level. The chamber is a box with cathode walls defining a uniform electric field inside two adjacent drift cells. Along the axis separating the cells, 4 sense wires alternated with 5 guard wires collect the drifting electrons.

● **Simulazioni GEANT4 per una β decay station presso la facility SPES.**

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Lo studio del decadimento β di nuclei esotici è necessario per la comprensione dell'evoluzione della struttura nucleare in condizioni estreme di rapporto tra protoni e neutroni. Una stazione di decadimento per la misura dei decadimenti di nuclei esotici, di futura produzione presso la facility SPES, è in fase di progettazione. Simulazioni GEANT4 sono state effettuate per caratterizzare il setup sperimentale, composto da rivelatori HPGe e scintillatori plastici. Per le simulazioni sono stati sviluppati algoritmi di add-back e soppressione Compton. Dai risultati delle simulazioni sono stati ottenuti valori per efficienze e rapporti picco-fondo per diverse configurazioni.

● **Lambda polarisation at fixed-target with LHCb using Machine Learning algorithms.**

De Angelis C.
Uni. Roma e INFN-LNF

LHCb is the only experiment, among the four big experiments at the LHC, able to run in fixed-target mode, in parallel with the beam-beam collision mode. In this unique scenario, master thesis results about the Λ_0 polarisation at the 110 GeV center of mass energy and up to high rapidities are presented. The hyperons are reconstructed both via classical kinematical cuts and more modern Machine Learning techniques.

● **Il nuovo tracciatore interno a GEM cilindriche per l'esperimento BESIII: un'istantanea del processo di costruzione.**

Gramigna S. per il Gruppo CGEM-IT
Università degli Studi di Ferrara

Il CGEM-IT, un innovativo tracciatore interno a GEM cilindriche, è la proposta italiana per la sostituzione della camera a deriva interna dell'esperimento BESIII. Il tracciatore è composto da tre strati indipendenti, ciascuno avente tre stadi di moltiplicazione. Gli stringenti requisiti in risoluzione, ingombro e lunghezza di radiazione, insieme alla capacità di sostenere una spedizione transcontinentale, richiedono l'uso di materiali avanzati e tecniche costruttive all'avanguardia. Nella comunicazione, si descriverà la costruzione dello strato più interno del tracciatore a partire dalle operazioni preliminari e dai controlli di qualità sui materiali, fino all'assemblaggio verticale operato tramite una speciale macchina a controllo numerico.

Study of fragment distributions populated via fusion-fission and quasi-fission reactions.

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Nuclear fission is a collective process often affected by quantum shell effects leading to asymmetric mass splits. The inverse kinematics technique coupled with the VAMOS magnetic spectrometer at GANIL allows to obtain a complete isotopic identification of the fission fragments, giving access to the fragment distributions in terms of their proton and neutron content, as well as their neutron-to-proton ratio. These observables are extremely sensitive to the shell structure effects. This contribution will be focused on the latest results of the study of fusion-induced fission at high excitation energy ($E^* = 62$ MeV) in the super-heavy system ^{265}Db and the competition with the quasi-fission mechanism.

Octupole correlations in ^{110}Xe.

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The observation of large quadrupole moments led to the suggestion that some nuclei might have spheroidal shapes, while others present a reflection-asymmetric shape, as for example pear shape. Nuclei around $N = Z = 56$, in the vicinity of the double-magic nucleus ^{100}Sn, are expected to show some of the largest octupole correlations in the whole Segrè chart, indeed the experimentally deduced $B(E3; 3^- \to 0^+)$ strength in ^{114}Xe is one the largest measured so far. In this contribution the preliminary results of the extended level scheme of ^{110}Xe, which is expected to have even larger octupole correlations, will be presented. The ^{110}Xe was populated via the ^{54}Fe(^{58}Ni,2n) fusion-evaporation reaction at the Accelerator laboratory of the University of Jyväskylä. After the separation of the fusion-evaporation products in MARA, the ^{110}Xe was implanted into a DSSD to further clean the in-beam gamma rays via the recoil alpha tagging technique. The gamma rays emitted from the excited ^{110}Xe levels were measured by the gamma-ray array Jurogam3.

CMS Phase-II improved RPC and Front-End electronics upgrade.

Paesani D. per la Collaborazione CMS
INFN, Sezione di Bari

In CMS Phase-II, improved RPC detectors (iRPC) will be installed in the forward region at high pseudorapidity (eta > 1.8), where high background conditions are expected during HL-LHC. Thinner gaps will prevent ageing in the harsh background and increase the rate capability. A dual-sided readout exploiting time-of-arrival difference will reconstruct the hit positions along strip axes. Dedicated Front-End electronics based on Petiroc ASICS has been developed for higher rate and improved time and space resolution. An extensive irradiation campaign using ^{60}Co photons, neutrons and protons is due in 2021 to validate the radiation hardness of the FEB against TID, DDD and SEE.

Study of bent MAPS silicon detectors for ALICE ITS3 upgrade.

Ricci R.
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The ALICE experiment at CERN has planned an upgrade of the Inner Tracking System (ITS), named ITS3, for the LHC Long Shutdown 3, in 2025. The cornerstone of the upgrade is a new CMOS pixel sensor built in 65 nm technology and in bent-cylindrical configuration, replacing the inner layers of the existing detector. The ITS3 will reach unprecedented tracking and vertexing performance, thanks to the improved spatial resolution and the much reduced material budget. Results of data collected at beam tests with the existing ITS with ALPIDE chips bent in a cylindrical configuration as foreseen for the ITS3 will be reported. The performance obtained studying their total efficiency and spatial resolution in different experimental configurations will be discussed.

Ricerca di decadimenti rari del bosone di Higgs a CMS.

Umoret G.
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Dopo la scoperta nel 2012 di una particella compatibile con il bosone di Higgs predetto dal Modello Standard, un'intensa attività di analisi è proseguita a LHC per studiare con precisione il settore dell'Higgs. Oltre a fornire un meccanismo consistente per generare le masse delle particelle fondamentali, il bosone di Higgs può essere usato come sonda per testare molte estensioni del Modello Standard. In molti casi, gli stati finali che indicano la presenza di nuova fisica non hanno equivalente nel settore dell'Higgs del Modello Standard, e sono per questo chiamati esotici. Questi studi possono esplorare molte teorie di nuova fisica: dalla supersimmetria alla materia oscura, dalla generazione della massa dei neutrini alla presenza di extra dimensioni. Presenterò lo stato di queste ricerche a CMS.

Strange-hadron correlation studies to investigate strangeness enhancement in pp collisions.

De Martin C.
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In pp collisions the strange hadron yields normalised to the pion yield increase with the multiplicity of produced particles. To understand if this phenomenon is related to soft or hard processes, the ALICE experiment has studied the strange hadron production in and out of jets, by exploiting the angular correlation between high-p_{T} particles and strange hadrons. In this contribution, the near-side jet yield and the out-of-jet yield of $\mathrm{K}^0_{\mathrm{S}}$ and Ξ are shown as a function of the multiplicity of charged particles produced in pp collisions at $\sqrt{s} = 13$ TeV. The results suggest that soft processes are the dominant contribution to strange particle production.

The MUonE experiment.

PILATO R.N.
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The latest measurement of the muon $g-2$, recently announced at Fermilab, exhibits a 4.2σ discrepancy from the Standard Model prediction. The hadronic contribution a_μ^{HLO} represents the main source of uncertainty on the theoretical prediction. The MUonE experiment proposes a novel approach to determine a_μ^{HLO} by measuring the effective electromagnetic coupling in the space-like region, via $\mu - e$ elastic scattering. The measurement is performed by scattering a 150 GeV muon beam, available at CERN, on atomic electrons of a low-Z target. The status of the experiment is presented, in view of a Test Run planned in fall 2021 with a reduced detector.

Online DAQ interfaces for the Mu2e experiment.

GIOIOSA A. PER LA COLLABORAZIONE MU2E
Università di Pisa e INFN Sezione di Pisa

The muon campus program at Fermilab includes the Mu2e experiment that will search for a charged-lepton flavor violating processes where a negative muon converts into an electron in the field of an aluminum nucleus, improving by four orders of magnitude the search sensitivity reached so far. Mu2e's Data Acquisition System (DAQ) uses *otsdaq* as its solution. Developed at Fermilab, *otsdaq* uses the *artdaq* DAQ framework and *art* analysis framework, under-the-hood, for event transfer, filtering, and processing. *otsdaq* is an online DAQ software suite with a focus on flexibility and scalability, while providing a multi-user, web-based, interface accessible through web browsers. A Detector Control System (DCS) for monitoring, controlling, alarming, and archiving has been developed using the Experimental Physics and Industrial Control System (EPICS) open source platform. The DCS System has also been integrated into *otsdaq*.

Probing the hypertriton structure in ALICE with precision measurements of the lifetime and the Λ separation energy.

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The hypertriton is a bound state of proton (p), neutron (n) and Λ baryon. The combined study of its lifetime and its Λ separation energy provides insights about the strong interaction between the lambda and ordinary nucleons. Thanks to the large dataset of Pb-Pb collisions collected during the Run 2 of the LHC, the ALICE Collaboration has performed systematic studies on both the hypertriton lifetime and the binding energy. The precision of the new ALICE results is comparable with the current world averages and they can be used to constrain the state-of-the-art calculations which describe the hypertriton internal structure.

Configuration mixing investigation in germanium isotopes through measurement of *E*0 transition strengths.

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Experimental and theoretical studies of the germanium isotopes point increasingly toward the emergence of triaxiality, configuration mixing, and shape coexistence. Studies of the $E0$ strengths, which can provide a direct measure of the amount of configuration mixing, are lacking. Thus, determining $E0$ transition strengths is essential for an understanding of the evolution of structures in the Ge isotopes. Beta-decay experiments populating excited states in the ^{72,74,76,78}Ge isotopes were performed at the TRIUMF-ISAC radioactive beam facility. The GRIFFIN spectrometer combined with the PACES silicon array enabled us to perform both gamma-ray and electron spectroscopic investigations, to measure $E0$ strengths between states of $J > 0$. Preliminary results from this study will be discussed.

High rate capability studies of triple-GEM detectors for the ME0 upgrade of the CMS muon spectrometer.

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The high-luminosity LHC upgrade is setting a new challenge for particle detector technologies. In the CMS Muon System gaseous detectors, the increase in luminosity will produce a particle background ten times higher than at the LHC. To cope with the high rate environment and maintain the actual performance, the triple-Gas Electron Multiplier technology is a promising candidate for high-rate capable detectors for the CMS-ME0 upgrade project in the innermost region of the forward CMS Muon Spectrometer. An intense R&D and prototype phase is currently ongoing to prove that such technology meets the stringent performance requirements of highly efficient particle detection in the harsh background environment expected in the innermost ME0 region. The authors will describe the recent rate capability studies on triple-GEM detectors and the novel foils design based on double-sided segmented GEM-foils, high voltage distribution powering and filtering, which the collaboration adopted for the realization of the latter projects, and their impact on the performance of the detector in the light of new rate capability studies, with a summary of the ongoing R&D activities.

The electromagnetic calorimeter for the MUonE experiment: PbWO4 crystals characterization

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The MUonE experiment aims to determine the hadronic component of the running electromagnetic coupling through a precise measurement of the muon-electron elastic cross section, to evaluate the leading hadronic contribution to the muon $g-2$. MUonE will use the CERN intense muon beam M2 at an energy of 150 GeV. The detector layout is composed of identical stations containing a low Z target and silicon tracker modules, plus an electromagnetic calorimeter (ECAL). The calorimeter is required for unambiguous identification of the electron and muon tracks, for the electron energy measurement, for the event selection, and for the background estimation. The ECAL consists of scintillating PbWO4 crystals, selected for their features: fast light emission time, good light yield, compact dimensions, and radiation hardness. For the beam test foreseen in 2021 a prototype will be used, consisting of 25 PbWO4 crystals with the same geometry used by the CMS Collaboration. Other geometries are considered for the final ECAL. I will present measurements on PbWO4 crystals with cosmic rays, testing different geometries. The light signal is detected by PMT or Si APD in different experimental conditions.

Quarkonium polarization in Pb-Pb collisions at the LHC with ALICE.

Micheletti L. per la collaborazione ALICE
INFN, Sezione di Torino

Polarization measurements represent a valuable tool to test our understanding of the quarkonium production mechanisms occurring in proton-proton collisions. When considering heavy-ion collisions, particle polarization could also be used to investigate the characteristics of the quark-gluon plasma created at LHC energies. In ALICE, the quarkonium polarization is extracted by measuring the anisotropies in the angular distribution of the muon-antimuon pair coming from the quarkonium decay. In this contribution, recent results on J/Ψ and $\Upsilon(1S)$ polarization in Pb-Pb collisions at a center of mass energy of $\sqrt{S_{NN}} = 5.02$ TeV will be presented as function of p_T and collision centrality.

Stato dell'apparato FRAISE in costruzione ai Laboratori Nazionali del Sud dell'INFN (INFN-LNS).

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Lo studio di nuclei esotici rappresenta un importante campo della fisica nucleare. Le proprietà di tali nuclei sono utili per studiare modelli di struttura nucleare, le caratteristiche dell'interazione forte e anche reazioni di interesse per l'astrofisica nucleare. Negli ultimi 15 anni, presso i Laboratori Nazionali del Sud dell'INFN (INFN-LNS) i fasci radioattivi sono stati prodotti attraverso il metodo In-Flight, utilizzando l'apparato FRIBs. Attualmente, la comunità scientifica dei LNS è impegnata in un progetto di upgrade del ciclotrone superconduttore, il quale consentirà di produrre fasci stabili di elevate intensità. In questo contesto, è in corso anche la costruzione di un nuovo apparato, denominato FraISe (Fragment In-flight Separator) che permetterà di produrre fasci radioattivi di alta intensità, sfruttando fasci primari con potenza di circa 2–3 kW. In questo contributo si riporta lo stato dell'apparato FraISe con relativo sistema di diagnostica e del sistema di tagging in sviluppo sulla linea CHIMERA.

Ricerca di materia oscura leggera con un fascio di positroni.

Bisio P.
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Negli ultimi anni la ricerca della materia oscura (DM) si è estesa dal modello tradizionale delle WIPMs verso modelli alternativi in grado di includere aree inesplorate dello spazio dei parametri della DM. In particolare, la DM con massa nell'intervallo 1–1000 MeV (detta Light Dark Matter o LDM) è ben motivata teoricamente e rappresenta una valida opzione che può essere efficacemente investigata attraverso l'utilizzo di un fascio prodotto agli acceleratori. In questo campo, gli esperimenti che utilizzano un fascio di positroni hanno la caratteristica di poter sfruttare al meglio l'annichilazione risonante con gli elettroni in un bersaglio: questo processo rappresenta un meccanismo vantaggioso per generare LDM con una chiara segnatura sperimentale. Lo scopo della tesi è quello di studiare, attraverso le simulazioni, la fattibilità di una misura di energia mancante effettuata per investigare l'esistenza della LDM; questa misura prevede l'utilizzo di un bersaglio spesso ed attivo sul quale incida un fascio di positroni con energia di una decina di GeV.La caratterizzazione e l'ottimizzazione del rilevatore rappresentano quindi il primo passo verso l'effettiva realizzazione del detector.

Absolute efficiency of microchannel plate to low-energy electrons.

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In many experiments of particle physics the determination of the absolute efficiency of electron detectors is an unavoidable issue and this is particularly true for the low-energy region. For instance, in the context of the development of a new light dark matter detector with a target of vertically aligned carbon nanotubes acting as a photocathode. We report on the characterisation of a two-stages MCP (microchannel plate). We studied the MCP response to low-energy electrons in the 30–900 eV range, with a custom electron gun at Università Roma Tre. By measuring the absolute input current in the fA range with a Faraday cup, we determined the MCP efficiency as the ratio of the output count rate to the input current. Studying the pulse-height distribution of the MCP we observed a weak energy resolution. Furthermore, the extensive analysis of the MCP pulse shape allows the single- from multi-electron events discrimination.

Two parameter fit of the Standard Model lepton and quark masses.

Palmonari F.
INFN e University, Bologna

The Standard Model (SM) is a beautiful scheme describing elementary particles as four families of three elements each with their antiparticles: leptons (charge -1), quarks up and down ($+2/3$, $-1/3$ charges) and neutrinos. It describes correctly the forces acting in their mutual interactions, weak, electromagnetic and strong, and the mass spectroscopy of hadrons. Understanding the constituents of matter, the electron with his neutrino, the proton and the neutron is however the most difficult problem of subnuclear particle physics, due to the very large span of mass-energy levels, from few meV/c^2 in the neutrino masses, to order of hundred GeV/c^2 in the quarks. In this work some regularities one can find in the mass ratios of the three particles of each family have been studied and recursive formulae have been found to fit their masses. A global fit of all masses has been obtained using only two parameters, which have been identified with the electron mass and the fine structure constant. Some peculiarities of this model are discussed.

Testing Pauli Exclusion Principle for electrons at the LNGS underground laboratories.

De Paolis L. per la Collaborazione VIP-2
Laboratori Nazionali di Frascati, INFN, Laboratori Nazionali del Gran Sasso, INFN e Stephan Meyer Institute, Vienna

The VIP-2 experiment at the Underground Gran Sasso Laboratory (LNGS) is performing high precision tests of Pauli Exclusion Principle (PEP) for electrons. The experimental method consists in circulating a DC current in a copper strip, searching x-rays emitted by PEP prohibited Kα transitions (*i.e.*, occurring with 1s level already occupied by two electrons). The VIP experiment already set a strong limit on PEP violation probability for electrons: $\frac{1}{2}\beta^2 < 4.7 \times 10^{-29}$. The VIP-2 experiment aims to improve VIP limit by at least two orders of magnitude and explore theories beyond Standard Model allowing for small violations. Experimental apparatus and preliminary results will be presented.

Search for decoherence and CPT violation effects in the $\phi \to K_S K_L \to \pi^+\pi^-\pi^+\pi^-$ channel at KLOE.

D'Amico R. per la Collaborazione KLOE-2
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Entangled Neutral Kaons produced at the e^+e^- collider DAΦNE, the Frascati ϕ factory, constitute an unique system that can be used to test quantum mechanics and its predictions about the time correlation of the two kaon decays. The results of a detailed study of the $\phi \to K_S K_L \to \pi^+\pi^-\pi^+\pi^-$ channel observed in the KLOE experiment is presented. Improved stringent limits on possible decoherence and CPT symmetry violation mechanisms are obtained, reaching the level at which —in the most optimistic scenarios— quantum gravity effects might show up.

Testing Objective Collapse Models in the LNGS undergrund laboratory.

Napolitano F.
INFN - Laboratori Nazionali di Frascati

Quantum superposition collapse is a key and unique feature of quantum mechanics, yet the dynamics of the collapse itself is still an open question and the quantum-to-classical transition is treated purely phenomenologically. Several models were put forward to solve this decades old problem in quantum mechanics, in particular gravity-related and more generic Continuous Spontaneous Localization (CSL) models. At the Gran Sasso National Laboratory, we test with unprecedented sensitivity several collapse model scenarios, by searching for the predicted spontaneous emission of radiation in very low background environment. We set a lower bound on the parameters of these models, and we discuss the future outlook.

A new analysis for the measurement of phi-meson pair production.

Rubini N.
University and INFN Bologna

Strangeness enhancement has been recently observed in pp collisions by the ALICE Collaboration. Since this discovery a great effort has been put to understand the underlying mechanism responsible for such behaviour. In this context the phi meson has proven to be a useful probe, and thus the characterisation of its properties is of great importance. In this contribution a new analysis aiming to measure phi-meson pair production with ALICE is presented and potential improvements foreseen making use of ALICE data from Run 3 of LHC operation are discussed.

New tracker system for the MAGNEX focal plane detector at LNS-INFN within the NUMEN project.

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In the context of the NUMEN experiment, an upgrade of the MAGNEX spectrometer is mandatory in order to cope with the tracking and the identification of heavy ions at the expected high rate. A new tracker system for the MAGNEX focal plane detector, based on Multiple-Thick GEM, is under development. It must be capable to handle the rates of particles as high as MHz and it must guarantee a high resolution of the phase space parameters at the focal plane. A tracker prototype has been built and characterized with radioactive sources and beam at the INFN Laboratori Nazionali del Sud in Catania.

Evidence of partial seniority conservation in the $\pi g_{9/2}$ shell for the $N = 50$ isotones.

Pérez-Vidal R.M. per le Collaborazioni AGATA, VAMOS and IKP Plunger
INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy e Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Valencia, Spain

In order to shed light on the open question of the seniority conservation in the proton $g_{9/2}$ orbital in the $N = 50$ isotones, reduced transition probabilities in ^{90}Zr, ^{92}Mo and ^{94}Ru nuclei, have been determined experimentally for the first time via lifetime measurements at the GANIL laboratory. The unconventional use of multi-nucleon transfer reaction with the differential IKP Cologne plunger allowed to measure lifetimes of the yrast low-spin states despite the presence of isomers in the proton-rich isotones. The required sensitivity to the lifetimes could only be achieved due to the excellent performance of the AGATA+VAMOS++

detection system. The $B(E2; 4^+ \to 2^+)$ and $B(E2; 2^+ \to 0^+)$ values for ^{92}Mo and ^{94}Ru and the $B(E2; 4^+ \to 2^+)$ and $B(E2; 6^+ \to 4^+)$ values for ^{90}Zr determined in this experiment will be shown. In this contribution these results will be interpreted on the basis of realistic shell-model calculations in the $f_{5/2}$, $p_{3/2}$, $p_{1/2}$, $g_{9/2}$ proton valence space, where it emerges that seniority is conserved in the first $\pi g_{9/2}$ orbital.

Upgrade of the CMS muon trigger at high-luminosity LHC: The drift tube slice-test.

Lunerti L.
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The CMS barrel muon spectrometer is instrumented with drift tubes (DT): gas-ionizing detectors providing both tracking and trigger capabilities. In order to handle the unprecedented event rate expected at High-Luminosity LHC (HL-LHC), the current frontend readout and trigger electronics will be replaced with a new architecture. Within this upgraded system, the backend electronics will then process full resolution hits from the detector, allowing for an improved, offline-like, reconstruction of track segments already at trigger level. During the second LHC long shutdown, prototypes of the upgraded electronics were installed in four DT chambers as an early test of the HL-LHC DT setup (so-called slice-test). Performance measurements of the upgraded DT trigger, based on cosmic data-taking with the slice-test which includes upgrade and legacy electronics chains, will be presented.

Fast simulation of the IDEA detector concept for a future very large circular leptonic collider.

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The IDEA detector concept was devised by several INFN groups for exploitation at a future very large circular leptonic collider. IDEA is considered for both FCC-ee at CERN and CEPC in China and is described in the respective Conceptual Design Reports. IDEA is composed of a silicon pixel micro vertex detector, followed by a large wire chamber ensuring an excellent PID, surrounded by a light superconducting solenoid. After the magnet there is a preshower detector, a dual-readout calorimeter and finally a muon detection system. A fast simulation of IDEA has been developed using the DELPHES framework specifically designed to simulate the response of a multipurpose detector. Important improvements have been obtained with the introduction of a module that computes the full covariance matrix to smear the track parameters. Different generators can be used with DELPHES to generate the processes of interests such as Pythia8 and Madgraph. With the current IDEA's DELPHES module, different physics benchmark channels have been studied and some of the most recent results will be shown. This fast simulation will be instrumental to study possible design improvements of the IDEA subdetectors.

Study of intruder states towards ^{78}Ni with lifetime measurements following ^{82}Se(d, p)^{83}Se.

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Quadrupole interaction between protons and neutrons drives the nucleus into deformed configurations at low excitation energies. Since ^{83}Se is at the mid of the proton shell ($Z = 28$–40), it is a good candidate to study the properties of particle-hole intruder states lowered in energy by large quadrupole correlations. The measurement of the lifetime of the low-lying intruder state with spin $1/2^+$, originating from $s_{1/2}$, will provide information on its wave function and guidance on what to expect for more exotic $N = 49$ isotones. It will also allow one to estimate the degree of $N = 50$ core breaking in the ground state of Se isotopes. The lifetime of the 500 keV $1/2^+$ level was measured using the Recoil Distance Method. A beam of ^{82}Se, with intensity 0.1 pnA accelerated at 270 MeV from TANDEM accelerator at LNL-INFN, was sent into a deuterated polyethylene foil (C_2D_4), with thickness 1 mg/cm^2, evaporated on a 6 mg/cm^2 thick gold layer. Then GALILEO γ-array was coupled to SPIDER silicon array, allowing one to obtain the needed channel selectivity through coincidence measurements between γ rays and protons coming from the (d,p) reaction.

First bent wafer-scale sensor in truly cylindrical geometry for the ALICE ITS3 detector.

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An upgrade of the three innermost layers of the ALICE ITS, intended to be installed during the LHC Long Shutdown 3, is under development. The detector concept foresees the usage of curved, wafer-scale Monolithic Active Pixel Sensors. Performance studies on the consequences of bending a single ALPIDE chip (used for the current ITS) have been carried out and the results will be presented. These tests on small sensors open the way to the investigation of a large scale sensor, called super-ALPIDE, composed by 18 non-diced ALPIDE chips, which has been assembled for the first time in a cylindrical shape. Such activity required the development of special shaped FPCs for matrix single-chip readout and special tools and procedures to perform the bending and wire bonding.

Costruzione e qualifica degli outer end-cap local support del pixel detector di ATLAS per l'upgrade HL-LHC.

Vannoli L.
Università degli studi di Genova e INFN Genova

L'attuale Inner Detector dell'esperimento ATLAS sarà sostituito con un nuovo Tracciatore Interno (ITk) per l'operazione in HL-LHC nel 2027. Nella zona dell'end-cap esterna, ITk sarà composto di moduli a pixel alloggiati su semi-anelli (supporti locali esterni) in carbonio. Questi supporti vengono costruiti e qualificati attraverso test termici e metrologici presso i laboratori INFN a Genova. Per monitorare la costruzione e i test dei componenti dei supporti locali è stato realizzato un database di produzione. Inoltre, sono in corso studi per capire l'impatto sulle future tecniche di allineamento software della precisione iniziale della posizione dei rivelatori e i possibili movimenti strutturali.

Search for heavy resonances in a semi-leptonic final state at $\sqrt{s} = 13$ TeV with the ATLAS detector.

Auricchio S.

University of Naples "Federico II"

A search for heavy resonances decaying into WW, ZZ or WZ using proton-proton collision data at $\sqrt{s} = 13$ TeV is reported. The data, corresponding to an integrated luminosity of 139 fb^{-1}, were recorded with the ATLAS detector from 2015 to 2018 at LHC. The search is performed for final states in which one boson decays leptonically, and the other decays hadronically. A Recurrent-Neural-Network–based algorithm has been used to separate vector-boson fusion from Drell-Yan/gluon-gluon fusion production mechanisms. Upper limits on the production cross sections of new resonances are derived in the mass range 300–5000 GeV.

Study of ^{4}He (^{4}He, ^{4}He) ^{4}He* inelastic scattering at the MAGNEX facility.

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A recent *ab initio* calculation of the monopole transition form factor of ^{4}He pointed to a strong dependence on the different realistic potentials used. The inconsistencies met between the recent *ab initio* form factor calculation and the existing data from ^{4}He(e,e$'$)^{4}He* call for further investigation. In order to shed some light on this challenging subject, an exclusive measurement of the ^{4}He + ^{4}He → ^{4}He + ^{4}He* → ^{4}He + ^{3}H + ^{1}H reaction in the region of the first 0+ excited state of ^{4}He was performed at the MAGNEX facility of INFN Laboratori Nazionali del Sud. The ^{4}He ions were momentum analyzed by the MAGNEX spectrometer, while the ^{3}H ions were detected by the OSCAR telescope. The ^{4}He + ^{4}He → ^{4}He + ^{4}He* → ^{4}He + ^{3}He + n reaction was also measured simultaneously thanks to the large momentum acceptance of the MAGNEX spectrometer. The data analysis, including the relevant Monte Carlo simulations and preliminary reaction and structure calculations will be presented and discussed.

Regression deep neural networks for top-quark–pair resonance searches in the dilepton channel.

Guerrieri G.
Università degli Studi di Trieste - Gruppo collegato di Udine e INFN Trieste

Several BSM theories predict the existence of new massive particles decaying to pairs of top quarks $t\bar{t}$. In this concept work, the key observable for such resonance searches, the top-pair system invariant mass $m_{t\bar{t}}$, is reconstructed by training a deep neural network on a sample of simulated SM $t\bar{t}$ events. A regression task is then performed on both SM $t\bar{t}$ events and $Z' \to t\bar{t}$ events, using $m_{t\bar{t}}$ as output parameter. The comparison between this machine learning approach and more traditional system reconstruction techniques highlights a tangible improvement in the ability to correctly reconstruct and resolve a TeV-scale $t\bar{t}$ resonance peak.

Light dark matter seraches with the BDX-mini experiment.

Spreafico M.
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Light Dark Matter (LDM) is the new compelling hypotesis that identifies Dark Matter with new sub-Gev “hidden sector” states, neutral under SM interactions and interfacing with our world through a new interaction. This model, theoretically well motivated and compatible with astrophysical observations, predicts DM particles in the mass range 1 MeV–1000 MeV. Accelerator-based searches using medium-energy beams at the intensity frontier are uniquely suited to explore this scenario. BDX-mini is an experiment installed at Jefferson Lab. that used an intense 2 GeV electron beam impinging on a thick target to produce a forward-boosted secondary beam of light dark matter particles, measured by a dedicated downstream detector. This experiment has accumulated a sizable statistics during a 6 months run in 2020. In this work, BDX-mini data will be analyzed exploring a wide region of the parameter space to set the limits for LDM existence. The analysis process will be fully covered, from the analysis of the waveforms registered in the calorimeter to the evaluation of the upper limits for the main LDM models.

System test setup for the half-rings of the ATLAS pixel detector for the HL-LHC upgrade.

Ressegotti M.
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From 2026 the central tracking system of the ATLAS experiment will be completely replaced for operating at the High Luminosity LHC. The test of the new half-rings for the pixel end-caps requires setups of increasing complexity from simple systems for QA/QC of individual modules down to about -15 °C, to the test of complete half-rings with close-to-final system designs with controlled humidity, CO_2 cooling, X-ray sources and related interlock and safety systems, Data AcQuisition (DAQ) close to the experiment's system and lower temperatures. A proposed design, DAQ and Detector Control System (DCS) for the test setups is described.

Real-time data analysis at LHCb with FPGA-based computing architectures.

Sticchi M.
Uni. Pisa e INFN Pisa

In the next run beginning in 2022, the LHCb software trigger will start reconstructing events at the LHC average crossing rate of 30 MHz. Within the upgraded DAQ system, LHCb established a testbed for new heterogeneous computing solutions for real-time event reconstruction, in view of future runs at even higher luminosities. One such solution is a highly parallelized custom tracking processor ("Artificial Retina"), implemented in state-of-the-art FPGA devices connected by fast serial links. We describe the status of the development of a life-size demonstrator system for the reconstruction of pixel tracking detectors, that will run on real data during Run-3.

Present and future of CP asymmetry measurement in $D^0 \rightarrow K_S K_S$ decays at LHCb.

PICA L.
Uni. Pisa e INFN Pisa

The observation of CP asymmetry in the $D^0 \rightarrow KK, \pi\pi$ decay marked the start of the experimental investigation of CP violation in the up-quarks sector. Additional measurements of CP asymmetries (ACP) in the decays of charm hadrons are crucial to make progress. A good target for further study is the $D^0 \rightarrow K_S K_S$ decay, where a sizable ACP is expected (up to ∼1%). The precision achieved in the recent ACP($K_S K_S$) measurement by LHCb shows promise for further interesting results in the upcoming Run 3. This motivates a focused effort for boosting the efficiency of the LHCb trigger for K_S decays, to make the most of the huge statistics that is going to be collected in the next run.

First results on beta decay in the $A \sim 225$ Po-Fr region from the DESPEC campaign at GSI in 2021.

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(12) *Department of Physics, University of Surrey, Guildford, UK*
(13) *National Physical Laboratory, Teddington, Middlesex, UK*
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The HISPEC-DESPEC Collaboration aims at investigating the inner structure of exotic nuclei formed in fragmentation reactions with decay spectroscopy measurements at GSI, as part of the FAIR Phase-0 campaign. The talk will report on first results of the experiment performed in the spring campaign in 2021, with a focus on beta decay studies in the Po-Fr nuclei in the $220 < A < 230$ island of octupole deformation exploiting the FRS+DESPEC setup. Ion-beta correlations and fast timing techniques will be exploited to attack these exotic nuclei, giving an insight into this hard-to-reach region.

Electric field simulation in the new TPC prototypes of T2K near detector with COMSOL Multiphysics simulation.

Cicerchia M.
INFN Laboratori Nazionali di Legnaro, Legnaro, PD, Italy

The T2K experiment is a long baseline experiment searching for a hint of CP violation in neutrinos by measuring different appearance probabilities of neutrino and antineutrinos. For some years, a vigorous upgrading program of the T2K Near Detector (ND280) has been undertaken to reduce the effects of the systematic uncertainties and achieve the required large statistics. In this extensive program, the Italian INFN groups (Padova, Bari and LNL) are involved in the project for the new TPC field cages. Over the past two years, the field cage prototypes have been constructed and are being tested. Among other tests, the electric field distortions are being measured. The COMSOL Multiphysics simulator was used to carry out the behaviour of the electric field inside the field cage and evaluate the possible distortions. A detailed description of such simulation results will be presented.

Experimental studies of the kaon-nucleus interaction at low energy with X-ray spectroscopy of kaonic atoms: From SIDDHARTA to SIDDHARTA-2 experiment.

Sirghi D. per la Collaborazione SIDDHARTA-2
INFN-LNF e IFIN-HH

In the exotic atoms in which one electron is replaced by a negatively charged kaon, the kaon-nucleus hadronic interaction introduces an energy shift and broadening of the low-lying states of the kaonic atoms. The shift and width can be determined with high precision from the atomic X-ray spectroscopy, and this experimental method provides unique information to understand the low-energy kaon-nucleus interaction at the production threshold. The most precise kaonic hydrogen measurement to date was performed by SIDDHARTA at DAFNE. The kaonic deuterium X-ray measurement, important experimental information missing in the low-energy antikaon-nucleon interactions filed, will be realized by the SIDDHARTA-2 experiment. SIDDHARTINO setup was installed in DAFNE in 2019 aiming to measure kaonic helium, to quantify the background in the new DAFNE configuration, followed by the kaonic deuterium measurement with the SIDDHARTA-2 setup in 2020.

Proposal for a high-precision measurement of the neutron-neutron scattering length at CERN n_TOF facility EAR-2.

Zannoni R.
Dipartimento di Fisica, Università degli Studi di Bologna, Italia

The aim of this thesis is to provide both a collection of scientific documentation and a set of preliminary results for an experiment devoted to the high-precision measurement of the neutron-neutron scattering length. The proposal experiment concerned is planned to take place in EAR-2 experimental area at n_TOF facility. The analysis of the parameter concerned is expected to occur by detecting two low relative momentum neutrons from a deuterium-enriched target breakup reaction by a fast neutrons flux in a energy range between 10 MeV and 100 MeV. The experiment in question is intended to study the extent of strong isospin asymmetry between neutrons and protons. We expect to achieve the neutron-neutron scattering length parameter with at least comparable accuracy with the most precise neutron-proton scattering length. The basic approach of this work is to provide an extensive overview of the past main experimental results in order to analyse the existing flaws and the disputes related to this measure. Afterwards, we define the main theoretical and experimental features of which the experiment must be equipped in order to perform a high-precision measurement of this parameter.

Non-prompt D_s^+ production in pp and Pb-Pb collisions with ALICE.

Politanò S.
Politecnico di Torino, Italia e INFN Torino, Italia

High-energy heavy-ion collisions produce a state of strongly interacting matter in which matter undergoes a phase transition to a colour-deconfined state called quark-gluon plasma (QGP). Strange quarks production in heavy-ion collisions is enhanced, therefore also the production of heavy-flavour hadrons with strange quark content is expected to be enhanced. D_s^+ mesons measurements originating from charm quarks hadronisation and from beauty-hadron decays (non-prompt) are crucial to study the hadronisation mechanisms in the QGP. The results of the ALICE Collaboration on the production of non-prompt D_s^+ mesons with Machine Learning techniques and the expected performance in the next LHC Run are presented.

LHCb heavy-ion physics results and prospects.

Litvinov R.
Uni. Cagliari e INFN Cagliari

Since 2015, LHCb has expanded its heavy-ion physics program by recording lead-lead (PbPb) collisions for the first time. The LHCb detector performances, outstanding for the proton-proton (pp) and the proton-lead (pPb) collisions systems, do however present limitations in the reconstruction of high-multiplicity events, mainly due to the tracking algorithms which were designed for low-multiplicity pp collisions. This limitation also affects the latest PbPb data recorded in 2018 and it will be a challenge in Run 3 (starting in 2022), although significantly reduced thanks to the upgrades of the LHCb detector. After summarizing the results achieved so far, we discuss the strategy for PbPb data taking and the related physics prospects.

A Silicon Strip Sensor readout ASIC for the PANDA MicroVertex Dector.

Mazza G., Calvo D., Cossio F., Mignone M., Wheadon R.
INFN sez. di Torino, Italia

A 64 channel Application-Specific Integrated Circuit has been designed for the readout of the Silicon Strip Detectors that will equip the Micro Vertex Detector of the PANDA experiment. The ASIC, named ToASt, provides both time of arrival and released energy measurement of the particle crossing the detector. The analog front-end consists of two parts: a charge sensitive amplifier followed by a shaper with programmable integration time and a signal integrator with programmable discharge current for linear ToT measurement. The ASIC is synchronous to a 160 MHz master clock, which also sets the time resolution. A common time reference, generated by a Gray-encoded 12 bits counter and distributed to all channels, provides the time reference. The time of arrival of both the rising and the falling edge of the analog front-end are recorded and transmitted, together with the channel address, via two serial links. The ASIC is implemented in a commercial CMOS 0.11 μm technology. The Triple Modular Redundancy technique has been implemented in most of the digital logic to protect the circuit from Single Event Upsets. The design is part of the FairNet EU project.

A comprehensive experimental and theoretical approach applied to the ^{12}C(^{18}O, ^{18}F)^{12}B single charge exchange reaction at 275 MeV.

Spatafora A. (1)(2)per la Collaborazione NUMEN
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A full understanding of the reaction mechanisms involved in double and single charge exchange nuclear reactions is mandatory for the purposes of the NUMEN project. An interesting case study to test the capability of state-of-the-art nuclear reaction and nuclear structure theories is the net of nuclear reactions involved in the ^{18}O + ^{12}C collision at 275 MeV incident energy. The experiment has been performed at the INFN-LNS and the experimental results and the theoretical analysis for the single charge exchange, elastic and inelastic scattering, one-neutron addition and one-proton removal nuclear reactions will be discussed during the communication. The main purpose of this work is to describe the newly extracted experimental cross-sections in a full comprehensive theoretical framework in which the reaction channels are treated consistently. Few of the many aspects that play a relevant role in the description of single charge exchange are the role of the couplings with the low-lying excited states of the involved nuclei, the choice and tuning of the imaginary part of the optical potential and the competition between the direct and the sequential reaction mechanisms.

SiPM timing measurement studies with charged particles for a new ALICE detector at the LHC.

Vignola G.
Department of Physics, University of Bologna, Italy

As a successor of the ALICE experiment at CERN LHC, a next generation experiment for heavy-ion physics at the LHC is currently in preparation: ALICE 3. The idea is to have an all-silicon tracker with precise tracking, vertexing and timing capabilities. In particular, to allow particle identification via Time of Flight techniques, a detector capable of 20 ps time resolution positioned at 1 m from the interaction point is being investigated. To this purpose, a huge R&D phase on different technologies for silicon timing sensors has just begun. Preliminary studies will be reported. In particular, the very first study on time resolution using a SiPM detector directly detecting charged particles will be discussed. The results will include tests with cosmic rays and a comparison with laser measurements.

Excited light systems at Fermi energies investigated with HIPSE and AMD.

Frosin C.
Dipartimento di Fisica, Università di Firenze, Italy e Sezione di Firenze, Italy

Four different reactions (^{32}S/^{20}Ne+^{12}C at 25 and 50 MeV/u) have been studied and compared with Monte Carlo simulations using the heavy ion phase space exploration (HIPSE) and the antisymmetrized molecular dynamics (AMD) models for the dynamical phase. In the latter case, the impact of the clusterization effect to form smaller fragments ($2 < A < 9$) is investigated. The models are combined with the Hauser-Feshbach Light (HFl) as an afterburner to simulate the decay of the excited primary fragments. In this context several observables, such as angular distributions and energy spectra, have been extracted and compared with the available experimental data. It is found that the cluster correlations take a crucial role into describing the productions of light charged particles and intermediate mass fragments. The AMD cluster model studied here provides a consistent overall reproduction of the experimental data, especially at 25 MeV/u beam energy where the degree of initial energy dissipation is better reproduced with respect to the higher energy case and with respect to HIPSE.

Characterization and modeling of the SiPM of the TOF-Wall detector of the FOOT experiment.

Montefiori M.
Dipartimento di Fisica, Università di Pisa, Italia

FOOT (FragmentatiOn Of Target) is an applied nuclear physics experiment aiming to perform cross section measurements for nuclear fragmentation reactions of interest in particle therapy. The charge identification of particles is performed through a ΔE-TOF system composed of two detectors. One of them, the TOF-Wall (TW) is composed of two orthogonal layers of 20 bars of plastic scintillator. Each end of the bar is optically coupled at 4 readout Silicon Photomultipliers (SiPMs). We investigated the impact of SiPMs on energy resolution performance of TW by studying their mean parameters and the response at an external pulsed light and including the obtained results in a Monte Carlo simulation of the SiPM response. The outcomes were studied to determine the energy resolution for different particles and by varying the operation parameters of the SiPMs. Results have shown a resolution worsening of about 1% due to SiPMs contribution. Moreover, simulation highlighted that the main operational parameter of SiPMs in energy measurement degradation is the PDE, which impact is relevant for low overvoltage.

The CMS DT Detector Safety System for the Phase2 upgrade at CERN HL-LHC.

De Remigis P., Dattola D., Maselli S., Rotondo F., Wheadon R., per il Gruppo CMS DT
INFN Torino

The front-end and the back-end electronics of the CMS Drift Tubes (DT) chambers will be significantly redesigned for the upgrade of the LHC (HL-LHC) at CERN. In particular, the upgraded front-end readout system will be based on a new card called On Board electronics for DT (OBDT). This card, which will be placed on the edge of the muon chamber, receives signal hits from each analog front-end circuit and hosts a multi channel time to digital converter implemented in a radiation-tolerant Field-Programmable Gate Array. During the upgrade, the Detector Safety System (DSS) of the DT front-end electronics will also undergo a redesign, which entails the development of a new hardware called MONitor for SAfety (Monsa) system. The Monsa system will react to the OBDT signals when an excess of current, voltage or temperature is detected, and it will transfer the information to the central CMS DSS in the counting room. In addition, the Monsa hardware will be capable of switching off or on each single readout card on the whole DT detector. The Monsa system will improve the detector safety and robustness during operations and provide new control features with an increased modularity of the DT detector.

CYGNO —A directional Dark Matter search experiment.

Torelli S.
GSSI, L'Aquila

CYGNO is an international collaboration aiming at developing an optically readout TPC for directional Dark Matter searches in the 1–10 GeV/c^2 WIMP mass range. The CYGNO demonstrator will consist of a 1 m^3 active volume, in a 50 cm drift back-to-back TPC configuration, filled with He-CF_4 gas (atmospheric pressure and room temperature), to be installed in the underground facilities of Laboratori Nazionali del Gran Sasso (INFN-LNGS). Conceived as an optical TPC, CYGNO will explore the unique combination of the TPC and the high-granularity and fast response of the most modern photosensors available (sCMOS and PMTs) to provide a detailed reconstruction of the event's topological signature, expected to result in a promising particle identification capability, essential to discriminate events taking place inside the detector's active volume. In the talk, the studies on the background, the expected performances, and the DM sensitivity with the 1 m^3 detector, based on the results obtained with the previous prototypes will be presented.

Test recenti sulla costruzione di un nuovo correlatore per neutroni e particelle cariche.

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Con l'avvento delle nuove facility per fasci radioattivi prevalentemente ricchi di neutroni, si pensi a SPES@LNL, a FRAISE@LNS a FAIR@GSI, per fare qualche esempio, diventa sempre più importante l'utilizzo di rivelatori per fisica con Ioni Pesanti atti alla rivelazione del segnale neutronico con alta risoluzione energetica ed angolare. Nel contributo saranno illustrati i risultati di recenti test eseguiti sui nuovi materiali plastici come l'EJ276 sia nella versione "green-shifted" che in quella ordinaria, in accoppiamento con PMT e Si-PMT. Tali lavori sperimentali sono volti alla costruzione di un prototipo di rivelatore per neutroni e particelle cariche con alta risoluzione energetica ed angolare.

Study of the $D(p,\gamma)^3$He angular distribution at LUNA.

MOZUMDAR N., PER LA COLLABORAZIONE LUNA
Università degli Studi di Padova, Padua, Italy

The Big Bang Nucleosynthesis (BBN) reaction of deuterium burning $D(p,\gamma)^3$He has the largest uncertainty which limits the theoretical predictions based on BBN. A recent work reports the cross sections for the $D(p,\gamma)^3$He reaction in the energy range of $30 < E_{cm} < 260$ keV with minimised uncertainties ($< 3\%$) based on an experiment carried out at the Laboratory for Underground Nuclear Astrophysics (LUNA) of the Gran Sasso Laboratory (Italy). In the current work we report a systematic study of the angular distribution of this reaction based on the same experimental data. The full energy peak, broadened due to the kinematics, has been fit using Legendre polynomial distribution. The coefficients obtained from the fit have been compared to those predicted by *ab initio* calculations.

Studio del breakup del quasi-proiettile in reazioni semiperiferiche di ^{64,58}Ni+^{64,58}Ni a 32 AMeV e 52 AMeV con l'apparato INDRA-FAZIA.

CIAMPI C. (1)(2)PER LA COLLABORAZIONE FAZIA
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Le collisioni tra ioni pesanti sono un ottimo strumento per studiare le proprietà della materia nucleare in condizioni di temperatura e densità lontane da quelle standard. In questo lavoro ci occupiamo di collisioni alle energie intermedie, o energie di Fermi, regione di transizione tra le collisioni a basse e ad alte energie, con l'obiettivo di ottenere informazioni sulla Nuclear Equation of State (NEoS). In questa comunicazione verranno presentati i risultati dell'analisi dei dati raccolti con l'apparato INDRA-FAZIA durante l'esperimento E789, che ha avuto luogo tra aprile e maggio 2019 a GANIL (Caen, FR) e che ha visto per la prima volta l'uso accoppiato dei due apparati. Le reazioni sotto esame sono ^{64,58}Ni+^{64,58}Ni a 32 AMeV e 52

AMeV. Ci soffermeremo soprattutto sulle reazioni semiperiferiche e periferiche, e particolare attenzione verrà riservata allo studio delle variabili legate all'isospin nel canale di breakup del quasi-proiettile. Le osservazioni fatte su quest'ultimo canale di reazione verranno inoltre confrontate con le caratteristiche ottenute per il canale di evaporazione del quasi-proiettile.

Confronting EFT Higgs portal with concrete completions.

Arcadi G.
Università di Roma Tre

Higgs portal models are very popular tools to interprete the outcome of direct and collider searches of Dark Matter. Their effective viability as benchmarks is investigated, especially for collider studies, by comparing them with increasingly refined theoretical completions.

Study of proton captures on carbon isotopes at LUNA.

Skowronski J.
Università di Padova, INFN e LUNA

Cross-section measurements at astrophysical energies often require the use of solid targets able to withstand high ion beam currents. Hence, it is crucial to monitor the target degradation during irradiation. One approach is the extraction of the target profile from the measured shape of a primary γ-peak. This procedure was refined and applied to $^{12}\mathrm{C}(p,\gamma)^{13}\mathrm{N}$ and $^{13}\mathrm{C}(p,\gamma)^{14}\mathrm{N}$ reactions measured by the LUNA Collaboration at LNGS. These are particulary important as $^{12}\mathrm{C}/^{13}\mathrm{C}$ ratio is a sensitive indicator of the degree of stellar nucleosynthesis. The experimental data taking and analysis will be discussed underlining the new implementation of the peak shape approach.

The experimental setup of FAMU to measure the proton Zemach radius.

Baruzzo M. per la Collaborazione FAMU
INFN, Sezione di Trieste e Università di Udine

The FAMU experiment data acquisition is approaching. During September 2022 the full experimental setup is going to measure for the first time the muonic hydrogen ground state hyperfine splitting and obtain a precise measurement of the proton Zemach radius, shedding some new light on the proton radius puzzle. This result will not be possible without a complete system which joins nuclear and laser physics. The FAMU setup is formed by a gas cryogenic target filled with a mixture of hydrogen and oxygen in which muons injected from the RIKEN-RAL facility (UK) are stopped. The muonic hydrogen produced is then exposed to a tunable infrared laser beam, unique for its energy and narrow linewidth, able to induce the hyperfine energy jump. The transition will be measured as a variation of the muonic transfer rate from hydrogen to oxygen, observed through the detection of the X-rays emitted during the de-exitation of muonic oxygen. This presentation will describe the final setup which is being installed in all its parts.

Study of the single-nucleon transfer reactions in the $^{18}\mathrm{O}+^{48}\mathrm{Ti}$ collision at 275 MeV.

Sgouros O. (1), Cutuli M. (1)(2), Cavallaro M. (1), Cappuzzello F. (1)(2), Carbone D. (1), Agodi C. (1) per la Collaborazione NUMEN
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Single-nucleon transfer reactions are considered among the best resources for probing single particle configurations in the populated many-body nuclear states. Besides a valuable spectroscopic tool, transfer reactions offer also an insight of the reaction dynamics. An example is the study of the degree of competition between sequential nucleon transfer and charge exchange reactions, the latter being of particular interest in the context of single and double beta decay studies. In this context, one-proton and one-neutron transfer reactions for the system $^{18}O+^{48}Ti$ were measured at the energy of 275 MeV for the first time under the NUMEN and NURE experimental campaigns. The experiment was carried out at the MAGNEX facility of INFN-LNS in Catania. Angular distribution measurements for the reaction ejectiles were performed by using the MAGNEX large acceptance magnetic spectrometer. The data were analyzed by using two different reaction models aiming at validating the adopted reaction and nuclear structure inputs as well as to study coupled channels effects. The results of the analysis will be presented and discussed.

Nuove tecniche senza traccia per il b-tagging ad alto impulso nell'esperimento ATLAS.

Tanasini M., Coccaro A., Schiavi C.
INFN, Sezione di Genova

L'identificazione di jet prodotti dall'adronizzazione di quark b (b-tagging) è un elemento cruciale del programma di fisica dell'esperimento ATLAS. L'identificazione si basa su informazioni discriminanti estratte dalle tracce e dai vertici ricostruiti all'interno dei jet. Con l'aumentare dell'impulso del jet, tuttavia, le problematiche sperimentali si fanno più complesse anche a causa della maggiore densità di particelle contenute e della relativa diminuzione dell'efficienza degli algoritmi di ricostruzione di traccia. Il lavoro presenterà nuove tecniche di b-tagging basate sullo studio dei segnali prodotti dalle particelle cariche nei singoli strati dei rivelatori traccianti che consentono di migliorare l'efficienza di identificazione dei b-jet ad alto impulso.

Readout electronics and DAQ software for micro-pattern gas detectors.

Bortone A. (1)(2)on behalf of the BESIII Italian Collaboration
(1) *Dipartimento di Fisica, Università degli studi di Torino*
(2) *Istituto Nazionale di Fisica Nucleare, sezione di Torino*

Micro-pattern gas detectors allow excellent performance keeping a low material budget. To keep the pace with the technology progress, readout electronics with specific characteristics need to be developed. A custom readout chain was designed for data acquisition of such detectors, in the frame of the CGEM-IT project. The system consists of a custom ASIC (TIGER), an FPGA-based off-detector module (GEMROC) and the Python-based control and DAQ software, called GUFI. The structure and features of the system will be presented, together with the field-test performance from a beam-test foreseen for July 2021 and from the running CGEM-IT tests.

Identificazione del flavor dei jet di particelle tramite una rete neurale profonda nell'esperimento ATLAS.

Di Luca A., Iuppa R.
Università di Trento, Fondazione Bruno Kessler e TIFPA

L'identificazione dei jet di particelle prodotti dall'adronizzazione di un quark b (in gergo "b-tagging") rispetto ai jet prodotti da quark più leggeri è molto rilevante per le analisi dell'esperimento ATLAS al Large Hadron Collider. Infatti molti processi interessanti per lo studio del Modello Standard contengono nello stato finale quark b. Per raggiungere una maggiore efficienza di identificazione, diversi tipi di informazioni, sia basate sulla topologia degli eventi ma anche prodotte da altri algoritmi di classificazione degli eventi, possono essere combinate insieme per risolvere questo compito. Per far ciò, è stato sviluppato un nuovo classificatore basato su una rete neurale profonda, chiamato DL1. Dopo aver discusso la struttura di DL1 e la strategia adottata per il training della rete neurale profonda, riporteremo un confronto con i precedenti classificatori utilizzati dalla collaborazione basati su Boosted Decision Trees.

Thickness characterization of the HERETIC target system prototypes.

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The NUMEN Experiment, based at INFN-LNS, aims to get information on the Nuclear Matrix Elements of the Neutrinoless Double Beta Decay, by measuring Double Charge Exchange reactions cross-sections. To get a good energy resolution, the target thickness and its non-uniformity must be minimized. Moreover, to allow heat dissipation (intense beams will be used), an innovative target system has been designed: around 400 nm of target isotope will be deposited on 2 μm thick Highly Oriented Pyrolytic Graphite substrate, that has high in-plane thermal conductivity. An experimental beam test, named HEat REsistance Test (HERETIC), will be performed at the INFN-LNL facility to study the heat dissipation capability of the designed target system. The germanium and tellurium target prototypes that will be used during the HERETIC beam test have been produced and characterized. Thickness and uniformity analysis performed by Alpha-Particle Transmission, Rutherford Backscattering Spectroscopy and Field Emission Scanning Electron Microscopy will be presented.

Studio del canale $H \to c\bar{c}$ ad un collisore di muoni.

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(8) *INFN sezione di Bologna, Italia*
(9) *Lawrence Berkeley National Laboratory, California, USA*

Uno dei possibili obiettivi della Strategia Europea per la Fisica delle Particelle è la realizzazione di un collisore di muoni ad energie oltre il TeV e alta luminosità. Tale macchina permetterebbe di misurare gli accoppiamenti del bosone di Higgs (H) ai fermioni di seconda generazione con grande precisione. Presenteremo, per la prima volta, uno studio del processo $H \to c\bar{c}$ ad un collisore di muoni. Abbiamo simulato e ricostruito il segnale ed i fondi principali del Modello Standard e sviluppato un algoritmo di identificazione dei jet da quark c usando tecniche di Machine Learning. Mostreremo una stima preliminare dell'accoppiamento Hcc.

Towards muon-electron scattering at NNLO.

Budassi E. (1), Carloni Calame C.M. (2), Chiesa M. (1), Mehedi Hasan S. (2), Montagna G. (1), Nicrosini O. (2), Piccinini F. (2)
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The proposed MUonE experiment at CERN aims at providing a new determination of the leading order hadronic contribution to the muon anomalous magnetic moment via the study of elastic muon-electron scattering at small momentum transfer. The required accuracy of the order of 10 ppm demands for high-precision predictions, including all the relevant radiative corrections. The theoretical formulation for the fixed-order NNLO photonic radiative corrections is described and the impact of the numerical results obtained with the corresponding Monte Carlo code is discussed for typical event selections of the experiment. In particular, the gauge-invariant subsets of corrections due to electron and muon radiation separately are treated exactly. The two-loop contribution due to diagrams where at least two virtual photons connect the electron and muon lines is approximated taking inspiration from the classical Yennie-Frautschi-Suura approach. The calculation and its Monte Carlo implementation pave the way towards the realization of a simulation code incorporating the full set of NNLO corrections matched to multiple photon radiation, that will be ultimately needed for data analysis.

Two-loop QED correction to the mu-e elastic scattering.

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In this talk we present the analytic evaluation of the two-loop QED corrections to the mu-e elastic scattering, retaining the full dependence on the muon mass and considering the electron as a massless particle. These virtual corrections are relevant for the analysis of the MUonE experiment, recently approved at CERN, aimed at a high precision measurement of the leading hadronic contribution to the anomalous magnetic moment of the muon, providing an independent determination of the latter. We discuss the generation of integrands from Feynman diagrams, as well as the evaluation of the latter by recalling the analytic expressions of their two-loop master integrals and the renormalization procedure, that will lead to a UV finite amplitude. We also comment that this calculation can straightforwardly be applied to crossing related processes like di-muon production, $e^+e^- \to \mu^+\mu^-$.

Search for four-top-quark production in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector.

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The recent search for four-top-quark production in the single-lepton and opposite-sign dilepton channels is presented. A multivariate technique is used to discriminate between signal and background events. The dominant background coming from top-quark pair production in association with jets is estimated using data-driven corrections applied to Monte-Carlo simulation. The measured four-top-quark production cross section is found to be 26^{+17}_{-15} fb, with a corresponding observed (expected) significance of 1.9 (1.0) standard deviations over the background-only hypothesis. The result is combined with the previous measurement performed by the ATLAS Collaboration in the multilepton final state.

Effetti di isospin in collisioni che portano alla formazione di superpesanti.

Cabibbo M.
Laboratori Nazionali del Sud, Catania

Nell'ambito della teoria delle collisioni che portano alla formazione di superpesanti si presenta un progetto la cui idea centrale consiste nella realizzazione di un modello ibrido che vede accoppiati un calcolo microscopico del tipo TDHF (time-dependent Hartree-Fock) con un modello statistico evaporativo di tipo Monte Carlo. Con il nuovo strumento di calcolo, che tiene conto dell'evoluzione dinamica della GDR (preequilibrio), si vuole valutare quanto il raffreddamento del sistema fuso, in seguito all'emissione gamma (GDR) di preequilibrio, favorisce la formazione del superpesante cercato, nel caso in cui il canale d'ingresso è caratterizzato da un'asimmetria di carica.

Search for Higgs boson pair production in the $b\bar{b}\gamma\gamma$ final state with the ATLAS experiment.

Mazzeo E.
Università degli Studi di Milano

A search for di-Higgs boson production in the $b\bar{b}\gamma\gamma$ final state is performed, using data collected by the ATLAS experiment during the Run2 of the LHC, amounting to an integrated luminosity of 139 fb^{-1}. Studying the production of Higgs boson pairs constitutes a direct probe to the structure of the Higgs potential, responsible for the mechanism of electroweak symmetry breaking in the Standard Model. While no excess with respect to background expectations is found, upper limits on the di-Higgs production cross section are derived, and an exclusion interval on the Higgs boson trilinear coupling modifier κ_λ is set.

Studio del canale $H \to ZZ^* \to 4\mu$ ad un collisore di muoni.

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Un collisore di muoni rappresenta la macchina ideale per raggiungere elevate energie nel centro di massa e luminosità. In tale contesto, verrà presentato, per la prima volta, uno studio di fattibilità del processo di produzione del bosone di Higgs (H) e decadimento nel canale $H \to ZZ^* \to 4\mu$. Lo studio dei 4 muoni nello stato finale permette di ottimizzare la ricostruzione di muoni e fornisce riscontri utili alla progettazione dei detector. Questo studio è basato su simulazioni Monte Carlo di eventi di segnale, fondo irriducibile e fondo indotto dalle interazioni dei muoni dei fasci e fornisce una stima preliminare della precisione nell'accoppiamento HZZ.

Study on the transition probability discrepancy along the $N = 28$ neutron shell closure via direct transfer reaction on ^{46}Ar.

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The evolution of the nuclear shell closure along $N = 28$ has gathered interest due to the observed discrepancies between the well established shell model with SDPF-U interaction and measurements of the half-magic ^{46}Ar isotope. While remarkable agreement was observed between theoretical and experimental values of S_n, transition probabilities measured with intermediate Coulomb excitation diverge by a factor of two from their predicted values. The reason behind this mismatch has been pinned down to the proton transition matrix elements and hints at an incorrect description of the sd proton space below $Z = 20$. The experiment we proposed aimed at shedding light on the matter by directly probing the proton component of the wave function via a proton-pickup direct reaction: ^{46}Ar(^{3}He, d)^{47}K at an energy of 350 MeV. The experiment, performed in GANIL with a radioactive ^{46}Ar beam impinging on a cryogenic ^{3}He target, will assess the amount of $d_{3/2}$ state relative to the $s_{1/2}$ relying on the VAMOS+MUGAST+AGATA setup for a complete reconstruction of the reaction. Experimental results will be compared with theoretical models to infer information on the proton wave function of ^{46}Ar.

Studi sulla misura della vita media effettiva del mesone B_s^0 nel suo decadimento in due muoni con l'esperimento ATLAS.

Raffaeli F.
Università degli Studi di Roma Tor Vergata

Il decadimento dei mesoni B^0 e B_s^0 in due muoni è fortemente soppresso nel Modello Standard poiché mediato da processi di tipo FCNC. Perciò i due Branching Ratio e la vita media effettiva del decadimento del B_s^0 in due muoni sono grandezze particolarmente sensibili a scenari di nuova fisica. In questa presentazione particolare attenzione verrà data agli studi preliminari sulla misura della vita media del B_s^0 in due muoni, quantità mai misurata dalla collaborazione ATLAS ad oggi. La selezione degli eventi, l'ottimizzazione del rapporto segnale/fondo e la precisione attesa nell'estrazione della vita media effettiva del decadimento saranno discussi e illustrati.

Ricerca di produzione diretta di coppie di $\tilde{\chi}_1^+\tilde{\chi}_1^-$ che decadono in $W^+\tilde{\chi}_1^0 W^-\tilde{\chi}_1^0$ in stati finali con due leptoni, in regioni a "mass splitting" $m(\tilde{\chi}_1^\pm) - m(\tilde{\chi}_1^0) \sim m(W)$, nei dati raccolti dall'esperimento ATLAS nel Run 2 di LHC.

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La Supersimmetria rappresenta una delle teorie più eleganti fra le estensioni del Modello Standard delle Particelle Elementari, e ormai da tempo si cercano estensivamente sue evidenze ad LHC. Vengono qui illustrati i risultati della ricerca di produzione elettrodebole di coppie di chargini ($\tilde{\chi}_1^+\tilde{\chi}_1^-$) che decadono in un bosone $W^{\pm}$ e nel primo neutralino ($\tilde{\chi}_1^0$), in regioni dello spettro delle masse cosiddette “moderatamente compresse”, in cui $m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0) \sim m(W)$. La ricerca è condotta nel canale con due leptoni, energia trasversa mancante e assenza di jet adronici nello stato finale, analizzando i dati raccolti dall’esperimento ATLAS durante il Run 2 di LHC, corrispondenti ad una luminosità integrata di 139 fb^{-1}.

Multi-channel–constrained analysis of heavy-ion charge exchange reactions: The ^{18}O+^{40}Ca case at 15 AMeV.

Calabrese S. per la Collaborazione NUMEN
Laboratori Nazionali del Sud, INFN, Catania, Italia

Heavy-ion–induced charge exchange reactions arouse a renewed interest in nuclear physics due to their possible link with neutrinoless double beta decay. Their accurate measurement, under specific experimental conditions, represents the goal of the NUMEN project, which is currently ongoing at INFN-LNS. The obtained promising experimental results highlight the need of stricter model constrain to perform an accurate analysis of the charge exchange mechanisms. In particular, the competitive processes like multi-nucleon transfer reactions and the initial/final state interactions must be assessed. For such reason, neutron/proton transfer as well as elastic and inelastic scattering reactions are also investigated under the same experimental conditions and then analyzed. In this contribute, the described approach and the obtained results will be presented and discussed for the ^{18}O+^{40}Ca system at 15 AMeV.

Approccio multivariato per la riduzione del fondo dominante nel canale di analisi ATLAS di produzione del bosone di Higgs associato al bosone W con decadimento leptonico.

Camerlingo M.T.
Università degli studi di Roma Tre, Sezione INFN Roma Tre e CERN

La ricerca sul bosone di Higgs rimane uno dei principali obiettivi dell’esperimento ATLAS. L’Higgs può essere prodotto in associazione ad un bosone mediatore dell’interazione debole, e decadere in due bosoni W, costituendo un diretto accesso all’accoppiamento dell’Higgs con essi. Un’analisi in corso sui dati raccolti da ATLAS nel Run II di LHC considera eventi WH, come eventi di segnale, e tre leptoni isolati ed energia mancante, come stato finale. La sensitività del segnale è affetta da fondi riducibili ed irriducibili. Si è, quindi, implementata una rete neurale per migliorare la discriminazione tra gli eventi WH e WZ, fondo irriducibile dominante.

L’upgrade del tracciatore a barre scintillanti di ASACUSA.

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La collaborazione ASACUSA (Atomic Spectroscopy And Collisions Using Slow Antiprotons) è attiva presso l’Antiproton Decelerator al CERN e si propone di studiare le proprietà dell’antimateria formando atomi di anti-idrogeno. Alcuni dei rivelatori dell’esperimento sono stati recentemente rinnovati e, fra questi, i piani di barre scintillanti necessari a tracciare i pioni carichi provenienti dalle annichilazioni degli antiprotoni. I fotomoltiplicatori multianodo, usati per la raccolta della luce di scintillazione, sono stati sostituiti da SiPM e l'elettronica di front-end adattata di conseguenza. In questo intervento verranno descritte le diverse fasi dell'upgrade, dalla progettazione ai primi test, fino all'installazione in area sperimentale.

ECR plasma investigation by simultaneous Optical Emission Spectroscopy and Microwave Polarimetry measurements.

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In the framework of the PANDORA (Plasma for Astrophysics, Nuclear Decays Observation and Radiation for Archaeometry) project an innovative multi-diagnostic method for the characterization of the Electron Cyclotron Resonance (ECR) plasma parameters in compact trap has been developed. In PANDORA, the plasma properties investigation is important for several purposes: a) to determine the plasma density and temperature during β-decay measurements; b) to characterize the plasma properties during plasma opacity measurements that are of potential interest for kilonovae. In this work we will present the experimental hydrogen plasma characterization, carried out in an ECR plasma trap (called Flexible Plasma Trap) at INFN-LNS, by simultaneously Optical Emission Spectroscopy (OES) and Microwave Polarimetry for different conditions of neutral pressures, microwave powers and magnetic field profiles. OES provides a method to determine electron density for the cold electrons population (few tens eV of temperature), whilst the Microwave Polarimetry allows to determine the total mean electron density along the line of sight.

Lifetime measurements in ^{105}Sn.

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The nuclear shell model has proven to be a very effective tool for the understanding of the nuclear structure, especially for magic nuclei and their neighbours. One of the main goal of nuclear physics research is to investigate the evolution of the original shell closures when moving far from stability. The region close to the doubly magic and self-conjugated nucleus ^{100}Sn has been intensively studied in the last decades in order to prove the robustness of the double-shell closure $Z = N = 50$ and investigate nuclear structure at this very edge of the Segrè chart. In this context, the spectroscopy of the Sn isotopic chain down to ^{101}Sn becomes crucial. In this contribution I will present the details and the results of an experiment for the measurement of the lifetime of nuclear excited states in the nucleus ^{105}Sn. The obtained lifetime values, in particular for the $7/2^+$ and the $11/2^+$ excited states, are of special interest for the study of nuclear structure close to ^{100}Sn: they provide additional constraints for shell model calculations which help to improve the definition of the nucleon-nucleon interaction as well as the one of the valence space.

Simulating V+jets processes at ATLAS.

Frattari G.
Sapienza Università di Roma e INFN Roma

The production of a vector boson in association with hadronic jets is one of the most frequent background processes to precision measurements and new physics searches carried out at the LHC. One frequent issue for these analyses comes from the limited amount of events which is possible to produce with a fixed computing budget. Different methods have been investigated to optimise statistical power of the simulated samples via phase-space biasing during the Monte Carlo event generation. The recent developments from the ATLAS Collaboration will be presented, with a focus on the techniques adopted for mass production of Monte Carlo events.

Ricerca di decadimenti invisibili del bosone di Higgs nel canale di produzione VBF con l'esperimento ATLAS ad LHC.

Padovano G.
Sapienza Università di Roma e INFN Roma

Numerose osservazioni cosmologiche suggeriscono l'esistenza della Materia Oscura, descritta da teorie oltre il Modello Standard. Alcuni modelli prevedono la possibilità che il bosone di Higgs possa accoppiarsi con particelle di Materia Oscura, dando luogo a decadimenti invisibili. In questo intervento verranno presentati i più recenti risultati ottenuti dall'esperimento ATLAS nella ricerca di decadimenti invisibili del bosone di Higgs, utilizzando stati finali con due jet adronici ed impulso mancante nel piano trasverso e sfruttando il campione di dati del Run2 di LHC a $\sqrt{s} = 13$ TeV. Verranno inoltre discussi brevemente i risultati che si ottengono aggiungendo un fotone nello stato finale ricercato.

Test di risposta di FARCOS in stabilità e temperatura.

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Il correlatore FARCOS è costituito, nella sua configurazione finale, da 20 telescopi, ognuno dei quali possiede due stage di Double-Sided Silicon Strip Detectors, seguiti da quattro cristalli di CsI(Tl). FARCOS, in modalità stand-alone o accoppiato al rivelatore CHIMERA dei LNS, si presta allo studio di reazioni tra ioni pesanti alle energie intermedie, incluse quelle indotte da fasci di ioni radioattivi. Sono state analizzate le caratteristiche di risposta dei DSSSD utilizzati, studiando gli spettri di particelle α acquisiti con tecniche digitali (campionamento) al variare delle caratteristiche degli algoritmi di filtraggio e della temperatura delle motherboard di FARCOS, allo scopo di individuare i parametri di filtraggio che consentono risoluzioni di ~ 10 keV per strip.

Status of the PANDORA project at INFN-LNS: In-plasma β-decay investigations of nuclear astrophysical interest.

NASELLI E. PER LA COLLABORAZIONE PANDORA
INFN - Laboratori Nazionali del Sud, Catania, Italy

The status updates of the PANDORA (Plasmas for Astrophysics, Nuclear Decays Observation and Radiation for Archaeometry) project (procurement, models and construction) are here presented. PANDORA aims at measuring in-plasma nuclear β-decays lifetimes, correlating plasma parameters to nuclear activity. A high-performance Electron Cyclotron Resonance (ECR) plasma trap, in combination with a plasma multi-diagnostics setup working synergically with a γ-rays detection system (in order to tag the in-plasma β-decays), has been conceived. Here we will also discuss preliminary results concerning simulations of a virtual experimental run, including the feasibility of decay rates measurements (in terms of 3σ confidence level) of several nuclei involved in s-processing nucleosynthesis.

Study of strangeness production in pp as a function of the charged particle multiplicity and the effective energy with ALICE at the LHC.

ERCOLESSI F.
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ALICE results in pp have shown an increase in the ratio of strange baryons to pions with the charged particle multiplicity in the event, reaching values similar to those observed in Pb-Pb, where the phenomenon can be ascribed to the formation of the Quark Gluon Plasma. In order to better understand the origin of strangeness production in pp a multi-differential study is performed exploiting the effective energy available for particle production in the initial stage of the collision, estimated through the anti-correlated energy deposited in ALICEs Zero Degree Calorimeters. First preliminary results and perspectives for Run 3 will be discussed.

The GEM Gas Monitoring system: Using a gaseous detector as a gas detector for CMS Triple-GEM safe operation.

FIORINA D.
Università e INFN Pavia

The CMS experiment will exploit the Gas Electron Multiplier (GEM) technology during the next LHC run. These detectors will work with Ar/CO_2 (70/30) gas mixture and maintaining its quality and concentration is fundamental for the safe and correct operation of such gaseous detectors. This contribution will describe the GEM Gas Monitoring system from the design to the commissioning. It will report the calibration procedure, illustrating all the necessary steps to detect gain changes of around 5% corresponding to a systematic variation of argon (or CO_2) concentration of 0.33%.

Caratterizzazione di rivelatori a tripla GEM ad altissima risoluzione spaziale per sistemi di tracciamento in futuri test beam.

STAMERRA A.
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I rivelatori a tripla GEM rientrano tra le più avanzate tecnologie nell'ambito della fisica delle alte energie. L'elevata risoluzione spaziale e l'alta efficienza di rivelazione raggiunte, anche in condizioni di alta radiazione di background, rendono questi rivelatori adatti ad essere utilizzati nei grandi esperimenti ai collider, allo scopo di fornire precise informazioni per la ricostruzione di traccia delle particelle cariche. Questo contributo mostra le misure di caratterizzazione effettuate su rivelatori a tripla GEM ad alta risoluzione spaziale, ottenuta grazie a una più alta densità delle strip di lettura dei segnali (con un passo di circa 260 μm e una risoluzione spaziale attesa di 75 μm). In particolare, sono presentate le misure di guadagno, efficienza e risoluzione spaziale di questi rivelatori, che saranno utilizzati nei sistemi di tracciamento per futuri test beam e, nello specifico, il LEMMA Test Beam, previsto per il 2022 per testare lo schema di produzione di un fascio di muoni, e l'RD51 Test Beam nel 2021 per testare l'integrazione delle camere di GE2/1 e ME0 di CMS con l'elettronica del sistema di acquisizione di CMS.

Scattering tra due bosoni vettori W dello stesso segno con decadimento adronico del leptone τ nello stato finale con il rivelatore CMS ad LHC.

Magherini M., Piccinelli A.
Università degli Studi di Perugia, Italia

Lo scattering tra due bosoni W dello stesso segno si presenta come un processo estremamente promettente per lo studio della rottura di simmetria elettrodebole. La misura di eventi di questo tipo, all'interno di modelli di effective field theory, può essere utilizzata per caratterizzare i coefficienti degli operatori di ordine maggiore di 4. Ad oggi i risultati in questo canale sono basati sulla presenza di due leptoni leggeri (e, μ) dello stesso segno. Verranno qui mostrati i primi risultati della prima inclusione del decadimento adronico del tau nello stato finale, mai indagato finora, ed il suo potenziale.

Experimental challenges towards full exploitation of the FCC-ee potential.

Azzi P.
INFN, Sezione di Padova

The integrated FCC program combines in the same 100 km infrastructure a high-luminosity Higgs, electroweak and top factory e^+e^- collider, FCC-ee, followed by a 100 TeV hadron collider. With its high luminosity, its clean experimental conditions, and a range of energies that cover the four heaviest particles known today, FCC-ee offers a wealth of physics possibilities, with high potential for discoveries. It is an essential and complementary step towards the 100 TeV hadron collider, and the whole combined program is uniquely rich and powerful. This vision is the backbone of the 2020 European Strategy for Particle Physics. The main challenges of the study are now to design the detector systems that can, demonstrably, fully exploit its potential, while being technically feasible and affordable on the project time scale. As an example, with 5×10^{12} Z produced, the TeraZ run offers precision challenges on electroweak precision observables, unique searches for feebly interacting particles, and a rich flavor physics program, that imply specific detector requirements. The opportunities will be reviewed and the most striking detector challenges of the program will be highlighted.

Performance study of the MUonE calorimeter from GEANT4 Monte Carlo simulation.

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MUonE, a proposed experiment at CERN, aims to measure the running of the electromagnetic coupling constant in the space-like region by scattering high-energy muons on atomic electrons of a low-Z target through the elastic process $\mu e \rightarrow \mu e$. MUonE will measure the shape of the differential cross section of μ-e elastic scattering, which is defined by the measurement of the scattering angle of the outgoing electron and muon; a measurement of the electron energy would allow an over-constrained determination of the momentum transfer for perfectly elastic events, sizeably reducing the systematic uncertainties. The proposed detector is built of 40 identical stations, where each station is composed of a beryllium (Be) target and three silicon tracking layers. The electromagnetic calorimeter (ECAL) is placed downstream to all the stations. I will present a detailed study of the ECAL performances using GEANT4-based Monte Carlo events, as a function of the calorimeter size and the position of the Be target.

Il preciso sistema di calibrazione dell'esperimento Muon $g-2$ a Fermilab.

GIROTTI P. PER LA COLLABORAZIONE MUON G-2
INFN, Sezione di Pisa

La collaborazione dell'esperimento Muon $g-2$ a Fermilab ha recentemente annunciato la prima misura del momento magnetico anomalo a_μ dopo quasi 20 anni dall'esperimento presso Brookhaven. Il valore, compatibile con la misura precedente, è stato misurato con una precisione di 460 parti per miliardo. L'incertezza è dominata dall'errore statistico, mentre le sistematiche legate alla misura della frequenza di precessione sommano a 56 parti per miliardo. In questa presentazione descriverò il sistema laser di calibrazione dei calorimetri, sviluppato dal gruppo INFN, che permette di rendere stabili i fotomoltiplicatori al livello di 10^{-4}. L'incertezza sistematica associata alle fluttuazioni di guadagno è, grazie a questo sistema, inferiore a 20 parti per miliardo.

Search for shape coexistence in Zn isotopes across $N = 40$.

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The neutron-rich region around $N = 40$ has attracted much attention since the discovery of shape coexistence in ^{68}Ni, more recently measured in $^{64-66}$Ni with the first observation of shape isomers in medium-heavy nuclei. These phenomena can be understood in the context of Monte Carlo Shell-Model calculations, in terms of the monopole component of the proton-neutron tensor force. However, the role of this interaction is less clear in Zn isotopes, only two protons away from Ni nuclei, for which contrasting descriptions exist. In this work, we present a recent measurement performed at the IFIN-HH laboratory in Bucharest, aimed at studying, by γ-ray spectroscopy techniques, the structure of ^{72}Zn populated in a sub-barrier, two-neutron transfer reaction across $N = 40$. Low-lying 0^+ and 2^+ states were characterized by γ-ray angular distributions and lifetime measurements using DSAM methods. Preliminary results on possible shape coexistence phenomena will be presented and discussed in the framework of the aforementioned state-of-the-art calculations.

Effetto sistematico della phase-acceptance nell'esperimento Muon $g-2$ a Fermilab.

COTROZZI L. PER LA COLLABORAZIONE MUON G-2
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L'anomalia magnetica del muone, $a_\mu = (g_\mu - 2)/2$, è un'osservabile di bassa energia che può essere sia misurata che calcolata con grande precisione: è quindi uno dei test più accurati del Modello Standard e una sonda per processi di Nuova Fisica. L'anomalia è stata misurata con una precisione di 0.54 ppm nell'esperimento E821 al Brookhaven National Laboratory e con una precisione di 0.46 ppm nei recenti risultati dell'esperimento Muon $g-2$ a Fermilab. L'attuale differenza tra valore teorico e sperimentale è di $4.2\,\sigma$: l'obiettivo di Muon $g-2$ è di ridurre l'incertezza di un fattore 4, in modo da chiarire l'origine di questa discrepanza. Uno degli effetti sistematici più importanti nella prima fase di presa dati era dovuto alla dinamica del fascio di muoni dentro l'anello di $g-2$: si trattava della cosiddetta "phase-acceptance", un effetto dipendente dal tempo che correlava lo spin dei muoni con l'accettanza dei rivelatori. In questo lavoro verranno presentate le tecniche con cui l'effetto è stato studiato e con cui è stato stimato il relativo errore sistematico su a_μ.

Ruolo della non-sfericità del ^{6}Li nelle reazioni nucleari sotto barriera Coulombiana.

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Viene analizzato l'impatto della deformazione quadrupolare del ^{6}Li sulle dinamiche di reazione di alcuni processi ad energie al di sotto della barriera Coulombiana. Si presterà particolare attenzione alle possibili implicazioni per il "problema dello screening elettronico", l'eccessivo incremento osservato nelle sezioni d'urto a energie astrofisiche di diverse reazioni nucleari, rispetto alle attese teoriche relative all'influenza degli elettroni atomici. Nello specifico, si studierà il trasferimento diretto di una particella nella reazione $^6\text{Li} + \text{p} \to {}^3\text{He} + \alpha$, e il processo di fusione di ^{6}Li e p tramite la valutazione della penetrabilità della barriera in approssimazione WKB. Il ^{6}Li viene descritto in un modello a due cluster inerti che ne riproduce le principali osservabili di struttura.

Characterization of innovative pixel detectors with 3D technology.

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During the high-luminosity runs of the LHC collider the detectors will face great challenges due to the increase in the particle density. Precise time information will be fundamental to maintain a good detector performance. We will present a study of the characteristics of an innovative 3D-trench pixel sensor with precise time measurement developed at the FBK in Trento by the TIMESPOT Collaboration. The detector should be capable of 20 ps time resolution, withstanding high radiation doses. In this work, we first measured the static characteristics of the pixel sensor and studied its time resolution with a laser system. Next, we tested the sensor with a 2 MeV proton beam in Legnaro. The time resolution has been extracted using an innovative time tag system, based on a thin layer of organic scintillator deposited above the detector. The uniformity of the time response in the pixel active area has been studied with a precision of a few μm. Preliminary results are promising and received enthusiastic feedback by the TIMESPOT Collaboration.

A new ^{3,4}He cryogenic target for exotic beams.

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Direct transfer reactions provide a unique tool to study the single-particle structure of atomic nuclei. Reactions like (^{4}He,^{3}He) of (^{3}He,d), where one neutron or proton is added to an heavier nucleus, are fundamental to explore the evolution of single-particle structure in neutron-rich nuclei. More in detail, proton-adding (^{3}He,d) reaction Q-values in neutron-rich nuclei produced by the SPES facility in the ^{132}Sn and ^{78}Ni regions are well matched to the energy or re-accelerated exotic beams from the ALPI accelerator (10–15 MeV/u). This implies cross sections of several mbarns, which make measurements feasible with beams down to an intensity of 10^4 pps, if the target has a thickness larger than 10^{20} at/cm^2. This calls for the use of cryogenic targets where helium is kept at temperatures < 10 K, so that a desired target density can be obtained with a thickness of only 1–3 mm along the beam direction. In this framework, the Cryogenic Targets for Direct Reactions (CTADIR) project has been financed by the PRIN2017 call for funding. The talk will describe the status of the project and the integration with the gamma-ray tracking array AGATA.

Study of the $H \to WW$ same flavour channel with the ATLAS detector.

Carnesale M.
Università di Roma La Sapienza e INFN, Sezione di Roma

The $H \to WW$ decay channel has the second largest branching fraction and contributes significantly to the most precise measurements of the Higgs properties. The analysis of the channel with the two W bosons decaying leptonically, $H \to WW \to l\nu l\nu$ with $l = e, \mu$ and the two leptons having the same flavour, is particularly challenging due to the Drell-Yan dominant background. In this contribution a study of the $H \to WW \to l\nu l\nu$ same flavour channel is presented, using Monte Carlo samples and data collected by the ATLAS experiment during the Run2 of the LHC, for a luminosity of 139 fb^{-1}.

Development of the Mu2e electromagnetic calorimeter mechanical structures.

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The Mu2e experiment at Fermilab will search for the CLFV neutrino-less coherent conversion of a muon into an electron in the field of an aluminum nucleus. The observation of this process would be the unambiguous evidence of physics beyond the Standard Model. Mu2e detectors comprise a straw-tracker, an electromagnetic calorimeter and an external veto for cosmic rays. The calorimeter has been designed as a state-of-the-art crystal calorimeter and employs 1340 pure CsI crystals readout by UV-extended silicon photosensors and fast front-end and digitization electronics. The design consists of two identical annular matrices positioned at the relative distance of 70 cm downstream the aluminum target along the muon beamline. The hostile Mu2e operational conditions, in terms of radiation levels, magnetic field intensity and vacuum level have posed tight constraints on the design of the detector mechanical structures and materials choice. In this talk we will review the constraints on the calorimeter mechanical structures, the mechanical and thermal studies that have determined the design technological choices, and the status of components production, quality assurance tests and assembly.

Mu2e event display using the TEve framework.
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The Mu2e experiment is being set up at Fermilab to search for the CLFV neutrinoless muon-to-electron coherent conversion. The goal of our work is to develop the upstream module of the Offline Event Display and improve the matching between the Monte Carlo truth and the reconstructed particle trajectories in the Detector Solenoid volume. This is done using the ROOT based 3D event visualisation framework TEve. The idea is to include the Production and Transport Solenoids into the display window, which is solely focused on the Detector Solenoid at present. The addition of the upstream Monte Carlo tracks would enable a complete illustration of the experiment. It could be beneficial in understanding the processes occurring at the Production Solenoid more clearly and to follow the trajectory of muons from the production region to the muon stopping target, where the conversion may take place. The GUI would be reconfigured as well, to include the solenoid selection panel.

Esplorando l'innesco del meccanismo di multiframmentazione nei sistemi ^{58}Ni+^{40}Ca e ^{58}Ni+^{48}Ca all'energia $E(^{58}\mathrm{Ni})_{LAB} = 25$ AMeV.
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I frammenti emessi in collisioni centrali per i sistemi ^{58}Ni+^{40}Ca e ^{58}Ni+^{48}Ca a 25 AMeV, rivelati dal multirivelatore CHIMERA ai Laboratori Nazionali del Sud sono stati analizzati in dettaglio. In particolare, lo studio delle correlazioni in carica ed in velocità dei tre frammenti più grossi ha consentito di evidenziare la coesistenza tra il decadimento sequenziale e l'emissione pronta. Confronti dei dati con simulazioni dinamiche con i modelli dinamici BLOB e CoMD hanno confermato l'innesco del fenomeno di multiframmentazione anche in sistemi moderatamente eccitati, consentendo di selezionare informazioni sui parametri caratterizzanti la dinamica della frammentazione.

SHADES: $^{22}\mathrm{Ne}(\alpha,\mathrm{n})^{25}\mathrm{Mg}$ in the Gamow window.
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Neutron capture reactions are the main contributors to the synthesis of the heavy elements and to stellar evolution scenarios. Besides $^{13}\mathrm{C}(\alpha,\mathrm{n})^{16}\mathrm{O}$, which has recently been measured by the LUNA Collaboration, $^{22}\mathrm{Ne}(\alpha,\mathrm{n})^{25}\mathrm{Mg}$ is the second main neutron source in stars and its cross section is mostly unknown in the relevant stellar energy, where only upper limits from direct experiments and highly uncertain estimates from indirect sources exist. The ERC project SHADES (UniNa/INFN) aims to provide for the first time direct cross section data in this region and to reduce the uncertainties of higher energy resonance parameters. High sensitivity measurements will be performed at the new 3.5 MV accelerator facility available at INFN-LNGS laboratory in Italy: SHADES innovative setup, together with the

low LNGS background environment and the high beam current, promises to improve the sensitivity by over two orders of magnitude over the state of the art, allowing to probe the unexplored low-energy cross section. The measurement will be done within the LUNA-MV Collaboration. An overview of the project and the main preliminary results on the setup characterization will be presented.

Spectroscopy of the ^{179}Au.

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Excited states of odd-mass nuclei can be used as a powerful tool to study nuclear structure. Unpaired proton/hole acts as a probe of the even-even core. Excitation energies and order of the excited states, especially at low spin, can be used to determine the triaxial deformation of the core. We will present results of the in-beam study of the ^{179}Au isotope, which is a part of the extensive program aimed to systematically study the neutron-deficient Au isotopes. The experiment was conducted at the University of Jyväskylä, utilizing the RITU, GREAT and the SAGE apparatus. Multiple new transitions were identified for the first time, including a new rotational band. Its observation allowed us to determine the triaxial deformation parameters of the ^{179}Au based on the Particle + Triaxial Rotor Model calculations. Delayed gamma-ray analysis revealed presence of multiple new isomers. Most notable is the discovery of a 2.14 μs isomeric state, whose existence is unprecedented in the Au isotopic chain and will be a subject of further research. We also identified a new strongly coupled band feeding this newly observed isomer.

Advancements of nuclear reaction modeling for innovative medical radioisotope production.

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The theoretical analysis of cross sections, reaction rates, yields and purities for nuclear reactions is the first step in the study of possible routes to produce innovative radioisotopes of medical interest. Modern nuclear reaction codes, like TALYS, are the best tools to perform theoretical calculations in this field. Sometimes, unfortunately, the default excitation functions of the codes do not reproduce the trend of experimental data, like in the case of the new data on Sc isotopes obtained in the framework of the PASTA project. In our work, we consider these data and focus on the nuclear level densities (NLDs), varying the parameters of the most recent microscopic models implemented in TALYS, to reproduce the experimental data. With this technique we obtain new cross sections that are in agreement with the data and we make more accurate theoretical predictions of the production yields, a result which is extremely useful for subsequent dosimetric studies. We adopt this method also in the case of the METRICS and REMIX projects for the production, respectively, of ^{52g}Mn, of interest for MultiModal Imaging, and of Sc and Tb radionuclides, of interest for theranostic applications.

High-precision measurement of strangeness production in Pb-Pb collisions at $\sqrt{s_{NN}} \sim 17$ GeV with the NA60+ experiment.

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The NA60+ experiment proposal at the CERN SPS aims at measuring muon pairs, open charm and strangeness production with unprecedented precision in Pb-Pb collisions in the energy range $\sqrt{s_{NN}} \sim 17$ GeV. The main physics goal is to investigate the structure of the phase diagram of strongly interacting matter at large baryon density, a region poorly understood so far. I will present the expected performances for the measurement of ϕ and K^0_S production in very central Pb-Pb collisions at $\sqrt{s_{NN}} = 8$ and 17 GeV, using a very innovative silicon vertex spectrometer based on a new generation of monolithic active pixel sensors.

τ-lepton lifetime measurement at Belle II.

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The τ-lepton lifetime represents a fundamental parameter within the Standard Model framework, contributing to the test of lepton flavor universality. Exploiting the vertex detector resolution and the tiny beam spot size at the interaction point, Belle II is expected to improve the present τ lifetime value. The event topology where one τ decays to three charged pions (3-prong) and the other τ goes to a charged ρ meson (1-prong), allows to have an higher event yield respect to the 3-prong *vs.* 3-prong topology studied by Belle. Therefore, a measurement with a statistical uncertainty competitive with the world average could already be performed with an early Belle II dataset.

Test of the DCT board prototypes for the Phase-II Upgrade of the Muon Spectrometer of the ATLAS experiment at LHC.

Morodei F.
Università di Roma La Sapienza

The Muon Spectrometer of the ATLAS detector will be significantly upgraded during the Phase-II upgrade in order to cope with the higher luminosity of the HL-LHC in Run4. The readout electronics of the Resistive Plate Chambers (RPCs) will be replaced and new Data Collector and Transmitter (DCT) boards will be installed to collect and digitize the RPC data. In this work the test of the DCT board prototypes is presented: a test setup is prepared using an FPGA evaluation board and then the prototypes are tested, first on bench and then with cosmic rays, and their performances studied.

Ricerca di nuova fisica nel settore oscuro in stati finali con fotoni ed energia mancante a Belle II: risultati e prospettive.

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L'esperimento Belle II, installato al collisore asimmetrico e^+e^- SuperKEKB, ambisce a raccogliere 50 ab^{-1} di dati entro il 2031, aumentando la statistica di un fattore 40 rispetto al suo predecessore Belle. A marzo 2019 è iniziata la fase di presa dati con rivelatore completo e sono attesi 200 fb^{-1} entro l'estate 2021. Nella presente comunicazione verrà esposto lo stato dell'arte dell'esperimento Belle II nel campo della ricerca di particelle appartenenti al settore oscuro per masse dell'ordine del GeV$/c^2$ in processi che coinvolgono fotoni o energia mancante nello stato finale, presentando i risultati ottenuti con i primi dati raccolti dall'esperimento e discutendo le prospettive per le ricerche attualmente in corso.

Z and Dark Higgsstrahlung searches in events with muon pairs at Belle II.

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The Belle II experiment at the SuperKEKB e^+e^- collider is an upgrade of the B-factory at the KEK laboratory. Main operations started in March 2019: an integrated luminosity of about ~ 130 fb^{-1} has been collected so far. This early dataset, with specifically designed low multiplicity triggers, offers already the possibility to search for a large variety of dark sector particles in the GeV mass range. This talk is focused on first results and searches on Z' light gauge boson and Dark Higgsstrahlung process with muon pair final states, which could solve the dark matter puzzle and also the long standing anomaly of the muon $g-2$.

Studio della dinamica nella formazione dei frammenti di massa intermedia (IMF) e della fissione del quasi-proiettile a 20 MeV/A con i multirivelatori CHIMERA e FARCOS: l'esperimento CHIFAR

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L'esperimento CHIFAR è stato realizzato ai LNS-Catania. Si intende studiare la coesistenza fra emissione dinamica e statistica nell'emissione di IMF nei processi di fissione del quasi-proiettile nelle reazioni ^{124}Sn + ^{64}Ni, ^{112}Sn + ^{58}Ni,^{64}Ni e ^{124}Xe + ^{64}Zn all'energia incidente di 20 MeV/A. Dieci moduli del nuovo array modulare FARCOS (Femtoscope ARray for COrrelation and Spectroscopy) sono stati accoppiati al rivelatore 4π CHIMERA. Verranno illustrate le motivazioni dell'esperimento in rapporto ai precedenti risultati ottenuti alla più alta energia incidente di 35 MeV/A e i primi risultati dell'analisi dei dati. Inoltre saranno descritte le performances dei telescopi dell'array FARCOS qui utilizzati per la prima volta nella sua configurazione di elettronica di front-end definitiva.

Predicting β-decay rates of radioisotopes embedded in anisotropic ECR plasmas.

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Studying in-plasma decay rates as a function of ionic charge state distribution (CSD) is the fundamental objective of the PANDORA project. To this effect, we present here a theoretical model to calculate β-decay lifetimes of radionuclide ions embedded in an energetic ECR plasma, starting from anisotropic electron distributions. The model comprises a number of steps sequentially implementing electron-ion reactions, ion-ion charge exchange reactions and ion loss dynamics to arrive at space-resolved CSD. These data are then fed to a comprehensive code based on a technique developed by Takahashi and Yokoi in the 80s to calculate the position-dependent β-decay rate.

Update of the EvtGen decay models and branching ratios, together with masses tables for heavy flavour hadrons decay.

Curcio F.
INFN gruppo collegato di Cosenza and Università della Calabria, Dipartimento di Fisica
Updated decay modes and models for heavy flavour hadrons are studied for the EvtGen 1.7 Monte Carlo version using the Monte Carlo event generators: Pythia 8.244, Herwig 7.2.1, Powheg 04-05-01 and Sherpa 2.2.11. Heavy flavour hadron-related quantities such as production fractions, jet width and shape, stable and stable charged decay products multiplicities together with fragmentation functions are studied using inclusive $t\bar{t}$ samples generated for *pp* collisions at $\sqrt{s} = 13$ TeV. The new EvtGen 2.0 and Pythia 8.3 versions are also validated against their previous releases.

Constraining the dark sector with the mono-jet signature with the ATLAS detector at the LHC.

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Several Dark Sector models predict the existence of particles with macroscopic life-times, that can lead to final states with large missing transverse momentum recoiling against at least one high energetic jet, signature often referred to as mono-jet. The recent ATLAS mono-jet search based on 139 fb^{-1} of data collected in pp collisions at 13 TeV by the ATLAS experiment at the LHC is used to constrain such Dark Sector models. The results concerning the models involving long-lived particles are complementary to the ones of dedicated searches.

21 cm cosmology with millicharged dark matter.

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We study scenarios where a sub-percent fraction of dark matter (DM) carries a millicharge (mDM). The small energy density of the millicharged component avoids the strong constraints from CMB but can have interesting effects on the cosmological evolution at and after recombination. For large enough charges and at small relative velocities, non-relativistic effects like Sommerfeld enhancement and bound state formation significantly impact the

behavior of mDM. We systematically compute the scattering rates of mDM with hydrogen and helium and the rate of mDM capture in the interstellar medium. We discuss how these processes can impact the allowed parameter space of models explaining the anomalous absorption signal in the global 21 cm spectrum observed by EDGES.

Studio simulativo di produzione di fasci radioattivi presso FRAISE (LNS).

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Ai Laboratori Nazionali del Sud dell'INFN è attualmente in corso di realizzazione il nuovo fragment separator FRAISE (FRAgment In-flight SEparator) in grado di operare con i fasci di alta potenza disponibili a seguito dell'upgrade dell'attuale Ciclotrone Superconduttore. Con il nuovo fragment separator si avrà la possibilità di produrre fasci radioattivi utilizzando il metodo di frammentazione in volo, con intensità circa 20 volte maggiori rispetto al precedente apparato FRIBs. In questo ambito è stata analizzata, attraverso il software di simulazione LISE++, la produzione e l'ottimizzazione di diversi fasci radioattivi, per mezzo dei quali sarà possibile studiare interessanti ed innovative tematiche di ricerca per la fisica degli ioni pesanti.

Interazione a range finito in approcci di dinamica molecolare.

Papa M.
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Le correlazioni a molti corpi generate in modelli di dinamica molecolare sono analizzate nell'ambito del modello CoMD nel caso d'interazione efficace a range finito associabile a differenti valori della massa efficace del nucleone. Lo studio è condotto per equazioni di stato di materia nucleare allo stato fondamentale. Usando una stessa forma per l'interazione efficace nucleare, il confronto con calcoli di campo medio mette in risalto l'effetto delle correlazioni specifiche introdotte nel CoMD associate all'uso di pacchetti d'onda e al principio di Pauli. A bassa densità, tali correlazioni, responsabili del processo spontaneo di formazione di clusters, richiedono anche notevoli variazioni dei parametri dell'interazione efficace rispetto ai valori standard ottenuti nell'ambito di una trattazione di campo medio volendo al contempo riprodurre in ambedue gli approcci le note proprietà di saturazione della materia nucleare. Tali risultati possono avere una rilevanza non trascurabile negli studi che mirano ad avere informazione sull'EoS nucleare studiando processi di collisione tra ioni pesanti in cui la produzione di cluster è preponderante.

Prospects for the measurement of $\sigma_H \times BR(H \to \mu^+\mu^-)$ at a 3 TeV muon collider.

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Among the projects currently under study for the next generation of particle accelerators, the muon collider represents a unique machine, which has the capability to provide leptonic collisions at energies of several TeV. The multi-TeV energy regime is as yet unexplored and holds a huge physical potential that will enable a novel research programme ranging from high-precision measurements of known standard model processes to high-sensitivity searches for phenomena beyond the standard model. A multi-TeV muon collider will produce huge samples of Higgs bosons that will allow a precise determination of the Higgs boson properties, like its couplings to fermions and bosons and its trilinear and quartic self-couplings with unprecedented precision. This contribution will present an estimate of the muon collider reach on the production of the process $H \to \mu^+\mu^-$, one of the rarest Higgs boson decays that represents a gateway to the determination of the Higgs boson coupling to the second generation leptons.

Differential $t\bar{t}$ cross-section measurements in the lepton + jets channel.

Malito D.

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Differential cross-section measurements are presented for the production of top-quark pairs, in the lepton + jets channel at parton level. The study is based on the data sample collected by the ATLAS detector during Run2 (2015–2018) at a center-of-mass energy of $\sqrt{s} = 13$ TeV. The results are presented as a function of several kinematic variables characterising the top and $t\bar{t}$ system. Such measurements allow a detailed study of the properties of top-quark production and decay, enabling precision tests of several Monte Carlo generators and fixed-order Standard Model predictions.

Studio del break-up del proiettile a basse energie.

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Per reazioni realizzate in diversi regimi energetici e con sistemi di diversa taglia, in letteratura sono presenti molte indicazioni sul break-up del proiettile. Per proiettili di taglia media, questo meccanismo di reazione è stato osservato soprattutto nel regime dell'energia di Fermi. Per questo motivo, costituiscono un caso molto interessante i risultati ottenuti nell'esperimento ISODEC, in cui sono stati osservati, eventi dovuti alla rottura di proiettili medio-leggeri, il ^{78}Kr e il ^{86}Kr,a energie di 10 AMeV. L'esperimento è stato realizzato presso INFN-LNS utilizzando il multirivelatore CHIMERA. Un apposito metodo è stato sviluppato per selezionare i soli eventi dovuti al break-up del proiettile in competizione con altri processi, che popolano la stessa regione dello spazio delle fasi. Importanti informazioni sulla natura (dinamica o statistica) del meccanismo di interesse sono state ottenute dallo studio dell'angolo di prossimità. Grazie al differente contenuto neutronico dei due sistemi, è stato possibile inoltre indagare l'influenza dell'isospin sulla competizione tra break-up dinamico e statistico. Verrà presentato il confronto con le previsioni teoriche del modello BLOB.

^{33}Cl spectroscopic factors via the ^{32}S(^{3}He, d)^{33}Cl one-proton transfer reaction at the CN accelerator.

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In this communication we discuss new experimental data on the one-proton transfer reaction ^{32}S(^{3}He, d)^{33}Cl* at 9.68 MeV bombarding energy. An enriched ^{32}S target and a high-granularity hodoscope were used to obtain data for proton transfer reactions to bound and unbound states in ^{33}Cl. Angular distributions were interpreted by means of finite-range DWBA and coupled-channel calculations. The obtained spectroscopic factors have been compared with previous results reported in the literature and with shell model calculations.

Geometry of the D(2,1;α) supergravity.

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The geometric formulation of a 3-dimensional supergravity with a supersymmetry superalgebra D(2,1;α) is studied. Such algebra contains a $SL(2) \times SL(2) \times SU(2)$ subgroup, where the first two $SL(2)$ factors are interpreted as the isometry group of 3-dimensional anti de Sitter space, while the third $SU(2)$ as the manifest part of the R-symmetry. A (topological) twist à la Kapustin-Saulina is analyzed, which in this framework amounts to a different choice of the Lorentz spin connection in the AdS3 world-volume space-time.

La reazione di fusione ^{12}C + ^{16}O nel carbon burning: studio alle energie di interesse astrofisico mediante il Trojan Horse Method.

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La combustione del carbonio è un processo fondamentale per le fasi avanzate dell'evoluzione delle stelle massicce ($M > 8M_{\odot}$). Essa avviene principalmente attraverso la ^{12}C + ^{12}C, tuttavia a temperature maggiori di 10^9 K la ^{12}C + ^{16}O diventerebbe prevalente per l'accresciuta abbondanza di ^{16}O nelle ceneri della combustione dell'elio. La ^{12}C + ^{16}O gioca un ruolo centrale anche nella combustione esplosiva del carbonio nonché nella combustione dell'ossigeno. In letteratura esistono diverse misure della sezione d'urto della reazione ad energie di interesse astrofisico (tra 3 e 7.2 MeV nel centro di massa), tuttavia nessuna di esse si spinge al di sotto dei 4 MeV, rendendo necessaria l'estrapolazione. Recentemente le reazioni $^{16}\mathrm{O}(^{12}\mathrm{C},\alpha)^{24}\mathrm{Mg}$ e $^{16}\mathrm{O}(^{12}\mathrm{C},\mathrm{p})^{27}\mathrm{Al}$ sono state studiate nell'intera regione energetica di interesse astrofisico applicando il Trojan Horse Method ai processi a tre corpi $^{16}\mathrm{O}(^{14}\mathrm{N},\alpha^{24}\mathrm{Mg})^{2}\mathrm{H}$ e $^{16}\mathrm{O}(^{14}\mathrm{N},\mathrm{p}^{27}\mathrm{Al})^{2}\mathrm{H}$. In questa comunicazione, dopo una breve descrizione del metodo, verrà mostrato il setup sperimentale adoperato nonché le fasi preliminari dell'analisi dati in corso.

^{18}O + ^{48}Ti elastic and inelastic scattering at 275 MeV.

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In the context of the NUMEN experiment, the ^{18}O + ^{48}Ti reaction at 275 MeV incident energy was investigated at the INFN-LNS. In order to characterize the relevant initial-state interaction, an analysis of the elastic and inelastic scattering channels was performed. The absolute cross-section angular distributions for elastic and some inelastic transitions were

extracted in a wide angular range, using the MAGNEX magnetic spectrometer. A theoretical analysis was performed in order to extract the initial state interaction for the analysed system, using different approaches to describe the experimental data. The importance of the couplings of the elastic and inelastic channels to the first low-lying excited states of the involved nuclei was investigated by comparing both the distorted-wave Born approximation and the coupled channels calculations with the experimental data.

Form-factor–independent test of lepton universality in semileptonic heavy meson decays.

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In the semileptonic decays of heavy mesons the lepton-mass dependence factors out in the quadratic $\cos^2\theta$ coefficient of the differential $\cos\theta$ distribution. We call the corresponding normalized coefficient the convexity parameter. This observation opens the path to a test of lepton universality in semileptonic heavy meson decays that is independent of form-factor effects. By projecting out the quadratic rate coefficient, dividing out the lepton-mass–dependent factor and restricting the phase space integration to the τ lepton phase space, one can define optimized partial rates which, in the Standard Model, are the same for all three (e,μ,τ) modes in a given semileptonic decay process. We discuss semileptonic heavy meson decays such as $\bar{B}^0 \to D^{(*)+}\ell^-\bar{\nu}_\ell$ and $B_c^- \to J/\psi(\eta_c)\ell^-\bar{\nu}_\ell$ for each $\ell = e,\mu,\tau$.

Prima misura della sezione d'urto di fissione sul ^{235}U indotta da neutroni di alta energia ad n_TOF.

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Le sezioni d'urto delle reazioni indotte da neutroni sono tipicamente misurate rispetto ad una reazione di riferimento la cui sezione d'urto è conosciuta con una precisione migliore dell'1%, tra queste troviamo, per esempio, $^{6}\mathrm{Li}(\mathrm{n},\alpha)$, $^{10}\mathrm{B}(\mathrm{n},\alpha)$ e $^{235}\mathrm{U}(\mathrm{n},\mathrm{f})$. In particolare quest'ultima è considerata uno standard di riferimento per energie dei neutroni fino a 200 MeV. Nonostante la sua elevata importanza nella fisica nucleare di base e in diverse applicazioni che spaziano dalle tecnologie nucleari allo studio dell'efficacia biologica, la sezione d'urto $^{235}\mathrm{U}(\mathrm{n},\mathrm{f})$ è stata misurata sperimentalmente solamente tre volte tra 10 e 200 MeV di energia del neutrone, mentre oltre i 200 MeV, ad ora, non esistono dati sperimentali ma solamente valutazioni teoriche tra loro discordanti. Presso la facility per tempi di volo n_TOF, al CERN, è stata condotta una campagna di misure per ottenere dati accurati su $^{235}\mathrm{U}(\mathrm{n},\mathrm{f})$ oltre i 200 MeV, nel tentativo di estendere l'energia in cui la reazione è considerata uno standard, così come richiesto dalla IAEA. Verranno presentati l'apparato sperimentale e i risultati preliminari dell'analisi.

Fusion hindrance and Pauli blocking in ^{58}Ni + ^{64}Ni.

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Purpose: To measure the fusion cross section for the system ^{58}Ni + ^{64}Ni down to $\sim 1\ \mu$b to investigate the presence of the hindrance effect and the influence of the positive Q-value neutron transfer channels on fusion dynamics. Methodology: A ^{58}Ni beam from the XTU accelerator to bombard a ^{64}Ni target was used. The fusion-evaporation residues were detected by a beam electrostatic deflector followed by a DE-E-ToF telescope based on micro-channel plates, an ionization chamber, and a silicon detector. By correlating these variables, it is possible to estimate the total fusion cross sections. Also, the logarithmic derivative and the astrophysical S factor were obtained to verify the presence of the hindrance effect. Results: The logarithmic slope increases slowly, the S factor does not show any maximum and there is a good agreement between experimental data and coupled-channel calculations including low-energy vibrational modes and two-nucleon transfer couplings. Therefore there is no evidence for the fusion hindrance, suggesting that this is due to the $Q > 0$ transfer coupling that counterbalances the Pauli blocking when the two nuclei start overlapping.

Costruzione e test delle camere Micromegas di tipo SM1 per l'upgrade dello spettrometro a muoni di ATLAS.

Arcangeletti C.
INFN-LNF

I rivelatori Micromegas sono stati scelti come nuovi tracciatori di precisione per l'upgrade dello spettrometro a muoni di ATLAS, nell'ambito del progetto New Small Wheel. L'INFN ha costruito 32 camere Micromegas di 2 m^2 costituite da cinque pannelli per definire quattro gap, ciascuna formata da un piano catodico, una micro-mesh metallica ed un piano anodico, dove si trova il piano di lettura. Si presentano le tecniche di costruzione, insieme ai risultati dei test effettuati sulle singole componenti del rivelatore e sulla camera finale.

GALTRACE: A highly segmented silicon detector array for charged particle spectroscopy and discrimination.

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GALTRACE is an array of segmented silicon detectors specifically built to work as ancillary of the GALILEO γ-ray spectrometer array. GALTRACE consists of four telescopic ΔE-E detectors. The detectors are segmented into 4×4 mm^2 square pads that ensure 0.45 sr of solid angle resolution. The readout is performed with custom low-noise, low-power ASIC preamplifiers realized in 350 nm CMOS technology. This array is able to distinguish light particles thanks to pulse-shape analysis techniques. The good angular and energy resolutions and the particle discrimination capability make this array suitable for those experiments where the gate on a specific emitted particle allows for the isolation of reaction channels with very low cross-section, otherwise masked by concurring reactions with cross-section orders of magnitude larger. One example is the experiment performed in February 2021 at Laboratori Nazionali di Legnaro, where a narrow resonance, near-proton-threshold state in ^{11}B was studied monitoring the γ decays in coincidence with a proton emission from the compound nucleus ^{12}C in the reaction ^{6}Li (^{6}Li,p) ^{11}B.

Studi di performance dei rivelatori GEM per l'upgrade dell'esperimento CMS.

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Alla fine del 2020, una stazione di rivelatori a tripla GEM (GE1/1) è stata installata negli endcap del sistema a muoni dell'esperimento CMS, per garantire ridondanza nella regione coperta e migliorare la ricostruzione dei muoni a livello di trigger e offline in preparazione al Run 3 di LHC. La nuova stazione è attualmente in fase di commissioning con muoni cosmici. In questo contributo presentiamo per la prima volta una stima preliminare delle prestazioni dei rivelatori GE1/1, ottenuta sui primi dati raccolti, e un confronto con i risultati attesi estratti da simulazioni Monte Carlo.

The ISOLIGHT campaign with GARFIELD+RCo at LNL.

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Non-statistical effects in the emission of light charged particles from fusion-evaporation nuclear reactions are known for light and medium mass nuclei. We have been previously reporting cases where the comparison of the experimental data with statistical calculations shows discrepancies in decay channels with even residues, possibly due to alpha clusterization. To further investigate these topics, we have recently completed an experimental campaign at the Legnaro National Laboratories using the GARFIELD+RCo setup. The studied systems are: ^{18}O+^{13}C at 112 MeV and ^{18}O+^{12}C at 122 and 300 MeV. In the first two cases, the compound nuclei are produced with the same excitation energy, whereas the third one allows to probe the energy evolution of the effects. In this contribution, I will report on the data reduction and calibration for the three reactions, together with a qualitative comparison of the experimental results. Moreover, a preliminary comparison between different statistical decay codes (HFl and GEMINI) will be discussed.

Machine learning applications for fast simulation in high-energy physics experiments.

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One of the most challenging aspects of the LHC experiments and their high-luminosity upgrade is the need for large samples of simulated events. The limited computing resources will prevent the production of sufficiently large Monte Carlo samples. This limitation can be overcome with fast simulation techniques. Results of a new global fast simulation approach based on machine learning of sets where the reconstructed hadrons, photons, and leptons are simultaneously predicted given the set of truth-generated particles is presented. These deep learning models are based on graph networks combined with set-to-set algorithms optimized to work with different cardinalities between input and output sets. The work is based on a simulated environment inspired by a typical high-energy physics experiment.

Misura della frequenza di precessione anomala del muore nell'esperimento Muon $g-2$ a Fermilab.

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L'anomalia magnetica del muone, $a_\mu = \frac{g-2}{2}$, è un'osservabile di bassa energia che può essere misurata e calcolata con grande precisione. È quindi un test importante per verificare la correttezza del Modello Standard (MS) e una sonda per processi di nuova fisica. Una discrepanza del valore sperimentale dalla previsione teorica può essere infatti attribuita all'esistenza di processi di fisica oltre il Modello Standard. L'anomalia è stata misurata con una precisione di 0.54 ppm nell'esperimento E821 al Brookhaven National Laboratory. Questa misura ha mostrato una discrepanza di 3.7 σ con il valore previsto dal MS. L'esperimento Muon $g-2$ a Fermilab, il 7 aprile 2021, ha pubblicato i risultati della misura di a_μ sul primo run di presa dati. La nuova misura ha confermato quanto misurato nell'esperimento precedente con un'incertezza simile. L'obiettivo finale è di aumentare la precisione di un fattore quattro per chiarire l'origine della discrepanza osservata. In questo lavoro verrà presentata la tecnica di analisi della frequenza di precessione anomala del muone, le sistematiche ad essa associate ed i risultati della misura recentemente pubblicati.

The muon system of a muon collider experiment: Performance and technologies.

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A muon collider offers the possibility to reach the high centre-of-mass energy and luminosity of hadron colliders, with a greatly reduced pile-up effect. The project, however, poses a series of technological challenges, mainly due to the short muon lifetime and the beam-induced background. A complete simulation is ongoing to understand the performance of the detector. As far as the muon system is concerned, the study started from the CLIC's design, but other technologies are under investigation. The results on muon reconstruction efficiency and background mitigation are presented for a centre-of-mass energy of 1.5 TeV.

An experimental setup for detection of e^+e^- pairs in the decay of ^{8}Be*.

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A recent paper of Krasznahorkay and collaborators proposed the existence of a light neutral boson, named X17, for interpretation of an anomalous excess of e^+e^- pairs emitted in the decay of a excited states in ^{8}Be* and ^{4}He*, presenting a clear deviation from the expected correlation angle distribution. Different interpretations have been developed: Feng further developed the hypothesis of the existence of a 17 MeV boson mediator of a new fundamental force, while Zhang and Miller tried to explain the anomaly improving the nuclear physics modeling of the reaction. A new experimental setup is being developed at the National Laboratories of Legnaro in order to provide an independent measurement of the effect. In this contribution I will focus on the design of a dedicated setup, describing the detector layout, the simulation work done for its optimization and the experimental characterization of the first prototypes.

Simulazione veloce del test run dell'esperimento MUonE.

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L'esperimento MUonE ha come scopo la misura del contributo adronico dominante all'anomalia del muone (LO-HVP dovuto alla polarizzazione del vuoto). Il progetto è in via di sviluppo e nel 2022 è previsto un run di prova, volto a convalidare la scelta metodologica e tecnologica. Il mio contributo, attraverso la tesi di laurea, ha riguardato lo sviluppo di una simulazione parametrica e veloce della risposta del rivelatore. Sono state studiate le prestazioni attese e sono state valutate in particolare le possibilità di impiego del calorimetro elettromagnetico per la selezione degli eventi di collisione elastica fra muoni ed elettroni, a partire da eventi generati in approssimazione NLO, evidenziando il ruolo cruciale del calorimetro nell'esperimento finale.

A Phase 2 trigger study on Tau→3Mu channel with GEM detectors in CMS.

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The Large Hadron Collider is in the Long Shutdown 2 phase and is approaching a run-time period with luminosity up to 7.5×10^{34} cm^{-2} s^{-1}. The CMS experiment is upgrading its subsystems to cope with the machine's increased luminosity. The upgrade of the end-cap region of the CMS muon spectrometer includes the installation of three new muon detectors stations based on the GEM technology (GE1/1, GE2/1, ME0). The installation of GE1/1, almost 5 meters from the point of interaction and covering the pseudorapidity region $1.6 < \eta < 2.15$, has been completed in 2020. To help increasing the discovery potential of new physics the trigger system for this detector is under development By the end of Long Shutdown 3 the remaining stations GE21 and ME0 will be installed in the CMS endcaps at $1.6 < \eta < 2.4$ and $2.0 < \eta < 2.8$, respectively. This presentation will focus on the design of a trigger for a rare particle decay (tau to three muons) based on topological selections involving these new GEM detectors and covering high pseudorapidity regions; the study shows the possibility to trigger a few thousands of events in Phase 2, satisfying the low trigger rate requirement.

Global particle flow reconstruction with machine learning.

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In high-energy physics experiments, global particle flow techniques aim to reconstruct different particles in the final state starting from reconstructed objects. This complex task is particularly suited for machine learning algorithms that are able to optimally exploit the high-dimensional correlation between each object in an event. The machine learning community has recently proposed algorithms designed for problems featuring a variable number of final state objects. These techniques are known as set-to-set algorithms and are based on graphs and deep-set networks. We show how set-to-set algorithms are well suited for global particle flow reconstruction where the input set is made of reconstructed tracks and calorimeter cells whereas the output set represents the collection of the particles in the final state such as photons, leptons and hadrons with their kinematics.

The baryon density of the Universe from an improved rate of deuterium burning.

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The first nucleus produced in the Universe is deuterium whose accumulation marks the beginning of the so-called Big Bang Nucleosynthesis (BBN). Its primordial abundance is strongly related to the cosmological parameters, like the baryon density of the Universe and the effective numbers of the neutrino families. The main source of uncertainty in the primordial deuterium calculations was coming from the D(p,γ)^{3}He cross section at BBN energies. The million-fold reduction in cosmic-ray background achievable at the Laboratory for Underground Nuclear Astrophysics (LUNA) and a careful commissioning of the experimental setup aimed at minimizing all sources of systematic errors have led to D(p,γ)^{3}He cross-section data of unprecedented precision, with overall uncertainties below 3%. I will discuss how the new S-factor led to a remarkable improvement in the evaluation of the present-day baryon density, $\Omega_b h^2$, using standard BBN alone. Our value is now in better agreement with the one derived from the analysis of the Cosmic Microwave Background anisotropies and provides further support to the standard cosmological model.

Differenze negli spettri di evaporazione da nucleo composto di Si con energia di eccitazione di 72 MeV formato tramite fusione completa di diversi isotopi di O e C.

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La collaborazione NUCL-EX ha condotto negli anni una campagna di misure volta a studiare le proprietà della struttura nucleare di nuclei leggeri. Tale ricerca ha evidenziato la presenza di una struttura a cluster all'interno di questi nuclei, che si manifesta come una significativa deviazione dalle previsioni dei modelli statistici. Per realizzare tali misure è stato utilizzato l'apparato sperimentale GARFIELD + RCo installato presso i Laboratori Nazionali di Legnaro. L'apparato ha un'elevata efficienza geometrica che permette di ricostruire gli eventi completi. Su questo insieme di eventi è possibile distinguere i singoli canali di decadimento evidenziandone le deviazioni rispetto a quanto atteso dal modello statistico. Negli ultimi anni sono state misurate diverse reazioni tra cui ^{16}O+^{12}C a 130 MeV, ^{18}O+^{12}C a 122 MeV e ^{18}O+^{13}C a 112 MeV, corrispondenti alla stessa energia di eccitazione (72 MeV) del nucleo composto ^{28}Si*, ^{30}Si* e ^{31}Si*. In questo contributo verranno evidenziate le differenze sperimentali negli spettri di evaporazione di particelle leggere e nei branching ratios per le tre reazioni prese in esame.

Study of the structure of niobium isotopes of mass $A = 100$ produced by thermal neutron induced reactions.

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The nuclear structure of Niobium (Nb, $Z = 41$) isotopes of mass $A = 100$ is particularly interesting since these systems are located in a region of the nuclear chart characterized by abrupt shape changes, from spherical to prolate deformed and by the presence of vibrational states. The isotopes of ^{100,102,104}Nb, which have so far been little studied because of the difficulty of production and identification with standard nuclear reactions, were populated by thermal neutron induced fission reactions on ^{233,235}U, dissolved in a scintillator in order to provide a *fission tag*. The experiment was carried out at ILL in Grenoble and the gamma decay of these nuclei was measured using the FIPPS spectrometer, consisting of 8 clover of Compton suppressed HPGe detectors, complemented with 8 modules from IFIN-HH. Experimental data acquired at GANIL, using the AGATA array and the VAMOS spectrometer, were also used for further analysis. Preliminary results clearly show the coesistere of spherical and deformed structures extending up to about 10 angular momentum units.

Study of the gain variation of triple-GEM detector under heavy radiation.

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Micro Pattern Gaseous Detectors (MPGDs) guarantee high performance and the Triple-Gas Electron Multiplier (Triple-GEM) technology, in particular, promises high rate capability and spatial resolution. In high rate environment side effects due to discharges must be taken into account and they may lead to gain loss. Protection resistors can be added to block discharges, with the possible cost of a rate capability reduction. The contribution will present a study aimed at understanding the detector's behaviour under heavy radiation, varying the protection resistances and the initial gain. The results, showing that reducing protection resistances values of one order of magnitude helps to reduce the gain loss up to 60%, will be discussed.

Ricerca di evidenze della popolazione di un possibile stato di EFIMOV nel ^{12}C in misure di scattering alfa.

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Presso i LNS è stata misurata con il rivelatore CHIMERA la reazione $\alpha + {}^{12}C$ per lo studio della competizione alfa-gamma nei modi di decadimento dei livelli eccitati del ${}^{12}C$. In questo ambito è stata effettuata una ricerca dei possibili decadimenti diretti o sequenziali in 3 particelle alfa di uno stato di Efimov, di cui si è recentemente ipotizzata l'esistenza in alcuni lavori. Questo stato potrebbe esistere ad una energia di eccitazione di 7.458 MeV, circa 200 keV inferiore dell'energia di eccitazione dello stato di Hoyle (7.64 MeV) ed essere quindi coperto dalle sue code a causa della sua bassa sezione d'urto. Entrambi i modi possibili di decadimento diretto o sequenziale sono stati investigati con accurate simulazioni effettuate sia per lo stato di Hoyle che per lo stato di Efimov. Le simulazioni sono state confrontate con i risultati sperimentali. Verranno presentati i risultati di questa ricerca.

Studi delle prestazioni di ricostruzione e del trigger di muoni nella New Small Wheel del rivelatore ATLAS.

D'Amico V.
Università degli studi Roma Tre e INFN Sezione Roma Tre

L'aumento di luminosità istantanea previsto per il Run 3 e per la fase ad alta luminosità di LHC fino a 7.5×10^{34} cm^{-2} s^{-1} richiede un aggiornamento dello spettrometro a muoni dell'esperimento ATLAS. La New Small Wheel (NSW) sarà composta da rivelatori a gas di nuova generazione, Micromegas e small-strip Thin Gap Chambers, sostituendo la prima stazione di misura dello spettrometro nella regione in avanti. In questo contributo sono presentate le prestazioni di trigger e ricostruzione di muoni della NSW. Tali prestazioni sono studiate tramite simulazioni Monte Carlo con diverse configurazioni dei rivelatori e dei livelli dei fondi, e confrontate con dati acquisiti con fasci di particelle e con muoni cosmici.

Studio delle performance del rivelatore Resistive Plate Chamber con miscele di gas eco compatibili.

Proto G.
Università degli Studi di Roma Tor Vergata

Il tetrafluoroetano ($C_2H_2F_4$), che costituisce la componente primaria della miscela gassosa utilizzata nei detector a gas Resistive Plate Chambers, ha un alto Global Warming Potential (GWP) e, di conseguenza, sarà probabilmente bandito dal commercio e molto difficile da reperire. Sono in corso degli studi per la ricerca di una miscela di gas alternativa per gli RPC, che garantisca le stesse prestazioni raggiunte con quella attualmente utilizzata ma con un GWP più basso. La possibile miscela dovrebbe permettere di utilizzare i rivelatori in condizioni sperimentali caratterizzate da un'alta radiazione. In questo lavoro vengono presentati i risultati delle prestazioni di un rivelatore RPC con miscele gassose eco compatibili, basate su componenti innovative, selezionate per un possibile utilizzo nei grandi esperimenti presenti e futuri.

A proposed experimental set-up to solve the ${}^{8}Li(\alpha,n){}^{11}B$ cross-section puzzle.

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The ${}^{8}Li(\alpha,n){}^{11}B$ reaction is considered to have an important role in the early evolutionary stage of our universe, the Li overproduction problem, the starting of r-process nucleosynthesis in supernovae, collapsars and neutron star mergers. Though experimental efforts have been spent in order to estimate the ${}^{8}Li(\alpha,n){}^{11}B$ cross section at the astrophysical energies, the source of the discrepancy between the present data sets represents a really open question.

In order to solve this discrepancy, a LoI has been submitted to the GANIL PAC proposing a new experiment, described in this presentation, based on the high performances of the ACTAR TPC.

Caratterizzazione dei rivelatori a pixel per il sistema tracciante di ATLAS ad HL-LHC.

Cervato B.
Università degli Studi di Milano

Il progetto HL-LHC ha come obiettivo primario quello di aumentare la luminosità istantanea di LHC passando dal valore attuale di 2×10^{34} cm^{-2} s^{-1} a 7.5×10^{34} cm^{-2} s^{-1}. Per questo, i sistemi di rivelazione dovranno essere più veloci per poter analizzare un maggior numero di collisioni in ogni bunch crossing (si stima che si verificheranno circa 200 collisioni protone-protone ogni 25 ns) e dovranno avere una più alta resistenza ai danni da radiazione poiché saranno investiti da una dose più massiccia rispetto ai precedenti periodi di presa dati. Il tracciatore di ATLAS per HL-LHC, denominato Inner Traker (ITk), sarà costituito interamente da rivelatori al silicio. I rivelatori a pixel ibridi si collocano a pochi centimetri dalla linea di fascio. Essi sono costituiti da due porzioni distinte e interconnesse tramite flip-chip bump-bonding: il sensore e il chip di read-out. Per poter garantire gli alti standard di qualità richiesti, è necessario caratterizzare i prototipi, al fine di individuare la presenza di eventuali criticità e malfunzionamenti. In particolare, in questa presentazione, ci si concentrerà sugli aspetti problematici del bump-bonding e della catena elettronica.

Lucid fiber detector characterization.

Cremonini D., Lasagni Manghi F., Giacobbe B.
Università di Bologna

LUCID-2 was the luminometer for the ATLAS experiment for Run-2 and the same is expected for Run-3, but it will not be able to fulfil the requirements for HL-LHC. Thus, a new detector must be built. For this purpose, a prototype based on fibers will be installed before Run-3. Even if the fibers are radiation hard, we expect an opacization effect as a function of the wavelength and the absorbed dose. To study this, a session of gamma irradiation will be performed at the Calliope facility at Enea. In this contribution the irradiation results and the preliminary systematic studies are shown.

Misura e calcolo della resistenza elettrica delle strip resistive delle camere micromegas di ATLAS.

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Università della Calabria e Gruppo Collegato INFN di Cosenza

Micromegas è un rivelatore a gas planare il cui volume ịviso in due da una micro-mesh metallica distante circa 100micron dall'anodo. Un debole campo elettrico catodo-mesh separa le cariche di ionizzazione e conduce gli elettroni nella regione mesh-anodo dove un intenso campo elettrico innesca la moltiplicazione a valanga. Un segnale viene indotto su strisce conduttive poste sotto l'anodo resistivo dal movimento delle cariche nella regione di amplificazione. Nelle micromegas di ATLAS l'anodo ha lo stesso layout delle strip di readout. Presentiamo qui il modello di calcolo della resistenza elettrica delle strisce resistive e il confronto con i dati sperimentali.

Validazione dei Settori Micromegas per lo spettrometro a muoni di ATLAS.

Mancini G.
INFN LNF

La struttura dello spettrometro a Muoni prossima al punto di interazione di ATLAS sarà completamente sostituita con una nuova struttura capace di operare efficientemente alla luminosità finale di 7.5×10^{34} cm^{-2} s^{-1} prevista nella fase HL-LHC. I rivelatori MicroMegas, nello specifico, sono stati scelti per il tracciamento dei muoni per la loro ottima risoluzione ed efficienza ad alti flussi di particelle. Prima di essere montati sulla struttura meccanica, i settori indipendenti di Micromegas vengono caratterizzati e testati presso il CERN in termini di stabilità in alta tensione ed efficienza di tracciamento. Si presentano i risultati a più di metà campione testato e i risultati di alcuni studi dedicati sulle prestazioni dei settori.

Test di invecchiamento delle camere Micromegas di ATLAS alla sorgente GIF++ del CERN con la MiscelaAr:CO_2 e AR:CO_2_Iso-C_4H_{10}.

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Dipartimento di Fisica dell'UNICAL e INFN gruppo collegato di Cosenza

La tecnologia Resistive Micromegas è stata adottata da ATLAS per l'upgrade HL-LHC come rivelatore di tracciamento della prima stazione per muoni nella regione ad alta pseudorapidità. I siti di costruzione di Italia, Francia, Germania, Russia e Grecia hanno lavorato 3 anni per completare tutti i moduli del rivelatore. Il raggiungimento delle specifiche di progetto si è rivelato essere molto più difficile del previsto a causa di scariche elettriche frequenti anche a tensioni inferiori a quella di lavoro. Saranno descritte in questo lavoro le tecniche adottate per mitigare il problema e i risultati preliminare sull'invecchiamento del rivelatore con diverse miscele gassose.

Cosmic Rays measurements with the ATLAS Detector at LHC.

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The ATLAS experiment at LHC is able to detect cosmic-rays and measure their rate at about 90m underground. Of particular interest are the events called "muon bundles", composed of many parallel contemporary muons. To estimate the energy and composition of the primary cosmic-rays a dedicated MonteCarlo that includes the description of the Extensive-Air-Showers in the atmosphere, is required. Different MonteCarlo programs are investigated, including CORSIKA to produce the shower in the atmosphere by Ultra-High-Energy cosmic-rays. All secondary particles are tracked along their trajectories up to the ATLAS detector, where these particles are reconstructed and compared with other Monte Carlo samples.

Verso la misura della sezione durto della $^{12}C(\alpha, \gamma)^{16}O$ a basse energie.

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La $^{12}C(\alpha, \gamma)^{16}O$ svolge un ruolo centrale nella determinazione del rapporto fra le abbondanze di carbonio e ossigeno nell'universo e influenza il decorso dell'evoluzione stellare avanzata. Il valore della sezione d'urto impedisce una misura diretta all'energia di interesse astrofisico ($\sim$300 keV) rendendo necessarie misure di alta precisione ad energie maggiori per effettuare una estrapolazione accurata. Misure con incertezze inferiori al 10% nell'intervallo di energie da 1.9 MeV a 4.9 MeV sono state effettuate in passato con il separatore ERNA, attualmente installato presso il laboratorio Tandem dell'Università della Campania, Caserta. La collaborazione ERNA ha avviato una nuova campagna per estendere l'intervallo di misure fino a 1 MeV. A tal fine sono stati sviluppati un bersaglio gassoso a jet supersonico per migliorare l'accettanza del separatore; un TOF-E tracking detector che migliora la soppressione del fondo dovuto al fascio principale di carbonio; un array di scintillatori per la misura della distribuzione angolare della radiazione gamma. Nel presente contributo verranno descritte la tecnica sperimentale, l'apparato e il programma sperimentale.

Sezione II
Fisica della materia

Comunicazioni

Out-of-plane molecular coordination for on-surface vacuum self-assembly.

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A proper charge transfer through a hybrid interface requires a "holistic" approach to interconnect different elements: the electrode, the interface, and the molecular component. Among them, the contact interface plays a crucial role in the overall properties of the system. Epitaxial growth of coherent 2D+n stacked heterojunction in a controlled environment holds great promise, although the feasibility has never been demonstrated given multiple drawbacks, such as the surface-ligand effect, which foresees the electrode surface a special ligand of the deposited molecules. Here, we demonstrate how a coherent 2D+n (n = 3) layered heterorganic film is grown on a passivated Fe metal electrode. The groundbreaking achievement is the result of the in-vacuum integration of: i) chemical decoupling of the basal organic layer (a ZnII-tetraphenylporphyrine, ZnTPP) from the metal electrode, ii) 2D-ordering of the ZnTPP commensurate to the substrate, iii) rigid, stoichiometric, and orthogonally arranged, the molecule-to-molecule coupling between ZnTPP and a ditopic linear bridging ligand (*i.e.*, DPNDI) guided by self-assembly coordination chemistry, and iv) sharp termination of the layered film.

Formation and detection of Majorana modes in quantum spin Hall trenches.

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We propose a novel realization for a topologically superconducting phase hosting Majorana zero modes on the basis of quantum spin Hall systems. Remarkably, our proposal is completely free of ferromagnets. Instead, we confine helical edge states around a narrow defect line of finite length in a two-dimensional topological insulator. We demonstrate the formation of a new topological regime, hosting protected Majorana modes in the presence of s-wave superconductivity and Zeeman coupling. Interestingly, when the system is weakly tunnel coupled to helical edge state reservoirs, a particular transport signature is associated with the presence of a non-Abelian Majorana zero mode.

Roulette caustics: Tailoring light into cusps constellations.

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Caustics represent a widespread physical phenomenon, which occurs whenever the propagation of a wavefield is perturbed by phase discontinuities or inhomogeneity. In optics, caustics manifest themselves as high-intensity patterns originating from the envelope of the optical rays reflected, refracted, or diffracted by complex interfaces or media. We present here a novel method for the generation and control of regular caustics patterns of bright cusps by means of diffractive transformation optics. This theoretical and experimental study offers a recent insight into the field of caustics and accelerating beams, suggesting potential applications to particle manipulation, beam shaping, high-resolution lithography, and materials characterization.

Defect passivation of cesium lead halide perovskites by hydrogen treatment.

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We present results concerning hydrogen treatment realized for the first time on $CsPbCl_3$ thin films obtained by magnetron sputtering. We performed micro-PL and macro-PL experiments in a temperature range from 10 to 300 K. Exciton and carrier recombination dynamics have been studied by picosecond time-resolved PL measurements. The role of hydrogen is both to remove the compressive strain and to shift the PL peak at lower energy. At 10 K an increase of PL lifetime and a significant enhancement of the micro-PL and macro-PL intensity are found to be dependent on increasing hydrogen dose.

Entanglement signature of the Superradiant Quantum Phase Transition.

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Via the recently proposed entanglement measure, that applies for any pure and mixed state of an M-qubit system, we show that the quantum phase transition that takes place in the Tavis-Cummings model is associated with an entanglement crossover that, therefore, represents an order parameter. Our study clearly shows that the Tavis-Cummings model exhibits a true quantum phase/entanglement transition at the finite size that persists when the system size is increased.

Symmetry-dependent exciton-phonon interaction in MoS_2 monolayer.

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Two-dimensional (2D) transition metal dichalcogenides (TMDs), isolated into the monolayer phase, are the subject of intense investigations in 2D semiconductors due to their rich optoelectronic properties. Even at room temperature, the presence of excitons and their interaction with phonons allow the combined engineering of optoelectronic and structural properties. Herein, by varying the doping level of MoS_2 monolayers via thermal annealing, we report the discovery of the direct exciton-phonon coupling with exclusive in-plane symmetry.

Entanglement robustness via spatial deformation of identical particle wave functions.

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In this talk, we discuss the problem of entanglement protection against surrounding noise by a procedure suitably exploiting spatial indistinguishability of identical subsystems. To this purpose, we take two initially separated and entangled identical qubits interacting with two independent noisy environments. Three typical models of environments are considered: the amplitude damping channel, the phase damping channel and the depolarizing channel. After the interaction, we deform the wave functions of the two qubits to make them spatially overlap before performing spatially localized operations and classical communication (sLOCC) and eventually computing the entanglement of the resulting state. This way, we show that spatial indistinguishability of identical qubits can be utilized within the sLOCC operational framework to partially recover the quantum correlations spoiled by the environment. A general behavior emerges: the higher the spatial indistinguishability achieved via deformation, the larger the amount of recovered entanglement.

Atomistic simulations of Ge-rich GeSbTe for phase change electronic memories.

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Amorphous Ge-rich GeSbTe (GGST) alloys are emerging as promising materials for embedded phase-change memories thanks to their higher crystallization temperature of interest for applications in the automotive sector. GGSTs decompose into pure Ge and less GGST alloys upon crystallization which raises the stability of the amorphous phase but also gives rise to some drawbacks such as a drift of the electrical resistance with time in the resulting crystalline state. The details of the transformation process are, however, largely unknown. In this seminar, we report on a theoretical study based on density functional theory of the possible decomposition pathways of GGST.

Controlling chaos in a bistable Duffing oscillator.

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In this communication we address the problem of controlling chaos by using a selective filter inserted in a negative feedback loop. This has been achieved in driven double-well Duffing oscillator in a parameter region exhibiting both a boundary crisis and generalized bistability. The optimization of the filter response allows us to improve the reduction of the control signal when the periodic solution competing with the chaotic attractor is approached. The advantage in using a selective frequency approach with respect to the Pyragas's method mainly resides in the tunability of the maximum of its amplitude response and zero phase condition. Numerical simulations performed in the temporal domain match with the experiment and make us glimpse the potential of an automatic adaptive strategy adopting filter parameter variations in order to reach an optimal feedback signal reduction.

Ab initio circular dichroism of biomolecules: Developments and applications.

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Circular dichroism (CD) spectroscopy is a useful technique for characterizing chiral molecules, often more sensitive than total absorption to molecule conformation, in addition to its use for identifying enantiomers. We report on our implementation of CD calculations within the Density Functional Theory (DFT) framework, and on its application to several molecules of biological interest: single amino acids, cyclic dipeptides and selected drug molecules. This CD approach for molecules has been integrated in the 5.0 release of the Yambo code, distributed under GPL. Further work is in progress for its extension to beyond-IP methods (RPA, TDDFT, BSE), optimized for isolated systems.

Collisionless shock formation and particle acceleration in conditions relevant for NIF experiments.

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Collisionless shocks are ubiquitous in astrophysical plasmas and known to be important in field amplification and acceleration of both high-energy electrons and cosmic rays. Depending on the plasma conditions, different plasma processes mediate shock formation and particle injection, however, these are not yet fully understood. Recently laser-driven experiments performed at the National Ignition Facility (NIF) have observed for the first time the formation of collisionless shocks mediated by electromagnetic instabilities and nonthermal electron acceleration, opening a path for the laboratory study of shock acceleration. We will present kinetic simulations of counter-streaming plasmas relevant to NIF experiments, showing that the plasma profiles lead to efficient formation of turbulent shocks, on shorter time scale than predicted by previous analytical models. Our predicted formation time is in good agreement with recent measurements on NIF. Consistently with experimental measurements, simulations show that electrons can be effectively accelerated via a Fermi-like mechanism at the finite turbulent shock transition. This energisation mechanism can be relevant for young SNR shocks.

Variable angle spectroscopic ellipsometry investigation of CVD-grown monolayer graphene.

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Despite intensive investigations in the UV and visible range, the research on the optical properties of graphene in the extended near and mid infrared range by means of spectroscopic ellipsometry remains limited yet. The optical properties of a CVD-grown monolayer graphene, transferred from a copper substrate onto SiO_2/Si, were studied in the broad energy range (0.38–6.2 eV) using variable angle spectroscopic ellipsometry. The morphological and the structural properties of the samples were investigated by micro-Raman spectroscopy, wavelength dispersive X-ray (WDX) analysis, scanning electron microscopy and atomic force microscopy. An unintentional doping, revealed by micro-Raman spectroscopy and WDX, is reported.

Rivelatori a film sottile di fluoruro di litio a lettura di radiofotoluminescenza per la diagnostica di fasci di protoni.

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Film policristallini di fluoruro di litio (LiF), cresciuti per evaporazione termica su substrati di Si(100) e caratterizzati da buona qualità ottica, sono stati studiati per la realizzazione di rivelatori passivi di radiazione basati sulla radiofotoluminescenza visibile di centri di colore. Elevata risoluzione spaziale, ampio intervallo dinamico e linearità della risposta in un esteso intervallo di dose hanno consentito la mappatura spaziale della sezione trasversale del fascio di protoni prodotto dall'acceleratore lineare TOP-IMPLART per protonterapia in sviluppo presso ENEA Frascati, nonché la registrazione di curve di Bragg nel materiale. Sono presentati e discussi i primi risultati del confronto con cristalli di LiF, correntemente utilizzati per la determinazione dei parametri energetici del fascio di protoni.

X-ray radiation effects on opto-electronic properties of hybrid lead halide perovskite single crystals.

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Methylammonium lead tribromide ($MAPbBr_3$) single crystals show outstanding performance as X- and gamma-ray detectors, but thorough studies on the effects of ionizing radiation on their photophysical properties are still lacking. In our study, we measured optical properties of $MAPbBr_3$ before and after X-ray irradiation, as well as radiation-induced chemical composition and structural changes in the material. We found significant effects on the absorption and emission spectra, suggesting the formation of bound excitons, related to radiation-induced ionic migration phenomena. Surprisingly, these effects recover after only one day, showing an excellent radiation-hardness of the material.

Fourier transform infrared spectroscopy analysis of the H-bond network of water in cross-linked cellulose nano-sponges.

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In this work we report a detailed experimental vibrational analysis, performed by Fourier transform infrared spectroscopy in attenuated total reflectance geometry (FTIR-ATR), of water confined in the pores of cross-linked cellulose nano-sponges (CNSs). The analysis was carried out by varying hydration and cross-linker (bPEI) amount, with the aim of achieving a deep understanding of how the hydrogen bond (H-bond) scheme developed by engaged water molecules can play a role in the water adsorption process already observed at macroscopic level, furnishing at the same time evidence of a nano-porous network for CNSs. As main result, a destructuring effect of hydration on the H-bond pattern of interfacial water molecules was revealed, especially for low bPEI amounts. In addition, a supercooled behavior of entrapped water molecules was detected, supporting the idea of a nano-confinement for water in these systems. The obtained information can be very helpful in view of all the possible applications of CNSs as efficient adsorbent materials, with particular regard to water remediation.

Analisi spettrale della radiofotoluminescenza di centri di colore generati in cristalli di fluoruro di litio mediante irraggiamento gamma in funzione dell'intensità di eccitazione.

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Sono stati generati centri di colore F_2 ed F_3^+ in cristalli di fluoruro di litio mediante irraggiamento gamma a tre dosi cliniche nel fascio di riferimento del ^{60}Co dell'INMRI. Le caratteristiche spettrali della loro radiofotoluminescenza visibile a temperatura ambiente sono state studiate in funzione della densità di potenza dell'eccitazione laser a 445 nm. L'analisi degli spettri in condizioni stazionarie ha rivelato la presenza di una emissione nel verde dovuta a centri di natura ignota e ha permesso di calcolare un parametro caratteristico dello stato di tripletto dei centri F_3^+ in accordo con la letteratura, informazioni utili per applicazioni dosimetriche.

Hot-electrons characterization in the context of shock ignition approach to inertial confinement fusion.

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In the shock ignition approach to inertial confinement fusion, the high-intensity laser spike required in the ignition phase exceeds the thresholds for the generation of different laser-plasma instabilities. Large amount of supra-thermal electrons is generated and, depending on their characteristics, these electrons could preheat the hotspot or assist in generating a strong shock. In this context, we present the results of an experiment conducted on the OMEGA-EP laser facility with the aim of characterizing the hot electron source. In the experiment, one or two high-intensity UV interaction beams (1 ns UV with $I \sim 10^{16}$ W/cm^2) were focused on a multi-layer planar target, generating a strong shock and copious amount of hot electrons. The hot-electron source was characterized in terms of Maxwellian temperature Th and laser to hot-electron energy conversion efficiency η using two time-integrating hard x-ray spectrometers (BMXS) and The Zinc von Hamos (ZnVH) x-ray spectrometer. The post-processing of the spectrometer data relies on Monte Carlo codes in which the propagation of the electron beam in the target and the detectors' responses are simulated.

X-ray nanopatterning of TiO_2 single crystals and its possible application to memristive devices.

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X-ray nanopatterning is a powerful technique for tuning the electrical properties of oxide materials. In a recent experiment we investigated the modifications induced in TiO_2 rutile single crystals upon irradiation with a synchrotron X-ray nanobeam. The irradiated samples were characterized by combining XRF and XEOL mapping with electrical characterization and conducting AFM measurements. The results of the experiment showed the formation of conducting channels probably due to oxygen vacancies induced by X-rays, whose ordering upon application of an electric field can lead to reversible resistive switching. Therefore, this technique could be useful for the fabrication of titania-based memristive devices.

Dissipation measures in weakly collisional plasmas.

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The physical foundations of energy dissipation and heating in weakly collisional plasmas are poorly understood. Here, we compare several measures largely used to characterize energy dissipation and kinetic-scale conversion in plasmas by means of a suite of kinetic numerical simulations describing both magnetic reconnection and decaying plasma turbulence. We differentiate between i) *energy*-based parameters, whose definition is related to energy transfer in a fluid description of the plasma, and ii) *distribution function*-based parameters, requiring knowledge of the particle velocity distribution function. Dissipation occurs close to regions of intense magnetic stresses. The distribution function-based measures show a broader width compared to energy-based proxies, suggesting that energy transfer is co-localized at coherent structures, but can affect the particle distribution function in wider regions. The effect of inter-particle collisions on these parameters is finally discussed.

Textile pressure sensors for dynamic monitoring in sports and workplace.

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Recently, wearable technologies have emerged with the main focus to develop a new concept of physical and chemical sensors. Wearable pressure sensors are used in several applications, from touch detection for human-computer interaction (pressure below 10 kPa) to monitor stressful situations in sport or work activities (pressure up to 100 kPa). In this talk, we propose a fully textile pressure sensor based on a conductive polymer and provide a description of how the mechanical properties of several fabrics and different piezoresistive ink formulation impact the sensor's response during static and dynamic operation modes. Furthermore, this work can lead to a procedure for further improvements and optimizations useful for adapting textile pressure sensors to a large variety of applications.

Quantum noise in the spin transfer torque effect.

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The spin transfer torque is one of the most studied spintronics effects, in particular due to its applications in storage devices. Indeed, the magnetization direction of a ferromagnetic layer, acting as a bit, can be flipped by means of a spin-polarized current, inducing a torque. The dynamics of the macroscopic magnetization in the presence of a magnetic field is usually described by the Landau-Lifshitz-Gilbert (LLG) equation, which can be introduced by phenomenological arguments. We discuss an approach to obtain a systematic perturbative expansion around the semiclassical limit represented by the LLG equation. Differently from previous investigations we highlight the presence of both fieldlike and dampinglike noise contributions, and connect them directly to the spin-mixing conductance, which is expressed in terms of the transmission scattering amplitudes for electrons with opposite spin polarization. This is potentially important for extending our treatment to more complex scattering regions, whose behavior may, nevertheless, be described in terms of the spin-dependent transmission scattering amplitudes.

Tunneling transport of strongly interacting atomic Fermi gases across the superfluid transition.

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Tunneling transport measurements provide a powerful tool to unveil both the coherence properties of many-body systems, through the Josephson effect, and the role of excitations in conduction dynamics. Here I present our results in probing condensation of strongly interacting fermionic superfluids, by injecting controlled currents in an ultracold atom two-reservoirs system coupled through a tunneling barrier. In the absence of any applied chemical potential difference, we directly measure Josephson supercurrents, that depend sinusoidally on the relative phase, and devise a method to extract the condensed fraction throughout the BEC-BCS crossover. We clearly pinpoint the superfluid phase transition at unitarity by observing the Josephson supercurrents to vanish when approaching the critical temperature. Remarkably, we observe the condensate to contribute also to resistive currents: we detect a large anomalous normal conductance at low temperature, arising from the coherent coupling between the condensate and Bogoliubov-Anderson phonons. Our work highlights the key role of transport measurements to disclose the nature of quantum materials.

Integration of $CsPbBr_3$ nanocrystals with dielectric microspheres: A novel metasurface for enhanced emission in the green.

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Cesium lead halide perovskites ($CsPbX_3$ with $X = \mathrm{Cl, Br, I}$) are an emerging class of semiconductors promising for photonics and optoelectronics. Recently, SiO_2/TiO_2 core/shell beads (T-rex) have been employed as resonators for Raman detection. The realization of metasurfaces based on the integration of $CsPbX_3$ nanocrystals in different kind of structures is a new born field of interest for light manipulation and control. Here we present the results obtained by coupling $CsPbBr_3$ perovskite nanocrystals to T-rex beads deposited on a silicon substrate. Samples were fabricated by depositing on a silicon substrate 2 μm SiO_2 spheres covered by a TiO_2 thin layer (50 or 100 nm), on which a thin film of $CsPbBr_3$ was deposited by Radio-Frequency Magnetron Sputtering. By means of picosecond photoluminescence experiments at 10 K quantitative information on the excitons and carriers recombination dynamics were obtained. A comparison with samples without T-rex spheres indicates an enhancement of the PL intensity and a faster PL recombination time. This suggests a role of such metasurface in the coupling between the excitons and the electromagnetic field.

Ultra-stable and robust response to X-rays in 2D layered perovskite micro-crystalline films directly deposited on flexible substrate.

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Hybrid organic/inorganic perovskites (HOIPs) represent a breakthrough in the direct detection of X-rays. In few years, HOIPs have become dominant, overcoming the performances of state-of-the-art detecting materials. However, the research on HOIPs detectors has largely focused on bulk single crystals which cannot be produced over a large area, and lack of mechanical flexibility. Polycrystalline films are thus preferred. We report the fabrication and characterization of pixelated X-ray direct photodetectors based on the 2D layered HOIP. We developed a method for the deposition of micro-crystalline films directly deposited onto pre-patterned electrodes on a flexible substrate by low-temperature solution process. The perovskite grains exhibit high crystallinity and provide excellent opto-electrical properties both in terms of charge carriers collection, stability, and ultra-fast response (< 200 ns). As a result of high stopping power, ultra-low dark current and good $\mu\tau$, the performances of the devices as X-ray detectors exhibit a remarkable sensitivity of 806 ± 6 μC Gy$^-1$ cm$^-2$, a detection limit down to 8 nGy s$^-1$ and an ultra-stable response under continuous operation.

The role of the linkage position on the charge transport properties of newly synthesized hole transporting materials and their impact on photovoltaic performance in perovskite solar cells.

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One of the main concerns for the scaling-up of perovskite-based solar cells (PSCs) is the search for new hole-transporting materials (HTMs) to replace the widely used spiro-OMeTAD, which is really expensive, difficult to synthesize, and with a poor stability. In the present work we studied a newly synthesized family of organic small molecules, which are characterized by the same units, such as a dibenzofulvene-core, a thiophene ring and three moieties of arylamine as redox centers, but we varied their number and as well as the anchoring position of the redox centers. Thus, we studied the effect of the molecular arrangement on the material optoelectronic properties, with a special focus on their charge transport properties. We were able to tune the hole mobility up to three orders of magnitude, and our best compound showed a hole mobility of $3 * 10^-5$ cm^2/Vs, comparable to spiro-OMeTAD. We realized and characterized PSCs based on these new molecules as HTMs, and we achieved performances similar to spiro-OMeTAD, but with the great advantage of an HTM that is simple and cheap to synthesize.

Magnetic properties and spin dynamics in lanthanide-semiquinone complexes: A NMR investigation.

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The slow relaxation of the magnetization in molecular nanomagnets (MNMs) studied, at the beginning, in regard to fundamental problems in Physics, can be exploited for technological benefits. In the last few years, the researchers has shifted the focus toward molecules containing a single lanthanoid (Ln) ion, aiming to improve the performance in this kind of MNMs.

Four years ago, outstanding results have been reported on Ln systems showing a blocking temperature close to the technologically relevant liquid nitrogen one. In this framework and in the framework of INFN NAMASSTE project, we studied the magnetic properties and the spin dynamics of the two Terbium(III) and Dysprosium(III) complexes bound to a semiquinonate, paramagnetic, radical ligand (in short TbSQ and DySQ). The samples have been characterized by means of magnetic susceptibility measurements and studied through ^{1}H NMR measurements as a function of temperature at different magnetic fields applied, exhibiting anomalies not explainable by a simple BPP law, as, instead, expected in these kind of MNMs.

Controlled coherent dynamics of [VO(TPP)], a prototype molecular nuclear qudit with an electronic ancilla.

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Here we demonstrate that [VO(TPP)] can be exploited as a multi-level (qudit) unit for implementing quantum computation algorithms. Indeed, the Vanadyl ion provides an electronic spin 1/2 coupled through hyperfine interaction to a nuclear qudit of spin 7/2 with remarkable coherence time. We perform an extensive broadband nuclear magnetic resonance study to characterize the nuclear spin-Hamiltonian of this system and measure the spin dephasing time. Combining numerical simulations and Rabi oscillation measurements we show that nuclear spin transitions, conditioned by the state of the electronic qubit, can be coherently manipulated by resonant radio-frequency pulses. Despite the small quadrupolar interaction of vanadium, the transitions between subsequent nuclear states are energetically well resolved and thus singularly addressable. This is due to the effect of the hyperfine interaction up to second-order perturbation theory, which yields a sizeable effective quadrupolar splitting between nuclear states. Addressability of single nuclear transitions and long coherence time make this system a promising platform to implement a quantum simulator or qubit with embedded quantum error correction.

Thermal noise effects on a coupled axion-Josephson junction system.

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In the last years Josephson junctions (JJs) have been supposed to interact with axions, the hypothetical elementary particles candidate as a possible component of cold dark matter.

Unexplained experimental effects on JJ dynamics can be well justified on the basis of the axion-JJ theory. This hypothesis, thus, paved the way to the possibility of thinking of JJs as possible axion-detectors. In our work we studied the axion-JJ system when the JJ is initially prepared in the superconductive state. We analysed the times in which the JJ switches to the resistive state because of the combined action of thermal fluctuations and external bias current, considering the axion interaction. We found a Kramers-like dependence with respect to the noise intensity, with slight modifications depending on the strength of the coupling between the axion and the JJ systems. Furthermore, a nonmonotonic behaviour of the switching times with respect to the parameter representing the ratio between the axion and the JJ energy has been highlighted. Since this parameter can be experimentally tuned, we can identify the optimal conditions for a Josephson-based axion detection.

Correlation plenoptic imaging with high-speed SPAD array.

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Correlation Plenoptic Imaging between arbitrary planes (CPI-AP) is an novel method to collect diffraction-limited plenoptic information by measuring second-order correlations of light between two transverse planes, arbitrarily chosen within the tri-dimensional scene of interest. This protocol enables to change the focused planes and, in post-processing, to achieve a unique combination of image resolution at the diffraction limit, and a depth of field larger by an order of magnitude with respect to conventional imaging. Based on this idea, we realized an ultra-fast CPI-AP camera, where the illuminating chaotic light is detected by an innovative $\times$ SPAD array working at 15 kfps with a minimum exposure time of 10 ns; this sensor enable performing CPI-AP measurements in a few seconds. Our results clearly indicate the high potentials of quantum and quantum-inspired CPI protocols in view of practical imaging applications.

Using Ising machines to solve hard optimization problems.

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The Ising model can calculate the ground state of interacting spins via an exchange interaction matrix. However, it is possible to map onto this matrix combinatorial optimization problems that are NP-hard (such as Max-Cut or Max-SAT) and are relevant from both a fundamental and a technological point of view. Among the many ways to implement Ising machines, probabilistic computing, a more general paradigm, is particularly convenient because of its possible hardware implementation with spintronic technology. In particular, here we show how a dynamical system describing more than 2000 interacting magnetic tunnel junctions can be used to face the Max-SAT problem.

PLD deposition and characterization of ^{10}B-based conversion layers for thermal neutron detectors: Results of the BoLAS-INFN experiment.

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Thermal neutrons detection is achieved through the detection of the charged particles produced by the interaction of neutrons with a conversion material. Within the BoLAS-INFN experiment, we investigated the deposition by PLD (Pulsed Laser Deposition) of isotopically enriched ^{10}B thin films. Up to 2 μm thick films were deposited on different substrates (carbon fibers, Al and Si/SiO_2) and fully characterised by SEM, TEM, XRD, RAMAN and RBS. Very pure ^{10}B films with a thickness uniformity better than 10% over a circular area of 3 cm in diameter were obtained. Their functionality and efficiency was estimated by exposing them to a thermal neutron field generated by a radioactive source and detecting the alpha particles released through the $^{10}\mathrm{B}(\mathrm{n},\alpha)^{7}\mathrm{Li}$ reaction.

Lead-halide perovskites thin film for direct X-ray detection.

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Lead-halide perovskites are recently emerging as promising materials for high-energy radiation detection thanks to the combination of a high absorption coefficient, excellent transport properties, even in polycrystalline films, and their solution processability. Here we present perovskite-based X-ray detectors based on solution deposited thin films, with a focus on the impact on the device's performances of different interface materials, in layered architecture. We show that by using interface engineering it is possible to obtain flexible detectors operating in passive mode with a sensitivity up to 9.3 μCGy^{-1}cm^{-2}. We also present the influence of perovskite active layer's composition on the detector stability.

Quantum walk classicalization by decoherence

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Quantum walks are widely used in modeling the transport of energy and information across a given structure in several systems. Moreover, quantum walks proved to be powerful tools for building quantum algorithms that substantially enhance efficiency with respect to classical protocols. On the other hand, experimental implementations of quantum walks necessarily introduce defects and noise that could potentially jeopardize this speed-up. We study how the dissipative dynamics arising from the unavoidable interaction between the system and the environment affect the quantum walk. We use a fidelity-based measure of non-classicality in order to quantify the differences between the dynamics of a quantum walker on a given graph and that of the corresponding classical walker. We then assess wether decoherence effects make the quantum process "more similar" to its classical Markovian counterpart, with respect to the ideal noiseless case. We study decoherence in the energy basis and in the position basis and prove that both suppress some of the quantum features of the perfectly coherent process.

Time domain diffuse optics can break the pile-up bottleneck thanks to high light harvesting single-photon detectors.

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Time domain diffuse optics (TD-DO) instruments are evolving from cumbersome to compact configurations thanks to the use of solid-state detectors like silicon photomultipliers, which allow to increase the light harvesting capability, reaching high throughput and extreme signal-to-noise ratio of the acquisitions. Within the SP-LADOS project (funded by EU Attract project), a very large-area single-photon detection module has been developed, enhancing the light collection capability by almost two orders of magnitude when compared with traditional detectors. To fully exploit the potential of this cutting-edge detector and avoid light attenuation to stay within the single photon statistics, the unexplored working regime of the very-high-count rates must be studied. In such conditions, a strong signal distortion arises from the saturation of the detection chain and it needs to be corrected. Such a working regime has never been investigated for TD-DO and represents one of the most promising directions for new instruments and their widespread application in the daily life. Both the new detector and preliminary results on the possibility to work in high-count rate regime will be shown.

Integration of 2D materials with nitride semiconductors for energy-efficient and high-performance electronics.

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2D materials integration with group III-nitride semiconductors is currently explored as a platform for novel optoelectronic and ultra-high-frequency electronic devices and sensors. In this talk, different approaches for the scalable fabrication of high-quality graphene and MoS_2 junctions with GaN and Al(Ga)N/GaN heterostructures will be discussed. Furthermore, the most recent progresses in the realization of ultimately thin 2D layers of GaN, AlN and InN by the "migration-enhanced encapsulated growth technique" using epitaxial graphene in an MOCVD reactor will be highlighted. Structural, chemical and electrical investigations of these heterostructures with advanced characterization techniques will be illustrated. Finally, examples of demonstrators based on these material systems will be presented, such as graphene/AlGaN/GaN Schottky diodes and vertical hot electron transistors for high-frequency applications, and future developments of these devices will be discussed. This work has been supported by the FlagERA-JTC2015 projects GraNitE and GRIFONE, the FlagERA-JTC2019 project ETMOS, and the CNR-HAS 2019-2022 bilateral project GHOST II.

Understanding magnetic relaxation in single-ion magnets with high blocking temperature.

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Single-ion magnets are emerging as one of the most promising platforms for high-density information storage, with some Dy-based complexes showing slow relaxation of the magnetization up to 80 K. To further improve their performance, a deep understanding of magnetic relaxation (arising from the interplay of different mechanisms) is mandatory. Here we present a simple model explaining the peculiar behavior of these compounds, derived by combining magnetization and nuclear magnetic resonance experiments with inelastic neutron scattering measurements of the phonon density of states and *ab initio* calculations of the crystal-field states and of local vibrations. We apply our approach to some paradigmatic molecules all containing a single Dy ion, but showing very different relaxation. We clearly explain such behaviors based on the different crystal-field symmetries and different phonon modes, arising from different arrangements of the ligands. Our model allows us to disentangle the different mechanisms at play, to identify the crucial ingredients behind slow relaxation and to derive a general recipe to design high-blocking-temperature rare-earth single-ion magnets.

Study of time-resolved electronic and magnetic structure of thin films and strongly correlated systems by means of a novel high repetition rate HHG source.

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Photoemission spectroscopy, the ultimate tool for studying the electronic properties of materials, is extremely challenging for time-resolved experiments, because of the reduced repetition rate of available lab-based sources. We describe pilot experiments at “SPRINT-lab”, commissioned in NFFA-Trieste facility, where we overcome such limitations. Our design of High-Harmonic-Generation (HHG) source delivers high-intensity harmonics up to the 27th order of the 2.4 eV fundamental, with a repetition rate up to 200 kHz; the end-station is equipped for angle-resolved photoemission spectroscopy and electron spin polarimetry. We report results of high-resolution static and pump-probe measurements on selected surfaces, probing ultrafast transient electronic and magnetic processes.

The origin of the ice II anomaly.

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Ice II is an unusual hydrogen-ordered phase, thermodynamically stable up to high temperatures without any disordered counterpart. The study of the hydrogen and oxygen dynamics is of great relevance for an accurate microscopic description of condensed water phases. We probed hydrogen and oxygen mean kinetic energy, $\langle E_k \rangle$, and mean square displacement, $\langle u^2 \rangle$, with Deep-Inelastic and Quasi-Elastic Neutron Scattering experiments, respectively performed on VESUVIO and IRIS spectrometer at the ISIS pulsed neutron source. The results suggest that the low hydrogen mean kinetic energy and high mean square displacement decrease the Gibbs free energy of ice II motivating its stability. Finally, the two experiments are supported by phonon calculations based on *ab initio* theory where the simulated vibrational spectra show how the anomaly can be linked to the competing quantum effects between the libration and stretching band.

Ferromagnetic resonance in a nickel thin film driven by optically excited surface acoustic waves in a Transient Grating (TG) setup.

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We observed the resonant coupling of optically excited surface acoustic waves (SAWs) and spin waves (SWs) in a 40 nm nickel film on fused silica. Our four-wave-mixing approach ensures a contactless operation. We implemented a UHV-ready TG-spectroscopy setup, with a 300 fs, high frequency laser (NFFA-SPRINT). Coherent SAWs drive SWs through magneto-elastic coupling; a time-delayed pulse probes the oscillations of the magnetization through the Faraday effect. Different acoustic wavelengths were selected. The measured SAW-driven ferromagnetic resonance curve gives insight in the sample properties.

Ultraviolet laser-induced degradation of amplified spontaneous emission in methylammonium lead bromide thin films.

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Lead halide perovskites have shown an outstanding performance in photonic and photoelectronic applications, including LEDs and lasers. Despite their promising properties, the possibility of practical application is actually limited by the lack of long-term stability, due to light- and environment-induced degradation. This aspect is particularly critical for laser applications, due to the intense light pumping regime needed to overcome the lasing threshold. In our work, we investigate the operational stability of Amplified Spontaneous Emission (ASE) in $MAPbBr_3$ thin films under nanosecond-UV laser irradiation in air and vacuum, in order to understand its limiting processes and develop suitable strategies to improve it. We demonstrated that the main process leading to ASE degradation is related to the laser-induced film melting, taking place at relatively limited excitation densities, that also cause the film stoichiometry variation.

Thermoelectricity in hybrid nanodevices.

Braggio A.
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Thermoelectrical devices have been mainly developed with semiconductors and applied in few research and market applications. Unfortunately, instead, in superconductors which play a major role in quantum technologies, thermoelectricity seems prohibited by the intrinsic particle-hole symmetry of the superconducting state. Historically Ginzburg has firstly suggested some not trivial thermoactive properties of superconductors. Recently with hybrid nanodevices new prediction and experiments have shown unexpected thermoelectrical effects which may be used in heat management of low-temperature quantum circuits and/or novel quantum sensors. We will discuss better few examples of thermoelectricity as generated by spin filtering or nonlocal Andreev reflections in Cooper pair splitters. We will show that standard and topological Josephson junctions may present unexpected nonlinear and nonlocal thermoelectrical effects. We will show that standard SIS junction may generate a strong bipolar thermoelectrical effect that is generated from spontaneous breaking of the particle-hole symmetry as determined by a nonlinear thermal gradient applied to a junction in the presence of asymmetric gaps.

Implementation and security analysis of continuous variable quantum secure direct communication channels

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The development of supercomputers and quantum computers is going to threaten current secure communication protocols. However, quantum mechanics offers a solution guaranteeing physical layer security and provable security of communication. In particular, quantum secure direct communication (QSDC) allows secret messages to be directly and securely communicated over a quantum channel. In this paper, we investigate implementations of continuous variable QSDC using single-mode squeezed coherent states, and state-of-the-art quantum optical technology. Indeed, the continuous variable regime can be well compatible with fully developed optical telecommunication technologies. The security of the protocols against different forms of attacks (*e.g.*, intercept-resend attack and collective attack) and against losses and noise is investigated, both theoretically and numerically.

Dynamics of a vortex lattice in a expanding polariton superfluid.

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If a quantum fluid is driven with enough angular momentum, at equilibrium the ground state of the system is given by a lattice of quantised vortices whose density is prescribed by the quantization of circulation. We report on the first experimental study of the Feynman-Onsager relation in a non-equilibrium polariton fluid, free to expand and rotate. We track the vortex core positions on picosecond time scales. We observe an accelerated stretching of the lattice and an outward bending of the linear trajectories of the vortices, due to the repulsive polariton interactions. We detect a small deviation from the Feynman-Onsager rule in terms of a transverse velocity component, due to the density gradient of the fluid envelope acting on the vortex lattice.

Interplay of multiple degrees of freedom in strained VO_2 films.

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Metal-Insulator Transition (MIT) is a fascinating phenomenon in solid-state physics, with a huge potential for applications. The control over the charge carrier flow is highly desirable and compounds exhibiting MIT have been widely studied. In this context, VO_2 is a prototypical material showing a reversible MIT triggered by temperature. Because of the technological appeal of VO_2, from energy-saving to new-generation devices, it is of paramount relevance understanding the controlling mechanism of the MIT. The nature of the MIT is itself ground for debate since VO_2 is described as both a Mott-Hubbard and a Peierls insulator, making it one of the reference system in strong correlation physics. VO_2 MIT is controlled by multiple interconnected degrees of freedom (charge doping, lattice order, orbital population, etc.) that determine the transition features, *e.g.*, the critical temperature. In this contribution, we will highlight the influence of strain and lattice disorder on the MIT. In particular, we will show how strain modifies VO_2 orbital hierarchy revealing the interplay among lattice, orbital population and metallicity.

Entanglement and classical correlations at the doping-driven Mott transition in the two-dimensional Hubbard model.

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Entanglement and information are powerful lenses to probe phases transitions in many-body systems. Recent measurements of entanglement-related properties of the Hubbard model using ultracold atoms in optical lattices hint that entanglement could provide the key to understanding open questions of this model. We study the local entropy and the total mutual information across the doping-driven Mott transition in the 2D Hubbard model within the cellular dynamical mean-field theory. We find that these two entanglement-related properties detect the Mott insulating phase, the strongly correlated pseudogap phase, and the metallic phase. Imprinted in the entanglement-related properties we also find the pseudogap to correlated metal first-order transition, its finite temperature critical endpoint, and its supercritical crossovers. Through this footprint we reveal an unexpected interplay of quantum and classical correlations. Our work shows that sharp variation in the entanglement-related properties and not broken symmetry phases characterizes the onset of the pseudogap phase at finite temperature.

The effect of a sub-nanometer thin insulator layer on the electronic structure of the Ag/Si(111) interface.

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In this work, we have observed quantum well states at the Ag/Si(111) and Ag/β-Si_3N_4(0001)/ Si(111) interfaces, by angle-resolved photoelectron spectroscopy. This has been made possible by the two-steps growth technique, where, firstly, silver is deposited at low temperature and is then left recovering at room temperature. The data display the full confinement of the electrons in the nitride gap for the Ag/β-Si_3N_4/Si(111) interface, comparing it to the case of Ag/Si(111), where the QW states partially resonate with the continuum of the bulk silicon bands. The nitride layer, although very thin (less than 1 nm), restores the vertical potential wall towards the highly n-doped silicon substrate, so that silver can show the valence electronic structure of a nearly free-standing layer.

Monolayer nickel phthalocyanine functionalization of graphene.

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In order to exploit graphene in several applications, such as photovoltaics, batteries and sensors, a chemical modification of its surface is required. Indeed, functionalization with different electron donors or acceptors can lead to doping effects or, specifically, the opening of a band gap. Already successfully tested as gas sensors, nickel phthalocyanine (NiPc) functionalized samples of graphene on silicon carbide (SiC) are produced by thermal evaporation in ultrahigh vacuum conditions and experimentally characterized by X-Ray photoelectron spectroscopy (XPS), near-edge X-ray absorption fine structure spectroscopy (NEXAFS) and resonant photoelectron spectroscopy (ResPES) at the ALOISA beamline of the Elettra synchrotron facility. The preliminary analysis of these data will be shared, focusing on the electronic modifications of the graphene substrate after the functionalization with a NiPc monolayer. The discussion will deal with the structure of the molecular layer and its role in the interaction with the substrate, which can include charge transfer effects. For the sake of completeness, AFM micrographs of the samples will be examined, in the light of the spectroscopic evidence.

Analisi ottica della dinamica delle bollicine di spumante in calice.

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Il *perlage*, ovvero la formazione di bollicine che vanno dalla base del bicchiere verso l'alto, è uno degli elementi che caratterizza e rende prestigiosi spumanti, prosecchi e champagne. Il gas responsabile della formazione delle bollicine è la CO_2 prodotta dai lieviti. Una volta stappata la bottiglia, il calo di pressione fa si che la CO_2 presente in soluzione si trasformi in gas, creando le bollicine. In questo lavoro presenteremo l'analisi della distribuzione di velocità delle bollicine in calice ottenuta tramite misure ottiche. La velocità delle bollicine è funzione

delle loro dimensioni e della viscosità del vino. Lo scopo immediato del lavoro è determinare l'eventuale correlazione fra le dimensioni delle bollicine e i parametri enologici del vino, quali il tipo di lievito responsabile della formazione di CO_2 durante la presa di spuma, il processo di spumantizzazione, le geometrie dei calici. I risultati potrebbero togliere un po' di poesia e magia al fascino del *perlage*, ma la conoscenza di quanto avviene nel microlaboratorio del calice può essere di grande aiuto per il controllo del processo enologico.

Strength from defects: Topological barriers to defect nucleation generate large mechanical forces in an ordered fluid.

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Common fluids cannot sustain mechanical stress at equilibrium due to the absence of molecular order. In this study, a cholesteric liquid crystal was confined under strong planar anchoring conditions between two curved surfaces with sphere-sphere contact geometry, creating concentric dislocation loops. During surface retraction, the loops shrank and periodically disappeared at the surface contact point, where the cholesteric helix underwent discontinuous twist transitions, producing weak oscillatory surface forces. On the other hand, new loop nucleation was frustrated by a topological barrier during fluid compression, creating a metastable state. This generated exceptionally large and long-ranged elastic forces, as well as extended blue-shifts of the photonic band gap. The cholesteric helix eventually collapsed under a high compressive load, triggering a stick-slip–like cascade of defect nucleation and twist reconstruction events. These findings were explained using a simple theoretical model and suggest that colloid-cholesteric mixtures can be engineered to create unique viscoelastic and optomechanical properties.

Cobalt on nickel surfaces and the role of carbide on its stability.

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Transition metal atoms are commonly used in catalysis and photocatalysis, but their potential reactivity vanishes with aggregation and alloying. We investigate in particular whether cobalt adatoms float on Ni surfaces or can displace substrate atoms and are incorporated into the metal. Density functional theory calculations have been performed in order to evaluate the stability of different cobalt adsorption configurations on nickel surfaces, mainly at (100) terraces and steps, and the relevant energy barriers for diffusion on terraces and across steps, segregation and dissolution into the substrate. The simulations have been compared with variable temperature scanning tunneling microscopy (STM) and low-energy electron diffraction (LEED). The results show that the cobalt adatoms and small aggregates are unstable with respect to the formation of Co-Ni alloys, and the presence of a carbide layer on Ni surface slightly improves their stability.

Carbon monoxide at graphene/Ni(100).

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The behavior of graphene/Ni(100) with a stripe-moiré pattern under a carbon monoxide flux has been investigated with density functional theory calculations and different surface science techniques, including in particular scanning tunneling microscopy (STM). Several kinds of defects have been identified by comparing simulated and observed STM images. Some of them, both in valleys and on ridges, can be attributed to carbon vacancies passivated by the substrate; others, to Ni adatoms trapped in the graphene network. New features appear after exposition to carbon monoxide: in particular, some of them can be ascribed to molecules getting trapped into vacancies, and the net effect is the healing of the carbon network and its functionalization by atomic oxygen.

Two-step deswelling in the volume phase transition of thermoresponsive microgels.

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Soft colloids, thanks to their internal degrees of freedom, often display complex phase behaviour and dynamics. Thermoresponsive pNIPAM microgels are smart soft particles, with highly tunable properties and a structural complexity manifesting in distinct transition temperatures for individual and collective properties. This can be visualised in the ratio between gyration and hydrodynamic radius, displaying a minimum at the Volume Phase Transition (VPT) that expresses the inhomogenoeous shrinking of the particles. With this work we aim to explain the microscopic mechanisms underlying their VPT combining static and dynamic light scattering experiments and numerical simulations, to assess the collapse of both the inner core of the particles and that of the peripheral corona. By performing molecular dynamics simulations of single microgels, using a coarse-grained model of the polymer network, we find that the presence of charges, together with the underlying disordered network, are crucial ingredients to reproduce the inhomogeneous deswelling among the core and the surface seen in the experiments. Moreover, we found a good indicator to predict the differences in the local swelling.

Ultra-low-crosslinked auxetic polymer networks.

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Against common sense, auxetic materials expand when stretched or contract when compressed by uniaxial strain, being characterized by a negative Poisson's ratio ν. The amount of perpendicular deformation in response to the applied force can be at most equal to the imposed one, so that $\nu = -1$ is the lowest bound for the mechanical stability of solids, a condition here defined as "hyper-auxeticity". In this work, we numerically show that ultra-low-crosslinked polymer networks under tension display hyper-auxetic behavior at a finite crosslinker concentration. At this point, the nearby mechanical instability triggers the onset of a critical-like transition between two states of different densities. This phenomenon displays similar features as well as important differences with respect to gas-liquid phase separation. Since our model is able to faithfully describe real-world hydrogels, the present results can be readily tested in laboratory experiments, paving the way to the fabrication of polymeric materials with unconventional elastic behaviour.

Tuning the optoelectronic properties of van der Waals heterostructures.

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Van der Waals (vdW) crystals such as graphite, hBN, transition-metal dichalcogenides (TMDs) and post-transition-metal chalcogenides (MCs) have attracted great interest for their exceptional electronic, optical, chemical, and mechanical properties when reduced to few layers. Furthermore, 2D crystals bind together via weak vdW forces and 2D heterostructures can thus be assembled layer by layer with unprecedented tunability. This LEGO-like game offers virtually unlimited possibilities and has already led to intriguing results, among which fascinating interaction effects between charge carriers in semiconducting heterostructures, such as interlayer and moiré excitons. Here, we investigate novel methods to tune the optoelectronic properties of van der Waals heterostructures based on TMDs and MCs, by strain engineering and alloy engineering. These approaches allow us to selectively modify the band structure of single van der Waals crystals, and in turn to engineer the relative band alignment of the constituent layers of vdW heterostructures. We discuss how these methods give rise to unique phenomena and to enhanced and tailored optical properties.

Coupled plasma waves in layered cuprates.

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Plasma excitations play a primary role in cuprates: indeed, they are responsible of the optical properties and also thought to be linked to the origin of high-temperature superconductivity in such systems. Due to their anisotropic structure, these systems can sustain two kind of plasma oscillations, the high-energy in-plane plasmon and the soft out-of-plane Josephson Plasma Mode (JPM). So far, TeraHertz (THz) radiation has been successfully used to resonantly excite the JPM. Also, the in-plane plasmon has been shown, despite of his high energy, to play a key role in mediating the THz non-linear optical response in such systems. Due to the breakdown of the longitudinal-transverse decomposition occurring in anisotropic systems, plasma waves cannot propagate along arbitrary directions in layered cuprates: one would observe, in general, mixed longitudinal-transverse excitations, which are linked to a finite coupling between the in-plane and the out-of-plane plasmons. A full quantum treatment of these collective anisotropic modes has not been yet discussed in the literature. Here we fill this knowledge gap and discuss their relevance for recent experiments.

Photonic jet writing of quantum dots self-aligned to dielectric antennas.

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Owing to their ability to generate non-classical light states, quantum dots (QDs) are the most promising candidates for the large-scale implementation of quantum information technologies. However, the high photon collection efficiency demanded by these technologies may be impossible to reach for "standalone" semiconductor QDs, embedded in a high-refractive index medium. In this work we present a novel laser writing technique for the direct fabrication of a site-controlled QD self-aligned (± 30 nm) to a dielectric microsphere, which increases by a factor 7.3 ± 0.7 the collection of an objective with 0.7 numerical aperture. This technique exploits the possibility of breaking the N-H bonds in $GaAs_{1-x}N_x$:H by a laser light, obtaining a lower-band gap material, $GaAs_{1-x}N_x$. The microsphere, deposited on top of a $GaAs_{1-x}N_x$:H/GaAs quantum well, is used to generate a photonic nanojet, which removes hydrogen exactly below the microsphere, creating a $GaAs_{1-x}N_x$ QD at a predefined distance from the sample surface. Second-order autocorrelation measurements confirm the ability of the QDs obtained with this technique to emit single photons.

Role of defects in the electrical conduction of metal oxides.

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Conduction mechanisms in metal oxides have been largely studied for its relevance in technological applications ranging from metal-oxide-semiconductor devices, power or memory capacitors, and memristives devices. It is known that atomic defects play an important role in the conduction in such materials, nevertheless there is a lack in the literature of a detailed discussion on the relationship between the defect proprieties and current-voltage characteristic. By using the Ginestra™ simulation software we were able to extract the defects properties from the measured current-voltage characteristics in different metal-insulator-metal devices and to gain a general comprehension of their effect in the conducting process in three model systems, $Al_2\,O_3$, HfO_2 and Al doped HfO_2. Defects near the interfaces with energies aligned with the electrodes Fermi level are responsible for displacement current measured at low electric fields, while those with lower ionization energies can transport electrons within the dielectric bandgap or enhance the electron tunneling in the conduction band at higher electric fields.

3D reconstruction methods in Correlation Plenoptic Microscopy.

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Correlarion plenoptic imaging represents a promising solution for high-resolution volumetric microscopy without requiring multiplanar scans. Since it encodes in a single acquisition information on multiple planes based on the simultaneous acquisition of spatial distribution and direction of light, reconstruction methods are needed to recast plenoptic images as a 3D volume. We concentrate on the correlation plenoptic microscopy (CPM) setup, and explore novel algorithms capable to superimpose refocused images of the 3D scene from different points of view, removing the artifacts due to the contribution of out-of-focus parts of the scene.

Magnetized particle heating by low-frequency waves with applications to astrophysical and laboratory plasmas.

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In this work we outline the possibility for charged particles in magnetic fields to be heated by non-resonant low-frequency (below cyclotron frequency) waves of large enough amplitude. The theoretical model is based upon the Hamiltonian neoadiabatic theory developed in the eighties. It has been recently revived for an explanation of solar corona ion heating by Alfvén waves. Here we suggest its validity within the context of Earth's magnetosphere electron heating by Lower Hybrid waves, basing upon the measurements from the Magnetospheric Multiscale (MMS) mission. Finally, we suggest its possible application to laboratory plasmas, too: tokamaks or Reversed Field Pinches, where the excitation of Alfvén waves has been recently numerically studied.

Towards the synthesis of MAX phases by Atomic Layer Deposition (ALD).

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MAX phases are polycrystalline nanolaminates of ternary carbides and nitrides with specific stoichiometry and layered structure, which exhibit unique properties. However, so far, there is no simple approach to successfully deposit MAX phases on conventional substrates. Atomic Layer Deposition (ALD) could represent a suitable choice for fabricating these materials. Here we present the synthesis and characterization of Tin+1GaNn films grown by ALD on SiO_2/Si. Stoichiometric analysis over the whole film thickness shows that ALD holds promise for the preparation of a new class of MAX phases with specific and controllable properties.

Isolanti topologici di ordine superiore in quasicristalli.

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La tradizionale classificazione dei materiali cristallini in metalli e isolanti è stata superata con la scoperta degli isolanti topologici. Essi infatti, pur manifestando comportamento isolante al loro interno (d-dimensionale), presentano stati metallici localizzati ai loro bordi (($d-1$)-dimensionali). Molto recentemente, un'ulteriore possibilità è stata esplorata: gli isolanti topologici di ordine superiore, in cui gli stati metallici hanno dimensione $d-n$, con $n \leq d$. Nel 2020 Spurrier e Cooper hanno proposto un modello che realizza una fase di isolante topologico del secondo ordine in un sistema quasicristallino, costituito da due piani di grafene sovrapposti con una rotazione relativa di 30°. Approfondendo lo studio di questo sistema con tecniche numeriche, abbiamo mostrato come la geometria della nanostruttura e la forma delle sue terminazioni rivestano un ruolo cruciale per la realizzazione della fase topologica. Inoltre, abbiamo dimostrato che, sotto opportune condizioni di geometria e scelta dei parametri del modello, insorgono nuovi modi 0-dimensionali con localizzazione atipica rispetto a quanto finora riportato in letteratura.

Fabrication of silicon microfluidic devices.

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Silicon high aspect ratio microfluidic devices characterized by a homogeneous and heterogeneous size distribution and spatial organization of the solid structure give the possibility to understand the coupling between chemical and physical processes of colloid transportation and bacteria filtration. To achieve Si-based filters a photomask is fabricated by photolithography replicating a suitable mask, then a multi-step dry etching is performed to achieve an aspect ratio of 1. This implies an etching of about 15 micron depth, preserving the perpendicularity of the structures. Metal-assisted chemical etching process has also been performed to compare the different profiles of the structures. These patterned structures are then used to quantify the coupling between pore-scale flow heterogeneity and particles-medium interaction on colloid filtration observing the overall filtration efficiency, the particles deposition profile and the consequent impact on the filter hydraulic properties.

Controlled generation of sine-Gordon breathers in long Josephson junctions.

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Long Josephson junctions admit a particularly elusive solitonic excitation, known as breather, whose experimental observation has yet to be achieved in these systems. We propose, together with appropriate detection techniques, the use of tailored magnetic pulses at the edge of the junction for the controlled generation of single breathers by means of the nonlinear supratransmission effect. Our theoretical/computational analysis, based on a sine-Gordon model which includes a dissipative term and an external current source, shows the effectiveness of the approach, both in a deterministic regime and in the presence of thermal fluctuations. We further investigate the dynamics of the induced breathers and their robustness to a stochastic perturbation, *e.g.*, by looking at their radiative decay process in a noisy environment.

Environment dependence of amplified spontaneous emission of all-inorganic perovskite nanocrystals.

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All-inorganic perovskite nanocrystals (NCs) are emerging as a new class of materials with advanced optical properties, depending on both the fabrication techniques and the diverse strategies of surface passivation. In particular, due to their intrinsic sensitivity to the ambient conditions (often inducing critical fast optical irreversible quenching) the development of novel strategies for effective surface stabilization is a current challenge. Here we present a study of lecithine-capped $CsPbBr_3$ NCs in terms of amplified spontaneous emission (ASE) and its dependence on the enviromental conditions. The NCs, deposited on quartz substrates and placed under two different air pressures (10^{-1} mbar and atmospheric pressure), have ASE threshold in line with the state of art for similar materials. Interestingly, our perovskite NCs

present a clear environmental sensitivity of ASE consisting in a reversible and reproducible variation of the intensity under vacuum and ambient conditions (up to 20%), against a variation of a few percent observed for the spontaneous emission. These results point out the opportunity to exploit such perovskite NCs for sensing or switching applications.

An approach to adiabatic elimination by means of Magnus expansion.

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Coherent state-processing of quantum systems is one of the main goals of quantum information and control. With the upscaling of quantum hardware, typically one has to deal with multi-level systems, whereas the relevant dynamics must be confined to a low-energy Hilbert subspace. The so-called adiabatic elimination is the simplest procedure allowing to derive in certain cases a low-dimensional effective Hamiltonian, nonresonantly coupled levels being removed from the relevant Hilbert subspace. However, such an approximation presents ambiguities, as the dependence on the gauge choice and difficulties in systematically improving it. This problem has been studied in the past in three- and four-level systems by analyzing exact solutions of the Schroedinger equation, by using Green function formalism, and by exploiting the Markov approximation approach. Here we use a method based on the Magnus expansion, which yields an ambiguity-free coarse-grained effective Hamiltonian, quantifying its performance in terms of the fidelity of quantum operations.

First-principles predictions of transport properties via the Boltzmann approach.

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Significant progress on parameter-free calculations of transport properties in real materials has been made during the past decade. Lately, very efficient and highly scalable computational infrastructures have been developed to study intrinsic, phonon-limited drift and Hall carrier mobilities of 3d semiconductors, within the framework of the first-principles Boltzmann transport equation. These advances open the possibility to refine approximations routinely adopted in the calculation of transport properties, and they also promise to enable the study of materials with complex unit cells for which the modelling of the electronic and phononic properties is hard to achieve. I will here discuss the latest results for state-of-the-art transport calculations with the Boltzmann formalism and will discuss some of the most interesting directions of the field.

Electric-field control of magnetism in monolayer $Cr_2Ge_2Te_6$: An ab initio study.

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The atomic thickness of two-dimensional materials provides the unique opportunity to control their electrical and optical properties. The discovery of two-dimensional magnetic materials, in particular, paves the way for the electrical control of magnetism and the realization of new functional devices for spintronic applications. The possibility of doping these few layer systems via the electric field effect is certainly very appealing. Only few experimental works

on electrostatic doping exist but the microscopic mechanism for the observed results is still not well understood. In this work, we present an extensive analysis, the based density functional theory (DFT), on the doping dependence of the magnetic properties of monolayer $Cr_2Ge_2Te_6$. We first show effects of electrons/holes doping on the electronic properties on the monolayer $Cr_2Ge_2Te_6$. Then we investigate its magnetic structure with a hybrid functional, with super-cells containing up to 160 atoms. We evaluate the magneto-crystalline anisotropy energy, all the relevant exchange couplings, and the Curie temperature as a function of the doping charge, comparing them with recent available experimental data.

2D carbon networks beyond graphene: Graphdiyne nanostructures from theory to experiments.

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Novel 2-dimensional carbon structures can be produced by properly combining carbon atoms with *sp* and sp^2 hybridization. Among these systems, graphdiynes represent 2D carbon crystals beyond graphene featuring structure-dependent properties. These systems have been intensively investigated by theoretical calculations while their experimental realization has been reported only recently. Here we present a combined theoretical and experimental investigation of different sp-sp^2 structures produced by on-surface synthesis of brominated molecular precursors evaporated on Au(111). The structure and properties of 2D graphdiyne-like networks and 1D nanoribbons have been investigated by STM and Raman spectroscopy and by density functional theory (DFT) simulations. The peculiar electronic and vibrational properties and the role of the Au surface have been unveiled by DFT calculations and by STM and Raman spectroscopy. This allows us to provide a thorough understanding/description of these novel carbon-based 2D systems.

Quantitative ultrafast electron-temperature dynamics in photo-excited Au nanoparticles.

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We quantitatively measured the temporal evolution of the electronic temperature of plasmonic gold nanoparticles (NPs) in the first picoseconds after ultrafast photo-excitation. To measure the temperature of the electronic bath, we performed ultrafast time-resolved photoemission spectroscopy around the Fermi edge of gold NPs by means of a pump-probe technique: the ultrashort exciting pulse was spectrally matched with the localized surface plasmon resonance of the NPs in order to maximize the absorption cross section, while the probe pulse, delivered by a High-Harmonics Generation (HHG) source, consisted in extreme-ultraviolet ultrashort radiation pulses, with high temporal and unprecedented spectral resolution. By fitting the experimental curves against a Fermi-Dirac distribution function, the ultrafast dynamics of the electron-gas temperature was extracted in a totally model-independent fashion. These results can be instrumental to refine the theoretical modelling of the ultrafast dynamics of metallic nanosystems.

Dense-wavelength division multiplexing of quantum and classical communication over a deployed fiber link enabled by up-conversion assisted detectors.

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The coexistence of classical and quantum communications within the same fiber optics infrastructure is still an open challenge, since the vast majority of displaced fiber optics infrastructures, representing a very appealing resource for quantum key distribution (QKD) purposes, are generally used for classical telecommunication. The most common approach followed today in order to exclude the classical signal from the quantum channel exploits dense wavelength division multiplexing (DWDM). Unfortunately, QKD is hardly susceptible to single-photon-level noise, so this expedient is far to be efficient. We realized an alternative setup based on a self-built single-photon detector able to convert C-band photons into visible wavelength photons taking advance of upconversion, a nonlinear optics process. The upconverted photons have then been detected using a silicon photon counter. Thanks to the properties of upconversion, we achieved a greatly sharp filter in both polarization and wavelength, showing that our scheme can tolerate a 4 dB more powerful signal into the classic channel compared to a scheme relying on a detector for C-band photons, even though they own comparable efficiencies.

Unravelling the P_3 centers origin in alkali phosphate glasses.

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In this talk we present a first-principle investigation of intrinsic paramagnetic point defects in P_2O_5 and in alkali phosphate glasses. Glass models of $NaPO_3$ are generated by combining classical molecular dynamics and Monte Carlo simulations, and validated by comparing their corresponding structure factor with available x-ray and neutron scattering experiments. We use the density functional theory to calculate the Electron Paramagnetic Resonance (EPR) parameters for a large set of paramagnetic oxygen-vacancy configurations. Our investigation, also by unveiling the effect of the local environment and disorder on the hyperfine tensor, enables us to propose a new model for the debated P_3 center. In particular, we establish the occurrence of two variants, which we name P_3^a and P_3^b centers. We have also carried out EPR calculations for oxygen vacancies in models of $LiPO_3$ glass derived from our $NaPO_3$ models. The calculated Fermi contacts at P_3^a and P_3^b centers in $LiPO_3$ shift to larger values with respect to the $NaPO_3$ glass, consistently with experimental data, and thus further confirm our assignment for the P_3 centers in alkali phosphate glasses.

Ultrafast charging of a high-power quantum battery.

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We propose a quantum battery made up of a collection of two-level systems embedded in a cavity with a single photonic mode. The important topic of fast and high-power charging is investigated studying an exotic coupling with the cavity, given by the two-photon interaction. Usually this kind of interaction is negligible compared to the single-photon one, but in some recent experimental proposal, based on superconducting qubits, has been enhanced and made dominant. Indeed we find a regime of parameters where this unconventional interaction dominates the dynamics, leading to important improvements of the quantum battery performances. Moreover, it is found that the scaling of the charging power with the finite number of qubits N shows a quadratic growth leading to a relevant improvement of the charging performance of quantum batteries based on this scheme with respect to the purely single-photon coupling case, where a $\sqrt{N}$ advantage was observed.

Amplified Spontaneous Emission (ASE) in lead halide perovskite thin films: A quantitative comparison between different methods to determine the ASE threshold.

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The demonstration of optical gain both in bulk polycrystalline and nanocrystals (NCs) thin films of lead halide perovskites opens the way to possible laser applications of these materials. In order to characterize a new material for laser application, Amplified Spontaneous Emission (ASE) properties are usually investigated and the ASE threshold value is typically used to compare different active materials. Currently, several methods to estimate the ASE threshold are found in the literature, thus preventing a comparison between values obtained with different methods. In this experiment we investigated the ASE properties of $MAPbBr_3$ bulk polycrystalline and $CsPbBr_3$ NCs thin films and we determined the ASE threshold with eight different methods. We demonstrate that the most reliable method is the "FWHM narrowing", which estimates the ASE threshold as the excitation density at the beginning of the line narrowing, that is, however, seldom used in the literature. The most used methods in the literature, on the other hand, always overestimate the ASE threshold.

Basic science approach to nuclear fusion research.

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Meaningful fusion burning plasma regimes that can be attained by experiments involving magnetic confinement are characterized by the fact that collisional processes are intrinsically weak and classical thermodynamics based criteria cannot be applied. Rather, plasma collective modes have a key role in determining the rates of particle and energy transport. Moreover self-organization processes that are present in current experiments on non-reacting plasmas are expected to become evident through new effects in plasmas where density and temperature profiles are interconnected with energy deposition (heating) by fusion reaction products. In fact, fusion reaction rates are strongly dependent on expected departures from Maxwellian of the reacting nuclei distribution functions resulting from the excitation of collective modes and "cool fusion" scenarios can be envisioned. These theoretical findings and considerations, consistent with present experimental observations, suggest that the needed approach in fusion research is that of multiple complementary efforts, exemplified by the Ignitor Program, devoted to uncover the non-thermal physics of fusion burning regimes.

Dynamics of charge transfer from plasmonic nanoparticles to cerium oxide.

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The combination of semiconducting oxide-based materials with plasmonic nanoparticles (NPs) aims to efficiently convert solar light into chemical or electric energy, exploiting the excitation of localized surface plasmon resonance (LSPR) in the NPs that leads to a significant energy/charge transfer to the oxide. For a knowledge-driven optimization of these materials, it is fundamental to understand the processes behind this energy transfer. We have recently demonstrated a highly efficient charge transfer from Ag NPs to CeO_2 and we are now focusing on the study of Au and Cu NPs. Performing UV-visible spectrophotometry measurements on systems composed by Cu/Au NPs embedded in a matrix of CeO_2, we observed a wide absorption band in the visible range, ascribed to the LSPR excitation in the NPs. Femtosecond transient absorption spectroscopy at different pump energies across the LSPR band of the NPs unveiled a persistent charge transfer from the NPs to CeO_2, in analogy with the case of Ag NPs. High injection efficiencies have been estimated: up to 10% for the system with Cu NPs and up to 35% for Au NPs.

Kinetic effects in nonequilibrium electron-positron plasmas.

VERESHCHAGIN G.
ICRANet

I will review several new effects discovered by simulations of nonequilibrium optically thick electron-positron plasmas, including: Bose-Einstein condensation of photons and avalanche thermalization due to Pauli blocking. I will also describe the progress in solving relativistic Boltzmann equations for electrons, positrons and photons out of first principles, where collision integrals are computed integrating QED matrix elements not only for binary processes, but also for triple ones. These results are of interest in astrophysics and cosmology.

Emergence and evolution of crystallization in TiO_2 thin films: A structural and morphological study.

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Titanium dioxide (TiO_2) is one of the most intensively studied oxides for its unique and attractive properties, which lead to a wide variety of application fields. TiO_2-based devices are indeed developed for photocatalysis, sensors, optical coatings, and self-cleaning application. While some applications (optical fibers, displays, solar cells) require amorphous materials, some others, *e.g.*, phase change memories, are based on the amorphous-to-crystalline transition. Here, we present an experimental study of the amorphous-to-crystalline transition in TiO_2 thin films, by exploring the effect of post-deposition heat-treatments. We investigate the earliest stage and evolution of crystallization, both as a function of the annealing temperature, T_a , and TiO_2 thickness, d. We explore morphological and structural properties of as-grown and heat-treated samples with atomic force and scanning electron microscopies, X-ray diffractometry and Raman spectroscopy, observing an increasing crystallization onset temperature as d is reduced. Finally, we also explore the phonon lifetime *versus* d and T_a, both ultimately affecting the degree of crystallinity.

Hydrodynamic spin lattices.

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A millimetric droplet bouncing on the surface of a vibrating liquid bath can self-propel across the surface through interaction with the wave field it generates by bouncing. These "walkers" comprise a droplet and its guiding wave, and have been shown to exhibit several behaviors analog to microscopic systems. Most analogs consider a single walker interacting with boundaries or experiencing external forces. Controlling multiple walkers is challenging as their continuous wave-mediated interactions usually lead to pair bound states and droplet-droplet coalescence. We introduce hydrodynamic spin lattices of walkers as a new class of active spin systems with particle-wave coupling. These systems reveal a variety of non-equilibrium symmetry-breaking phenomena, including transitions from anti-ferromagnetic to

ferromagnetic order that can be controlled by varying lattice geometry and system rotation. Theoretical predictions based on a generalized Kuramoto model derived from hydrodynamics rationalize the experimental observations, showing the potential of hydrodynamic spin lattices as versatile platforms for exploring active phase oscillator dynamics.

Local morphology effects on the photoluminescence properties of $CsPbBr_3$ nanocrystals thin films.

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Lead halide perovskites nanocrystals (NCs) are emerging as extremely interesting active materials for a wide variety of optoelectronic and photonic devices, thus stimulating the research to understand their photophysics. The photoluminescence (PL) temperature dependence is often used to determine fundamental quantities like the LO phonon energy and the exciton binding energy, interestingly obtaining widely scattered, and inconsistent with each other, values. In this work we demonstrate, in a $CsPbBr_3$ NCs thin film, that the local NCs aggregation has strong effects on the PL spectra peak wavelength, linewidth and intensity temperature dependence. We show that an analysis comparable to the ones in the literature leads to completely different conclusions about the intrinsic NCs emission properties extracted from spectra measured in different positions on the film. A more careful analysis instead allows to ascribe the inconsistencies to different contribution of NCs aggregates to the total PL. Our results demonstrate that the investigation of the local morphology is fundamental to correctly correlate the PL spectral features to the intrinsic emission properties of lead halide perovskites NCs films.

Adiabatic quantum operations with ultra-strongly coupled artificial atoms.

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Ultrastrong coupling (USC) between light and matter has been recently achieved in solid-state artificial atoms coupled to cavity modes. Such architectures are promising building blocks for quantum hardware performing ultrafast operations. However, faster dynamics has a cost since USC breaks conservation of the number of excitations. This leads to new physical effects of fundamental interest, which however are detrimental for quantum state processing. In particular, the highly entangled nature of the eigenstates, dressed by a potentially very large number of virtual photons, leads to leakage of excitation via the dynamical Casimir effect (DCE) and decay. In this work, we analyze quantum operations between a USC architecture with two artificial atoms, the cavity operating as a virtual bus. We show that an adiabatic protocol similar to STIRAP may overcome the problem of leakage in the USC regime. Moreover, optimal control theory allows for properly crafted controls that extend the high-fidelity region to large couplings. Our results suggest that adiabatic manipulations may be a promising tool for quantum state processing in the USC regime.

Simulazioni euleriane di onde elettrostatiche in plasmi non-neutri.

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Lo studio dei plasmi non neutri possiede vasta applicabilità in diversi settori scientifici: dal confinamento di antimateria in laboratorio, allo studio delle magnetosfere delle stelle a neutroni e delle strutture coerenti, frequentemente osservate nello spazio interplanetario. Le loro eccezionali proprietà di confinamento consentono lo sviluppo di numerosi esperimenti di laboratorio, generalmente effettuati all'interno delle trappole di Penning-Malmberg, poiché in analogia ai plasmi globalmente neutri, i plasmi non neutri sostengono numerosi effetti collettivi, come la propagazione di onde e lo sviluppo di instabilità. La sinergia tra modelli teorici, simulazioni ed esperimenti è decisiva per comprendere la dinamica di questi sistemi. La teoria relativa al lancio di onde elettrostatiche longitudinali, *e.g.*, le onde di Trivelpiece-Gould, in una colonna di plasma contenuta in una macchina di Penning-Malmberg viene qui discussa. Un nuovo codice numerico Vlasov-Poisson che permette di descrivere il fenomeno del lancio di tali onde con condizioni al bordo realistiche viene presentato. I risultati delle simulazioni, effettuate in regime lineare, sono in accordo con le previsioni teoriche.

Intrisic feedback optical trapping.

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As for many other fields, feedback control has been integrated with optical trapping in order to improve system performances, as for force or position control. Among the different approaches so far proposed, the trapping inside a laser cavity is interesting for different reasons: trapping can occur at lower optical intensities and with low numerical aperture lenses. Also, intracavity trapping allows to explore intriguing basic physical dynamics. When the trapping occurs in a cavity the particle alters its Q-factor, so triggering intrinsic feedback on the trapped particle. In our study we will analyze the behaviour of intracavity optical trapping in different optical schemes, using counterpropagating beams and unidirectional ones. Moreover, we analyze different hydrodynamic regimes, from the overdamped motion (in liquid) to the underdamped one (in air or vacuum). For the latter case, micrometric particles are trapped using a homemade loading system based on oscillating piezoelectric rings to win the van Der Waals adhesion forces. The fast motion of trapped particles at low-pressure gas should result comparable with that of the laser itself, giving place to non-predictable phenomena.

Incompatibility in multi-parameter quantum metrology across first- and second-order phase transitions.

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It is well known that many-body systems near their critical point become legit probe from a metrologic point of view. Moreover, the critical behaviour of many-body systems can improve also the compatibility in multi-parameter estimation schemes. The incompatibility in simultaneous estimation of different parameters, arising from the quantum nature of the underlying physical system, can be studied introducing a scalar index, proportional to the ratio between the mean Uhlmann curvature and the Fisher information. It turns out that, thanks to the Fisher information's divergences, the values of this index are affected by criticality. The systems analyzed, both related to the critical behaviour of Ising chains in a multi-parameter scenario, are: a XY Ising model that undergoes a continuum quantum phase transition and a 1-D Ising chain with transverse and longitudinal magnetic fields that undergoes a continuum quantum phase transition and a first-order quantum phase transition. In both the situations the criticality plays a pivotal role in the behaviour of the compatibility index, revealing high-compatibility regions in the phase diagram.

Numerical modelling of Alfvén waves in fusion plasmas.

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Alfvén waves are magnetohydrodynamic (MHD) waves that propagate in magnetized plasmas and have been the subject of intense study in laboratory, space and astrophysical plasmas in the last decades. In this study, we will investigate the mechanism of their excitation during Ohmic discharges in magnetically confined fusion plasmas with focus on reversed-field pinch (RFP) and tokamak configurations. The nonlinear 3D MHD cylindrical code SpeCyl will be used to analyze magnetic configurations with increasing level of complexity. Numerical solutions from these simulations will be analyzed by comparing them with the approximate analytical solutions obtained with the linearized ideal MHD model and cold plasma approximation. Alfvénic waves such as shear Alfvén wave (SAW), compressional Alfvén eigenmodes (CAEs) and global Alfvén eigenmode (GAE) will be identified and characterized, alongside phenomena like phase mixing of SAW and resonant absorption of CAEs. Modelling results are in good quantitative agreement with the experimentally observed Alfvén waves in the RFX-mod device.

Two low-frequency magnetic-field circuits for hyperthermia and drug delivery experiments.

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Two different low-frequency (LF) magnetic-field circuits are presented for the study of nanostructured superparamagnetic iron oxides mixtures. Such fields must be capable of reaching high SAR values at approximately 500 kHz frequency and at about 30 mT magnetic fields. The first circuit consists of a resonant circuit composed of a coil $L = 4.6$ μH and $C = 22$ nF managed by a switch made up of 4 power transistors; the second is always a resonant circuit consisting of a 2.8 μH coil and a transmission line fed by a high-voltage capacitor, 60 kV, governed by a homemade spark gap.

Information backflow with entropic quantities.

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Due to an inevitable coupling of quantum systems to external degrees of freedom and fragile nature of quantum resources, the theory of open quantum system is relevant in many different parts of physics. To better describe the phenomena occurring, exemplary, in solid-state physics, going beyond the standard Markovian description in terms of GKSL master equation is necessary. With this a vast interest in non-Markovian quantum dynamics has arisen, in particular different, non-equivalent definitions of quantum non-Markovianity have been introduced. Here we strengthen one of the definitions based on the non-monotonicity of the distance between two distinct reduced states. This has an interpretation in terms of information backflow from the outside world to the reduced system. We show that this interpretation can be preserved also when one uses different distinguishability quantifiers, in particular entropic quantities.

4π-periodic AC current through helical Josephson junctions.

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The last two decades of research in condensed-matter physics have brought to the forefront quantum materials with non-trivial topology. Such systems hold promise, among others, for applications in spintronics. A prominent role in this context is played by two-dimensional topological insulators (2DTI), thanks to the helical nature of their one-dimensional edge channels. Here, the manipulation of the helical states can be performed by usual metallic contacts, gates, external magnetic fields, superconductors, and quantum point contacts between the helical edges. In this framework, we consider a 2DTI between two opaque superconducting barriers, pierced by a magnetic flux and subjected to an external bias. We crucially include tunneling events between the two edges of the insulator occurring throughout the whole region, and analyse the AC and DC Josephson currents through our structure. We show that our model admits a 4π-periodic component in the AC Josephson current and analyse the zero-bias limit. Moreover, we discuss the robustness of the 4π feature in a wide range of parameters and its physical consequences.

Concept for producing "extreme" surface plasmon polaritons.

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We show via simulations how surface plasmon polaritons (SPPs) excited in a grating coupling scheme using a laser pulse with wavefront rotation (WFR) may have a duration down to the near-single-cycle limit and at the same time an enhanced peak amplitude. With WFR the effective angle of incidence rotates during the laser pulse, hence the resonance condition between the laser and the SPP is gated for a short time interval obtaining a SPP with duration down to 1.4 optical cycles. In addition, the WFR makes the laser focus to "slide" along the target sustaining the amplitude of a SPP propagating in the same direction. In the ultrahigh-intensity regime ("extreme light") the concept may be exploited to produce electron bunches with few femtosecond duration, tens of MeV energy, and tens of pC charge.

EXODUS: A new soft x-rays diagnostic system for tokamaks.

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The diagnosis of soft X-ray (SXR) emission from tokamaks represents a unique source of information, since it allows the study of several plasma parameters, such as the electron and ion temperature, the investigation of the ionization equilibrium, particle and runaway transport and the study of MHD fluctuations and disruptions. A new 2D-SXR diagnostic system called EXODUS (Enhanced X-ray Optimized Detector for Use in multiple Scenarios) has been developed with the aim to combine 2D energy resolved SXR emission profiles from the plasma with a high time (< 0.1 ms) and spatial resolution (< 3 mm^2). The EXODUS system is based on the Gas Electron Multiplier (GEM) technology coupled with a padded anode readout and a new data acquisition system custom designed for GEM called GEMINI. In this contribution we will describe the laboratory characterization carried out on the first detector prototype using a quasi-monochromatic X-rays beam at very high rate (> 150 MHz) and the design of a enhanced version of the detector that is planned for installation on a tokamak in the near future. Preliminary measurements taken on plasma will be also shown.

Gate-tunable Josephson hallmarks of unconventional pairing in oxides superconducting nanowires.

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In BCS superconductors inversion and time-reversal symmetries (ISs and TRSs) are preserved, so the breaking of these symmetries is expected to lead to unconventional superconducting pairing. This is the case of 2D electron systems in $SrTiO_3$-based heterostructures, *e.g.*, $LaAlO_3/SrTiO_3$ (LAO/STO), that are paradigmatic non-centrosymmetric superconductors that inherently lack IS. We present experimental evidences of unconventional superconductivity in the LAO/STO interface in weak links realized by high-resolution EBL, with the anomalous enhancement of the critical current I_c by small out-of-plane magnetic fields $B_\perp$ and the asymmetric response with respect to the $B_\perp$ direction, with a unique trend in intensity and sign upon electrostatic gating. We theoretically demonstrate that the experimental observations indicate a coexistence of Josephson channels with intrinsic phase shifts. The symmetry of $I_c(B_\perp)$ excludes TRS breaking for the occurrence of unconventional pairing. Our findings show that IS breaking and non-trivial multi-orbital superconductivity

are essential elements to account for the experimental observations and gate tunability of the effect.

Fractional magnetic excitations in a large ring-exchange cuprate observed by high-resolution RIXS.

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The spin-1/2 square-lattice antiferromagnet is one of the most studied systems in condensed-matter theory, and much effort has been put in the quest for exotic ground states and excitations. Different forms of Resonating Valence Bond (RVB) states have been predicted in many Heisenberg Hamiltonians with either frustrating or multi-spin couplings, which exhibit fractionalized collective excitations, each carrying spin 1/2: 2-dimensional spinons. Despite many efforts, they have so far eluded a conclusive observation in the AF square lattice. Motivated by a recent theoretical results, we have used Cu L_3 Resonant Inelastic X-ray Scattering to study the spin excitations of $CaCuO_2$, a cuprate with exceptionally large $J_c \sim J$. Close to the magnetic zone boundary, we observe a strong decrease of the magnon spectral weight, which decays into a broad asymmetric continuum at high energies. Polarization analysis on the scattered beam reveals that this continuum entirely belongs to $\Delta S = 1$ excitations. This is what is expected for a two-spinon continuum and we propose that this compound lies close to the quantum phase transition driven by the ring exchange predicted by the theory.

Theoretical/computational study of point defects in SiC and perspectives for quantum technologies.

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We theoretically study point defects in 3C-SiC for applications to Quantum Technologies. We focus on the silicon vacancy, which is an electron spin-1 magnetically interacting with the SiC nuclear spin bath containing ^{29}Si and ^{13}C nuclei. We calibrate the system's magnetic Hamiltonian with *ab initio* methods based on Density Functional Theory, by using the QE-GIPAW module of Quantum Espresso. We apply a Hahn-echo sequence on the electron spin and study the effects the bath dynamics has on the electron spin's coherence. We study the coherence signal's Electron Spin Echo Envelope Modulation (ESEEM) phenomenon, due to single nuclear spin flipping processes, and overall decay, or decoherence, due to the electron spin's entanglement with the bath. We exploit the Cluster Correlation Expansion (CCE) theory for calculating an approximate version of the coherence function, at various orders of approximation. We repeat the same kind of calculations on a *kk* divacancy in 4H-SiC and compare the results.

Electronic shot noise in the absence of currents.

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Shot noise is typically associated with the random partitioning of a current flowing through a conductor. However, recent experimental results, have demonstrated the appearance of charge current shot noise due to a pure temperature bias, in the absence of an average current. This effect, dubbed delta-T noise, is currently attracting a lot of interest. In this work, we show that this concept is much more general, occurring in different nonequilibrium realizations and for different types of currents. We derive a fundamental bound for the zero-current charge shot noise at the thermovoltage, providing explicit examples of mesoscopic conductors where this bound can be approached. In contrast, we show that such a bound does not exist for the heat shot noise in the absence of a heat current.

Pulsed laser deposition and nanoscale investigation of two-dimensional MoS_2.

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Among the most promising 2D materials, transition metal dichalcogenides (TMD), especially molybdenum disulfide (MoS_2), play a prominent role in 2D semiconductor physics, due to their peculiar optoelectronic and structural properties. Here, we present an experimental study of 2D MoS_2, in which we synthesize and characterize 2D MoS_2 nanostructures grown on different substrates (Au, Ag, graphite) by pulsed laser deposition under ultra-high vacuum. We conducted *in situ* scanning tunneling microscopy/spectroscopy investigations to study the deposited structures at the nanometer and atomic scale, revealing the epitaxial relation with the substrate and the local electronic properties. Raman spectroscopy allowed us to analyze the vibrational properties of 2D MoS_2, providing insight into the film-substrate interaction and the stability under ambient conditions. By combining different synthesis techniques in our experimental apparatus, we also approached the study of 2D heterostructures between different materials, not only in the TMD family (such as MoS_2/WS_2 heterobilayers) but also among different class of materials, such as hybrid heterostructures formed by pentacene molecules and 2D MoS_2.

Studies on dynamical shell formation for direct-drive laser fusion.

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Conventional targets for direct-drive laser fusion consist of a spherical shell with a thin inner layer of frozen deuterium-tritium fuel. Such targets can be effectively imploded at the velocities required for thermonuclear ignition by the ablation pressure generated by collisional absorption of laser light. Recently, a new concept has been proposed using much simpler homogeneous spheres. In this case, the shell is formed dynamically. A first laser pulse produces an imploding shock wave, which after bouncing from the center turns into a blast wave. Interaction of this blast wave with imploding waves driven by subsequent laser pulses eventually generate the shell, ready to be imploded as in the conventional approach. A reduced-scale proof-of-principle experiment on dynamic shell formation is now under design (at Rochester's LLE OMEGA Laser). We present and discuss relevant numerical hydrodynamic studies performed with Sapienza's DUED code. We have defined pulse timing and power required for shell formation using 1-D simulations, and studied robustness to deviations from spherical irradiation with 2-D simulations.

Carbon monoxide quartz-enhanced photoacoustic spectroscopy sensor for environmental monitoring applications.

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Carbon monoxide (CO) is mainly produced by incomplete combustion of carbon-based substances and is one of the most common and dangerous environmental pollutants. Its ready reaction with hemoglobin in human blood reduces the oxygen-carrying capacity of the blood and may lead to hypoxia for prolonged exposures to concentrations of tens to hundreds parts-per million (ppm). Thus, CO monitoring requires highly sensitive sensors. Laser-based spectroscopic techniques are the best candidates to fulfil this task. Quartz-Enhanced Photoacoustic Spectroscopy (QEPAS) is an innovative optical technique, employing quartz tuning forks as sensitive elements. In this work, a robust and portable QEPAS sensor aimed at CO detection is reported. The achieved sub-ppm sensitivity allows the monitoring of CO concentration in ambient air. A commercial electronic hygrometer was employed to compensate the water vapor influence on the CO photoacoustic signal. To prove the effectiveness of the prototype as a reliable ambient sensor of carbon monoxide, environmental measurements in urban and high-traffic areas have been taken.

Study of carrier transport across the ZnO/SnO_2 composite nanostructures.

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In this work we explored the possible role of defect states in charge transport in a type II heterointerface formed by ZnO/SnO_2 composite nanostructures (CNs) grown using VLS technique. XRD, Raman and HRTEM were used to study the structural and morphological properties of CNs which suggested the presence of defects. PL, PLE and XPS results confirmed the presence of oxygen vacancies in ZnO and SnO_2 and Zn interstitials in ZnO, which showed a dependence on the growth temperature. The role of defect states in the charge transfer process was probed by a temperature-dependent I-V characterization and it showed significant accumulation of charges at the interface, which was released by thermal excitation. It is, therefore, concluded that defects can be tuned and can play a role in catalytic devices, where excess charge is needed at the interface.

Experimental and theoretical THz spectroscopy of solid saccharides.

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Terahertz time-domain spectroscopy (THz-TDS) is a powerful tool for probing collective molecular vibrational modes of biomolecules. In this study, we used THz-TDS to investigate the low-energy vibrational modes of a group of organic molecules belonging to saccharides in their solid state. THz-TDS measurements were performed at room temperature on pellets made by saccharides and polyethylene optimized in order to get the highest measurable absorbance within the dynamic range of the set-up. *Ab initio* simulations based on density functional theory (DFT) were carried out by employing a state-of-the-art method for the calculation of the weak intermolecular forces driving the collective motion of organic molecules. DFT simulations allowed to compute the photonic eigenvalues and eigenfunctions at Γ point and Born effective charges needed to determine the IR active modes and the associated oscillator strengths from which it was possible to calculate the IR absorption intensities. The use of a combined experimental and theoretical approach allowed us to quantitatively determine the characteristics of vibrational modes of saccharides in the solid state at THz frequencies.

Terahertz spectra of 3D printed photonic structures.

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Thanks to the continuous innovation in 3D printing, structures with minimum size as low as 100 μm can be fabricated, opening up the possibilities of creating 3D-printed optical components for the THz ranges. We exploited this technology as a low-cost, rapid, and versatile tool for the fabrication of THz photonic structures characterized by given properties. By using fused deposition modeling 3D printing we fabricated photonic structures composed of rods arrays to control the THz photon propagation through the choice of their optical and geometrical parameters. The experimental optical response of 3D printed photonic structures was obtained by THz time-domain spectroscopy. Simulations of their optical response were performed by an analytical exact solution of the Maxwell equations for general incidence geometry. The THz spectrum shows the appearance of Bragg and Mie gaps. The effect of the disorder of the structures on the measured spectral properties was compared with simulations.

ECRH and ECCD modeling studies for DEMO.

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Among the additional heating systems foreseen for the first planned reactor DEMO, which has the aim of demonstrating the production of electricity through controlled thermonuclear fusion reactions, the Electron Cyclotron Resonance Heating and Current Drive (ECRH&CD) system is considered essential for granting reliable plasma operation. In this work the quantitative study of EC system performances in the main DEMO operational scenario is presented, focusing on the physics tasks which such system is foreseen to accomplish: bulk heating, current drive and mitigation of MHD instabilities in the core of the plasma, and control of thermal instability in the plasma edge region. To this aim, the EC system must provide proper different radial localizations and combination of heating and non-inductive CD. In order to find suitable launcher configurations, the beam tracing code GRAY has been used to perform scans in the launcher parametric space defined by the injection angles, the wave frequency and the antenna position. Main optimization results are shown, taking into account the peculiar physics requirements and issues, and the engineering constraints of a fusion power plant reactor.

Endurance of mesoscopic twin-beam states propagating in noisy channels.

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Quantum states of light represent a useful tool for encoding and transmitting information. The main obstacle to the successful implementation of Communication protocols, especially over long distances, is given by the losses and noise sources affecting the transmission channels, which can irreversibly change the statistical properties of the employed nonclassical light states. In contrast to the usual schemes, based on single-photon quantum states, in our work we show that mesoscopic twin-beam states of light exhibit very-good robustness to both losses and noise sources, thus open new frontiers in the realization of Quantum Communication protocols.

Squeezing in interacting quantum Hall edge channels $\nu = 2$.

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A mesoscopic device in a quantum point contact geometry emits microwaves with remarkable quantum properties when subjected to an external drive in the GHz range. We study the quantum fluctuations of the two quadratures of the emitted electromagnetic radiation generated by a quantum Hall device in a quantum point contact geometry. In particular, we focus our attention on the role played by the unavoidable electron-electron interactions between the two edge channels at filling factor two. We investigate quantum features of the emitted microwave radiation, such as squeezing, by studying the current fluctuations at finite frequency, accessible through a two-filters set-up placed just after the quantum point contact. We compare two different drives, respectively a cosine and a train of Lorentzian pulses, used for the injection of the excitations into the system. In both cases quantum features are reduced due to the interactions, however the Lorentzian drive is still characterized by a robust squeezing effect which can have important application on quantum information.

Stress-relaxation dynamics in colloidal glasses: New results from X-Ray Photon Correlation Spectroscopy.

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Residual stresses are known to affect and drive many physical properties of glassy materials. An example are the famous Prince Rupert's drops, beads of toughened oxide glass which exhibit peculiar strength-brittle properties. Despite the advancement in the field, the interplay between stresses and the microscopic dynamics is still an open topic and many systems, like colloidal or metallic glasses, show stress-related relaxations. In this talk recent results obtained with X-Ray Photon Correlation Spectroscopy (XPCS) to study the evolution of the density-density correlation function in a macroscopically arrested colloidal glass are reported. The observed dynamics are dominated by the residual stresses trapped in the network, which relax with a very rich phenomenology in the observed dynamical properties as the presence of compressed relaxation functions and ballistic dynamics. The study of the dynamical heterogeneities as a function of different length scales shows that the dynamics in this colloidal glass proceed through the cooperative motion of groups of particles with a characteristic size of the order of ten particle diameters.

Generation and dynamics of fluid V-states in a magnetized non-neutral plasma.

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V-states are two-dimensional (2D) non-axisymmetric fluid vortices and represent the generalization of Kirchhoff (elliptical) fluid vortices to a generic Kelvin-Helmholtz (KH) perturbation mode. While the conditions for ideal (inviscid) 2D fluids are not easily met in fluid experiments, non-neutral plasmas confined in a magneto-electrostatic trap are an excellent environment to investigate this topic, due to the isomorphism between such a confined plasma and an ideal 2D fluid. Thanks to an original technique we can selectively excite a single KH mode of arbitrary wavenumber in a fluid vortex using a proper multipolar rotating field. The wave growth can be controlled up to the nonlinear regime. Experiments and particle-in-cell simulations have been performed to investigate the properties of the V-state evolution, stability and damping —which appear to depend on parameters such as the deformation amplitude and vorticity profile— as well as opportunities for accurate manipulation.

Natural gas analysis via quartz enhanced photoacoustic spectroscopy: How to improve forecasting efficiency and minimize the impact on environment in petroleum exploration.

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In the oil & gas industry, down-, mid- and up-stream operations aim at optimizing costs and minimizing the impact on environment. These two goals can be pursued by empowering the exploration phase with valuable tools devoted to natural gas analysis for the estimation of reservoirs and the evaluation of the quality of rocks. Hydrocarbon detection in the gas phase provides a reliable asset for guiding exploration and drilling, thus resulting in a huge money saving and a more sustainable impact on the environment. Laser-based spectroscopic gas sensors proved to be highly selective and sensitive. Among different optical techniques for gas analysis, quartz-enhanced photoacoustic spectroscopy (QEPAS) can also offer a high level of compactness and ruggedness of the sensors, without affecting sensitivity and selectivity. The core element of any QEPAS system is the quartz tuning fork, employed as a high-quality factor optoacoustic transducer and capable of operating in a wide range of temperature and pressure. In this work, a QEPAS sensor capable of detecting methane, ethane, and propane from the ppm to the percent range and employing an interband cascade laser, is reported.

TRANSPORT phenomena in SFS Josepshon junctions.

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During the past 20 years a new research field has emerged, which combines superconductivity and spintronics, with the aim to pave the way for the development of new types of devices, combining the features of both by offering the possibility of long-range spin-polarized supercurrents. Such supercurrents constitute an advantageous starting point for the study of fundamental physics, combining macroscopic quantum coherence with microscopic exchange interactions and spin transport. In the past decade, several theoretical models have been proposed to explain how spin-polarized supercurrents can be created and controlled in S/F heterostructures, with key ingredients ranging from inhomogeneous magnetization to strong spin-orbit coupling, allowing improvements in the realization of new high-quality hybrid structures. Motivated by this, we study theoretically the Josephson effect in superconductor /ferromagnetic-insulator/superconductor junctions using a 2D tight-binding model, where the junction is described by the Bogoliubov de Gennes equations and the current is represented by the Matsubara Green's functions, numerically calculated by using the recursive Green's function method.

Oxidation resistance of silver? Let's do it at 20 K and 10^{-8} torr.

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Silver is universally known for taking great effort to be oxidized, often requiring beams of atomic oxygen and high temperature to obtain the formation of AgO e Ag_2O. Contrarily, when Ag is in the form of atomic clusters made of few atoms it is possible to achieve high degrees of oxidation even at ultra-low temperature. In our work, we deposited size selected atomic clusters of silver composed of 11 and 7 atoms on epitaxial graphene at $T = 20$ K and spectroscopically characterized them by means of high-energy resolution core level spectroscopy with synchrotron radiation. The monodispersed clusters were produced using ENAC, the new cluster source built at the Nanoscale Materials Laboratory at Elettra. After characterizing the clusters in their pristine form, we were able to oxidize them by inducing the dissociation of molecular oxygen into chemisorbed atomic oxygen, leading to a core level shift in the Ag 3d core level greater than for silver nanoparticles and bulk materials. Our experimental findings are supported by *ab initio* DFT calculation which allowed us to develop a model of the structure of the clusters both in the pristine and oxidized form.

Generation and characterization of super-thermal light sources for imaging applications.

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Among imaging techniques, ghost-imaging (GI) represents an excellent strategy in the case of weakly absorbing objects and photolabile samples to be imaged. Over the past two decades, it has been shown that the main requirement for implementing a GI protocol is that the two light beams employed are spatially correlated, regardless of their classical or quantum nature. In addition to the standard (pseudo-)thermal light used so far, it is possible to develop new sources of classically correlated optical states with increased fluctuations and super-thermal statistics, which are thus endowed with a higher level of correlation. Here we present two sources of super-thermal light. The first source is obtained by upconverting a pseudo-thermal speckle pattern in a nonlinear crystal, while the second one, more efficient and easier to manipulate, is produced by passing a laser light through a sequence of diffusers.

From optical orientation to photon-echo and four-wave mixing in GaAs: A real-time first-principle approach.

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We model, via a real-time *ab initio* scheme, the coherent dynamics induced in bulk GaAs by ultra-short laser sources. We first discuss the injection of spin-polarized electrons in the conduction band via a circularly polarized pulse, with a detailed analysis of the generation and the evolution of spin polarization $S(t)$. The k-integrated signal shows a time-dependent

$S_z(t)$ and decays few pico-seconds after the end of the laser pump due to decoherence induced by destructive interference. We interpret this result in terms of the free induction decay (FID) mechanism. Then we explore how the FID can be reversed via an echo mechanism. To this end we consider the standard spin-echo mechanism with π pulses, and then shift our attention to the free polarization decay and to photo-echo mechanisms with weak pulses in the perturbative regime. The modelling of the four-wave mixing signal in GaAs is finally presented.

Dimensional crossover in the superfluid-supersolid quantum phase transition.

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The supersolid is a counterintuitive state of matter where atoms, arranged in a periodic crystal-like structure, can still flow coherently as they do in a superfluid. The supersolid has been recently observed in trapped quantum gases of strongly dipolar atoms, emerging from the crystallization of a superfluid Bose-Einstein condensate. In this work we study for the first time the nature of the quantum phase transition associated with the formation of the supersolid both experimentally and theoretically. Although our supersolids are formed by a single row of density clusters arranged in a periodic structure, we observe two different types of transitions that are reminiscent of the first- and second-order phase transitions expected to occur at a thermodynamic level in 2D and 1D, respectively. We find a continuous crossover between the two regimes that can be controlled by changing the atom number and the trap confinement, and we characterize its scaling properties. The two types of phase transitions give rise to supersolids with different structures and dynamical properties.

ENRICHING perovskite solar devices by Ag@MgO nanoparticles via a gas aggregation nanocluster source: A morphological, optical and cell performance investigation.

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Core-shell metal-oxide nanoparticles (NPs) can be exploited in solar cells, in particular perovskite solar cells (PSCs), to improve light harvesting and power conversion efficiency (PCE), taking advantage of the plasmonic effect. The optical properties of these materials can be tuned by varying NPs aspect ratio and thickness of the shell. In this context, nanocluster aggregation sources allow a precise control over the NPs coverage and dimension. Herein, we exploit a sequential deposition method based on the nanocluster magnetron-sputtering technique to grow Ag NPs —embedded in a MgO matrix— therefore resulting in a proper core-shell structure of the NPs (Ag@MgO), on a mesoporous TiO_2 thin layer of the PSCs.

The morphology of the system has been investigated by TEM, SEM, and AFM. The NPs thermal stability up to $T = 150\ ^\circ$C has been evaluated by X-ray photoelectron spectroscopy. Ultraviolet-visible spectrophotometric measurements unveiled an intense and broad optical loss band, peaked at 430 nm for an optimised NPs surface coverage of 1.5%. Eventually, the core-shell Ag@MgO NPs were incorporated into PS devices resulting in a maximum relative increase in PCE of 5% (up to 17.8%).

First-principle integrated modelling of the main scenarios of the new Divertor Tokamak Test facility.

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In the European Roadmap towards thermonuclear fusion power production, studying the controlled exhaust of energy and particles from a fusion reactor is a top priority research item. This is the main goal of the Divertor Tokamak Test (DTT) facility, a D-shaped superconducting tokamak ($R = 2.19$ m, $a = 0.70$ m, $B_T \leq 6$ T, $I_p \leq 5.5$ MA, pulse length $\leq$ 100 s, auxiliary heating $\leq$ 45 MW, W first wall and divertor), whose construction is starting in Frascati. In order to support the device design and to help the elaboration of a DTT scientific work-programme, it is a key priority to achieve multi-channel integrated modelling of DTT scenarios based on state-of-art first-principle quasi-linear transport models. First modelling results of the main DTT scenarios are presented here. Steady-state profiles of ion and electron temperatures, densities, rotation, and current density were predicted with a calculated self-consistent equilibrium, with turbulent heat and particle transport calculated by the TGLF or QLK transport models, and with heating modelled self-consistently. As a result of this work, the heating mix was defined and reference profiles have been become available.

Microscopic mechanisms driving the self-purification of electrical deactivation defects in Se hyperdoped silicon: An ab initio study.

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By *ab initio* simulations we systematically investigate Se hyperdoped silicon by computing, for different types of Se complexes, the formation energy as a function of dopant concentration. We enlighten the microscopic mechanisms responsible of the dramatic reduction of electrical deactivation defects as the number of dopants approaches the critical concentration, x_c, at which the insulator-to-metal transition occurs. We discuss the electrical properties of Se complexes, studying the formation and the nature of the electronic band formed by the Se impurities in the gap and the role played by the presence of different Se complexes to determine x_c. We identify the optimal doping range, in which the donor density can be tuned to engineering the width and the shallowness of the impurity band, thus allowing the material design for electronic applications, ranging from long-wavelength infrared detectors to intermediate impurity band solar cell. Simulations of the structural properties of the Se complexes complete the work. Our finding can be extended to silicon hyper doped with other chalcogen impurities, paving the way toward the intermediate impurity band nano-electronics.

Inverse magnetic hysteresis of the Josephson supercurrent in magnetic Josephson junctions.

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Magnetic Josephson Junctions (MJJs) based on Superconductor-Insulator-Superconductor-Ferromagnet-Superconductor (SIS-FS) structures are promising candidate as unit cells in Random-Access Memory (RAM) compatible in speed and power dissipation to standard Single Flux Quantum (SFQ) technology. We have demonstrated that the scaling down of SIS-FS devices based on Nb technology and a strong ferromagnet ($Ni_{80}Fe_{20}$) has led to an optimization of our devices as switchable elements. Moreover, we provide evidence of an unconventional magnetic-field behavior of the critical current characterized by an inverted magnetic hysteresis, *i.e.*, an inverted shift of the whole magnetic-field pattern when sweeping the external field. This occurrence has been predicted by inverse proximity theory. Here we report on the first experimental observation supported by a systematic magnetic characterization on trilayers $Nb/Ni_{80}Fe_{20}/Nb$ and temperature characterization, through Josephson magnetometry, of SIS-FS JJs. Finally, we will discuss the crucial role of these findings in the proper functioning and optimization of scalable cryogenic memories.

Sugli invarianti topologici del tensore gradiente di velocità e campo magnetico in mhd.

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In questa presentazione vengono derivate e discusse le equazioni di evoluzione degli invarianti topologici del tensore gradiente di campo magnetico e del tensore gradiente del campo di velocità nella teoria magneto-idrodinamica. Le quantità invarianti considerate sono proporzionali alla traccia di varie potenze dei tensori gradiente di campo e velocità, descrivono completamente le variabili dinamiche tensoriali secondo il teorema di Cayley-Hamilton, e sono in completa analogia con quelle ricavate per il caso fluidodinamico. Il punto di partenza di questo lavoro sono le equazioni che descrivono l'evoluzione temporale del campo magnetico e del campo di velocità, in interazione tra loro, in forma Lagrangiana. Le equazioni di evoluzione degli invarianti possono rivelarsi particolarmente utili al fine di fornire un diverso approccio per la descrizione della turbolenza e dei processi dissipativi nei plasmi spaziali, basato sull'identificazione e sulla caratterizzazione delle strutture del campo di velocità e del campo magnetico.

Sezione III
Astrofisica

Comunicazioni

Detection of baryon acoustic oscillations via multipole expansion of neutral hydrogen power spectra in cross- and auto-correlation.

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A standard ruler akin in application to standard candles, Baryon Acoustic Oscillations (BAO) are a main feature of the matter power spectrum (PS), depending on fundamental quantities cosmologists are striving to measure. The SKA radio-telescope and the Euclid satellite will look for their signal in the post-reionisation universe via neutral hydrogen Intensity Mapping and spectroscopic galaxy surveys, a task made challenging by astrophysical foregrounds and resolution limitations. Following the discussion of BAO detection in the radial PS, to appear in "Il Nuovo Cimento C" (2021), we present an extended analysis of another promising tool, the monopole and quadrupole PS.

The DUNE Photon Detection System.

Bomben L. per la Collaborazione DUNE
Università degli Studi dell'Insubria e INFN, Sezione di Milano Bicocca

The DUNE Photon Detection System is based on a novel cryogenic light detector called X-ARAPUCA. It downshifts the 128 nm liquid argon (LAr) scintillation light and employs a dichroic filter to trap photons inside a reflective box, which is instrumented with SiPM arrays. In this talk, I will present the design and performance of the X-ARAPUCA in view of the Run II of ProtoDUNE-SP at CERN. Furthermore, two X-ARAPUCAs were employed in Run I to verify the effectiveness of xenon as a LAr dopant against the quenching effect of nitrogen impurities. The results of this special run will also be presented.

DAMA/LIBRA risultati recenti e implicazioni.

Caracciolo V. per la Collaborazione DAMA
Dipartimento di Fisica, Università degli Studi di Roma "Tor Vergata" e INFN, Sezione di Roma "Tor Vergata"

L'apparato sperimentale DAMA/LIBRA (circa 250 kg di NaI(Tl) altamente radiopuro) opera presso il Laboratorio Nazionale del Gran Sasso dell'INFN. In questa comunicazione saranno presentati risultati recenti, implicazioni e potenzialità.

New hypothetical scenario of the "Big Bang as a Big Crush" from a final gravitational "deflation" of the collapsing previous Universe.

Lorenzi L.
Società Astronomica Italiana e Società Italiana di Fisica

George Gamow proposed a rotating Universe to Albert Einstein, however unsuccessfully. Starting from a review of a previous paper, it is possible to show how Lemaitre's dynamic primeval atom can give rise to a Big Bang process, triggered by a deflation of the gravitational parameter G, through the sudden fall to $G = 0$ at $t = 0$. The hypothetical cosmic scenario of classical mechanics would require a collapsing previous Universe at $t < 0$, caracterized by

many orbital paths around its centre. Finally, the Big Bang event at $t = 0$ would have been produced by deflation, in place of the canonic inflation, with the instantaneous transfer of a fraction of the reached angular velocity into the parameter H of a Big Bang Hubble law, owing to linear and angular momentum conserved.

New developments in the SiPM cryo-electronics for Dark Matter low-background experiments.

Consiglio L.
INFN Laboratori Nazionali del Gran Sasso

One of the main issues of the large-volume cryogenic detectors searching for Dark Matter is the radioactive background from the electronic components and cabling that can give significant contribution. The SiPM technology in the configuration of arrays offers the opportunity to cover the wide sensitive surface detector keeping the number of the readout channels at reasonable levels. A low-noise cryogenic electronics is needed to equip wide-area assemblies of photosensors to be readout as a single channel with the appropriate timing and single-photon resolution. The newest results of this R&D, achieved at LNGS, will be presented.

The LAr veto system in the search of neutrinoless double beta decay.

Burlac N., Salamanna G.
University and INFN of Roma Tre

The LEGEND-200 experiment will search for neutrinoless double beta decay in the Ge-76 isotope at Laboratori Nazionali del Gran Sasso of INFN. The experiment will use about 200 kg of high-purity germanium, acting simultaneously as source and detector, surrounded by ultra-pure liquid argon (LAr). The LAr veto system, based on the read-out of Ar scintillation light, will be deployed to actively suppress background events, such as beta decays either near or on the detector surface and gamma background from natural decay chains. The experimental setup and the LAr veto system of the LEGEND-200 experiment will be illustrated.

Minimal theory of bigravity: Construction and cosmology.

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Following the path of minimalism in alternative theories of gravity, we construct the "Minimal Theory of Bigravity" (MTBG), a theory of two interacting spin-2 fields that propagates only four local degrees of freedom instead of the usual seven ones and that allows for the same homogeneous and isotropic cosmological solutions as in the Hassan-Rosen bigravity (HRBG). Starting from a precursor theory that propagates six local degrees of freedom, we carefully choose additional constraints to eliminate two of them to construct the theory. Investigating the cosmology of MTBG, we find that it accommodates two different branches of homogeneous and isotropic background solutions, equivalent on-shell to the two branches that are present in HRBG. Those branches in MTBG differ however from the HRBG ones at the perturbative level, are both perfectly healthy and do not exhibit strong coupling issues nor ghost instabilities. In both branches, the tensor sector exhibits the usual HRBG features: an effective mass term and oscillations of the gravitons. Therefore MTBG provides a stable nonlinear completion of the cosmology in HRBG.

La Time Projection Chamber (TPC) ad argon in doppia fase di ReD.

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L'esperimento DarkSide20k ricercherà materia oscura utilizzando una TPC ad argon in doppia fase. Nell'ambito di DarkSide, il progetto ReD (Recoil Directionality) si propone di caratterizzare le prestazioni delle TPC ad argon, valutandone la potenziale sensibilità direzionale e la risposta a rinculi nucleari di bassissima energia. Il rivelatore di ReD è una versione miniaturizzata della TPC di DarkSide20k, ed è equipaggiato con lo stesso tipo di fotosensori (SiPMs). La TPC è stata caratterizzata presso l'INFN Napoli utilizzando sorgenti γ e neutroni, per valutarne le prestazioni al variare dei parametri operativi. Verranno descritti i principali risultati ottenuti nella campagna di caratterizzazione, utilizzati anche per valutare le proprietà generali di scintillazione e ionizzazione in argon.

Il progetto Aria per la distillazione isotopica.

Stefanizzi R.
Universitdi Cagliari e INFN

Il progetto Aria consiste di una colonna di distillazione criogenica alta 350 m che è in corso di installazione all'interno di una ex miniera di carbone presso Nuraxi-Figus (SU), Sardegna. Lo scopo principale di questo progetto riguarda la distillazione isotopica dell'argon, depurato dal suo isotopo radioattivo argon-39. L'esperimento DarkSide, presso i laboratori del Gran Sasso, ha come obbiettivo la ricerca dei fenomeni di interazione della materia oscura proprio con l'argon-40, tuttavia la presenza del 39 ne disturberebbe la rilevazione; a tale scopo l'argon precedentemente distillato da Aria potrà essere utile per questo esperimento. Tuttora si stanno inoltre studiando le ulteriori potenzialità di Aria, come la distillazione isotopica dell'ossigeno (utile nell'ambito della fisica medica) o del carbonio.

Unveiling the origin of steep decay in γ-ray bursts.

Ronchini S.
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Gamma-ray bursts (GRBs) are transient cataclysmic events, whose role became central in the new multi-messenger era. In the present work I propose a novel investigation of the GRB emission mechanism, via time-resolved spectral analysis of the X-ray tails of bright GRB pulses observed with the XRT instrument onboard the Neil Gehrels Swift Observatory, discovering a unique relation between the spectral index and the flux. The investigation of the spectral evolution during the GRB tail is an ideal diagnostic to understand the connection between the emission processes, the cooling processes and the outflow environment. I thoroughly discuss possible interpretations in relation to current available models and I show the incompatibility of our results with the standard high latitude emission. Our results for the first time strongly suggest evidence of adiabatic cooling of the emitting particles, shedding light on fundamental physics of relativistic outflows in GRBs. Finally I discuss the crucial role of future wide-field X-ray telescopes, such as the mission concept Theseus, for the characterisation of the GRB tail emission, highlighting also its importance in the multi-messenger context.

Studio sulle capacità di ricostruzione della LIV da parte di CTA attraverso i tempi di volo.

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L'invarianza di Lorentz è uno dei concetti alla base del modello standard della fisica delle particelle, in cui sono unificate tutte le interazioni eccetto la gravità. Teorie di gravità quantistica sono state proposte per ottenere una globale unificazione delle forze. Alcune di esse prevedono la violazione dell'invarianza di Lorentz (LIV) ad altissime energie (scala di Planck) con la conseguente introduzione di modifiche alla propagazione dei fotoni. Per osservare tali effetti occorrono sorgenti extragalattiche molto energetiche, come i blazar. La presentazione riassume una valutazione delle potenzialità del Cherenkov Telescope Array per misurare anomalie nella propagazione dei fotoni consistenti con la LIV.

Esperimento GAPS: Misura di anti-nuclei cosmici di bassa energia come ricerca indiretta della materia oscura.

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GAPS (General Anti-Particle Spectrometer) è un esperimento su pallone il cui scopo è quello di misurare anti-nuclei cosmici di bassa energia (< 0.25 GeV/n). Il lancio è programmato per la fine del 2022 - inizi 2023 e avrà luogo in Antartica. GAPS cercherà di far luce sulla potenziale natura particellare della materia oscura, attraverso la rivelazione indiretta di anti-nuclei come anti-protoni, anti-deuteri ed anti-elii, o quali si teorizza possano essere prodotti da annichilazione o decadimento di materia oscura. Lo strumento è composto da rivelatori al Si(Li), circondati da due piani di scintillatori plastici che costituiscono il sistema di Time-of-Flight (ToF). GAPS utilizza una nuova tecnica di rivelazione che consiste nel catturare un anti-nucleo con successiva formazione di un atomo esotico eccitato. Questo si diseccita emettendo raggi X ad energie ben definite dalle transizioni atomiche e successivamente annichila emettendo delle particelle secondarie. La misura delle quantità coinvolte ($\mathrm{d}E/\mathrm{d}x$, tempo di volo, posizione del vertice di annichilazione, etc.), permette l'identificazione degli anti-nuclei con altissima precisione.

Multi-wavelength view of the M87 black hole captured by Event Horizon Telescope.

Principe G., Event Horizon Telescope Multiwavelength working group, EHT Collaboration, Fermi-LAT Collaboration, H.E.S.S. Collaboration, MAGIC Collaboration, VERITAS Collaboration, EAVN Collaboration
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In 2017, the first image of the center of the M87 galaxy was captured by the Event Horizon Telescope (EHT). It revealed a ring morphology and a size consistent with theoretical expectations for the light pattern around a weakly accreting supermassive black hole of mass of ~ 6.5 billion solar masses. In parallel to the EHT measurements, an extensive multi-wavelength campaign with ground- and space-based facilities from radio all the way up to the TeV range was organized. In this presentation we will give an overview of the results from this campaign. We present the most complete simultaneous, multi-wavelength spectrum of the active nucleus to date, as well as discuss the complexity and caveats of combining data from different spatial scales into one broadband spectrum.

Hydrated minerals on the surface of Solar System bodies: A multi-technique approach for laboratory studies in support of space missions.

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Spectroscopic observations of the surface of several Solar System bodies, such as Mars, Ceres, Enceladus, and some icy satellites of Jupiter (Europa and Ganymede), have revealed the presence of hydrated salt minerals, among which (Mg, Na) sulfates, Na carbonates and (Na, Mg) chlorides might occur. A systematic laboratory study of these minerals is of interest to support the interpretation of *in situ* analyses and remote sensing data by ongoing and future space missions (*i.e.*, ESA/ExoMars, NASA/JUNO, ESA/JUICE, NASA/Europa Clipper). Since size distribution, temperature, morphology and elemental composition of the grains of powered samples influence the main diagnostic absorption features, a multi-technique approach for sample characterization is of great relevance. The results of reflectance spectroscopy, scanning electron microscopy associated with energy-dispersive X-ray spectroscopy, and laser granulometry will be presented.

Use of machine learning in defocused photometry for exoplanetary transit observations.

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(4) *CNR-Area della Ricerca di Genova, Italia.*

Exoplanetary transit observations are often carried out with the defocussed photometry technique. Advantages include: reduced total readout time and mitigation of pixel-related issues. However, the typical donut-shaped PSFs are difficult to handle for tasks such as centroid determination useful for field solving. We trained a Neural Network to reconstruct focused fields starting from defocused ones. In focus, "artificially refocused" images are then successfully used to feed the plate-solver astrometry.net. As a result of this test, we find pixel-to-sky transformation parameters. This new information can now be used, for example, to superpose a stellar catalog and perform automatic aperture photometry.

Cryogenic vacuum issues affecting mirrors of future gravitational wave observatories.

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Interferometry has been established as a powerful tool to significantly enrich multi-messenger astrophysics. To improve the sensitivity at low frequency, future gravitational wave detectors will use cryogenic mirrors. At cryogenic temperatures, gases composing the residual vacuum will form a contaminant ice layer on the mirror surface. Such "frost" is a significant bottleneck in operating cryogenic mirrors, since it severely affects optical performance. Here we analyze the pressure requirements to mitigate frost formation on cryogenically cooled mirrors. Stringent ultra-high vacuum conditions are needed to allow long and continuous periods of data taking.

ASTAROTH: A novel technique for dark matter direct detection with Na(Tl) crystals at cryogenic temperatures.

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The DAMA experiment has a long-standing claim for dark matter detection with the use of NaI(Tl) scintillating crystals. The ASTAROTH project plans to improve the physics reach of this technology with the same target material, allowing a larger sensitivity to the expected annual modulation signal with respect to the present-generation detectors. In fact, it would lower the detection energy threshold, making it possible to explore for the first time the recoils in the unprobed sub-keV region. This can be accomplished by cooling the system to cryogenic temperature and reading all the crystal surfaces with silicon photomultipliers. These sensors exhibit a lower dark count noise than photomultiplier tubes at $T < 150$ K and a higher collection efficiency. Scintillating liquid argon ($T = 87$ K) will surround the crystal, providing cooling power and acting as veto. We present here a first characterization of the crystal conducted in 2021 at LASA (Milano) with radioactive gamma sources as well as the details of the innovative cryogenic chamber under construction that will expand the temperature range to be explored in the near future.

Detector characterization for Legend-200 experiment.

Biancacci V.
Università degli Studi di Padova e INFN Padova

The LEGEND Collaboration is developing an experimental search for the neutrinoless double-beta ($0\nu\beta\beta$) decay of the ^{76}Ge isotope. Its first phase, LEGEND-200, uses 200 kg of ^{76}Ge-enriched high-purity germanium (HPGe) detectors in an active liquid-argon shield and is currently under construction at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Inverted coaxial point-contact (ICPC) detectors are deployed in the experiment. Their peculiar geometry provides excellent energy resolution in a broad energy range and impressive discrimination of signal against background events. LEGEND's search for $0\nu\beta\beta$ requires a precise understanding of the behavior of germanium detectors, requiring extensive detector characterization. The acceptance tests aim to verify the performance of the delivered detectors meets specifications and to determine their optimal operational parameters. This talk will provide a review and the first results of the detector characterization program.

An optimal reconstruction of gravitational wave polarizations without model assumptions.

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The two polarizations associated with gravitational waves are currently reconstructed by both modeled and unmodeled methods. The latter do not assume any kind of waveform model, but simply estimate polarization components from the data. Over the years many techniques have been implemented to detect signals and reduce the noise content in the reconstructed polarizations. In this work we review the analysis performed within the coherent Wave Burst pipeline, and aim at finding ways to optimize the use of signal coherence among the detectors to reduce the noise contribution and improve the reconstruction of the polarization components.

The LIGO-Virgo third observing run: Performances and science results.

Rocchi A. per le Collaborazioni LIGO, Virgo eKAGRA
INFN Roma Tor Vergata

Started in April 2019 and ended in March 2020, the Observation Run 3 (O3) is the longest period of data taking for the Advanced LIGO and Advanced Virgo observatories, divided into two segments (O3a and O3b) by a month long commissioning break in October 2019. Furthermore, O3 marked the beginning of the gravitational waves open public alerts. The performances of the three instruments as parts of the worldwide network of ground-based gravitational wave interferometric detectors will be reviewed: from the sensitivity evolution to the observing mode duty cycle. The talk will also focus on the published science results accumulated during the whole O3.

Towards reconstruction of large-scale matter power spectrum.

Sorrenti F.
Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, Italia

Measuring the distribution of matter at large scale is difficult due to experimental limitations. An indirect reconstruction can be performed by studying how large scales affect small-scale nonlinearities. We realize a pipeline to study the impact of introducing information from reconstructed large-scale matter power spectrum on cosmological constraints in an extended cosmological model with massive neutrinos. The pipeline is then applied to a simulation of the Euclid spectroscopic survey. We obtain that including large-scale information is useful to constrain parameters that are mostly degenerate with neutrinos mass, and that rescale the matter power spectrum at all scales.

Real-time monitoring of solar energetic particles outside the ISS with the AMS instrument.

Faldi F.
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The Alpha Magnetic Spectrometer (AMS) is a particle detector operating on the International Space Station (ISS), measuring fluxes of cosmic rays for a mission of widespread physics objectives. Its low-latency data, namely the trigger count rates, are candidate measurements for real-time monitoring of the external radiation environment on ISS, nowcasting Solar Energetic Particles (SEP) events. The application of a nowcast system based on AMS would provide supplementary information on the radiation environment outside the ISS shielding, alerting astronauts on intense radiation conditions. A SEP Identification Algorithm has been developed to verify feasibility of this application, providing encouraging results.

L'algoritmo di ricostruzione per l'esperimento GAPS.

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GAPS (General Antiparticle Spectrometer) è un esperimento su pallone il cui scopo principale è la ricerca indiretta di materia oscura attraverso la rivelazione di antinuclei a bassa energia ($<$ 250 MeV/n) nei raggi cosmici. GAPS usa una tecnica innovativa per identificare antinuclei basata sulla cattura di un atomo esotico con successivo decadimento ed emissione di pioni, protoni e raggi X da un vertice di annichilazione comune. Sono state sviluppate diverse tecniche per ricostruire la topologia della "stella di annichilazione", determinando la posizione del vertice di annichilazione e ricostruendo i parametri cinematici della particella primaria e dei secondari. In questa presentazione verranno discussi l'algoritmo di ricostruzione e le sue performance ottenute con la simulazione, basata su GEANT4, dell'apparato sperimentale GAPS.

Caratterizzazione della risposta di una matrice di SDD per l'upgrade dell'esperimento KATRIN.

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Il progetto TRISTAN è un'upgrade dell'esperimento KATRIN il cui obiettivo è realizzare una ricerca del neutrino sterile con massa nel range dei keV tramite la misura precisa dell'intero spettro beta del trizio. Al fine di raggiungere questo obiettivo occorre sostituire l'attuale rivelatore di KATRIN con un rivelatore multipixel composto da Silicon Drift Detectors (SDD). Questi rivelatori, dotati di un'eccellente risoluzione energetica e in grado di sostenere alti ratei di interazione, sono comunemente utilizzati per spettroscopia di raggi X. Occorre quindi caratterizzare la loro risposta agli elettroni. A tal proposito è stato allestito un setup per misure dedicate, composto da una matrice di 8 SDD posta in una camera a vuoto. Dall'analisi di queste misure si costruisce un modello per la risposta di un rivelatore multipixel al singolo elettrone parzialmente basato su simulazioni in Geant4, che tenga conto dei vari fenomeni in gioco, quali lo strato morto del detector, il charge-sharing tra pixel e il back-scattering degli elettroni. Ottenere un simile modello è essenziale al fine di ricostruire con accuratezza lo spettro beta che verrà misurato in TRISTAN.

A new analytical model to study long-rising supernovae.

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Long-rising Supernovae (LR SNe) are Type-II SNe characterized by bolometric light curves with shapes resembling those of SN 1987A. In the recent decades, the growing number of such events has led to consider them as a new sub-class of SNe. However a comparative study focused on verifying the possible existence of systematic trends inside this sub-class is still missing. Moreover the real nature of their progenitors remains poorly understood, and this issue has become even more important in light of the discovery of LR SNe that are difficult to explain within the conventional neutrino-driven core-collapse paradigm. In order to clarify these questions, we have developed a new analytical model including heating effects due to Ni decay, that is able to reliably estimate the main physical parameters describing the progenitor star at explosion for LR SNe. As well as allowing a faster analysis than hydrodynamical modelling, one of the biggest advantage of this model is the possibility to derive Ni mass-dependent scaling relations. After a presentation of the model, the results of a comparative study on a sample of well-observed LR SNe based on this new model will be also discussed.

The Galileo for Science (G4S_2.0) project: Fundamental Physics experiments with the Galileo satellites DORESA and MILENA.

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G4S_2.0 is a new project funded by the Italian Space Agency which aims to perform measurements in the field of Fundamental Physics with the two satellites DORESA and MILENA of the Galileo-FOC constellation. These satellites are characterized by the high eccentricity of their orbits and the accuracy of their atomic clocks. An accurate orbit determination will allow to carry out a series of measurements in the fields of gravitation and cosmology, and the implementation of an inverse relativistic positioning system. After a general introduction to the main objectives of G4S_2.0, the activities developed at IAPS-INAF in Rome will be presented.

The DarkSide-20k veto detector.

Bottino B., The DarkSide Collaboration
Princeton University and INFN Sez. Genova

The DarkSide project aims to directly detect dark matter particles (WIMPs) using a dual-phase liquid-argon Time Projection Chamber (TPC). DarkSide-20k will be based on a 20 tonne fiducial mass TPC filled with radio-pure underground argon. It will be housed at the Gran Sasso underground laboratory and it is expected to obtain a sensitivity to WIMP-nucleon cross-section of 7.4×10^{-48} cm^2 (6.9×10^{-47} cm^2) for 1 TeV/c^2 (10 TeV/c^2) WIMPs, over a 200 t yr exposure. DarkSide-20k is designed to operate maintaining an instrumental background level in the WIMP search region of less than 0.1 events for the total exposure. To achieve this goal the TPC is surrounded by an active neutron veto detector. The veto consists of a gadolinium-loaded acrylic shell built around the TPC that will enhance the n-capture probability and produce high-energy deposit in argon. The scintillation signals will be read with custom-made cryogenic silicon photomultipliers. To obtain Gd-loaded ultra-pure acrylic, specific procedures to treat gadolinium nano-grains avoiding clusterization and consequent sedimentation in the in the polymerization process of the acrylic have been developed.

Calibrazione a bassa energia dell'esperimento XENON1T con ^{37}Ar.

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Al termine dell'acquisizione dei dati scientifici dell'esperimento XENON1T, una camera a proiezione temporale (TPC) con xeno in doppia fase per la rivelazione diretta di materia oscura, presso i Laboratori Nazionali del Gran Sasso, è stata diffusa direttamente all'interno del rivelatore una sorgente di ^{37}Ar per la calibrazione e la validazione delle prestazioni a basse energie. ^{37}Ar decade per cattura elettronica, emettendo elettroni Auger e fotoni, con rilascio

di energia di 2.82 keV e 0.27 keV. Verranno presentati i risultati di questa calibrazione in termini di risposta del rivelatore e guadagno in carica dello xeno per entrambe le energie di decadimento del ^{37}Ar.

Hunting the gamma-ray emission from Fast Radio Burst with Fermi-LAT.

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Fast Radio Bursts (FRBs) are one of the most exciting new mysteries in astrophysics. Their origin is still unknown, but recent observations seem to link them to soft gamma repeaters and, in particular, to magnetar giant flares. Taking advantage of more than 12 years of Fermi-LAT data, we perform a search for gamma-ray emission from all the reported repeating and non-repeating FRBs. In this talk we present the preliminary results of our study and we discuss their implications for the predictions of gamma-ray emission from this class of sources.

Multi-year monitoring of blazar TXS 0506+056 with MAGIC and multi-wavelength partners.

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(2) *INAF O.A. Roma*
(3) *DESY, Zeuthen*
(4) *Institut de Ciències del Cosmos - Universitat de Barcelona*
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(6) *Julius-Maximilian-Universität Würzburg*
(7) *FINCA, University of Turku*
(8) *University of Crete*
(9) *Max Planck Institute for Radioastronomy*
(10) *California Institute of Technology*
(11) *INAF O.A. Brera*
(12) *Armenian MAGIC Group: ICRANet-Armenia at NAS RA*

The origin of astrophysical neutrinos is still an open issue and an important step towards the understanding of cosmic-rays origin. Among the potential extragalactic neutrino sources, blazars are particularly interesting, as suggested by the detection of a high-energy neutrino in the direction of the flaring Blazar TXS 0506+056 in 2017. A multi-wavelength (MWL) monitoring of this source in the long term is essential to understand the radiative processes at work and the neutrino emission. Here we present lightcurves and simultaneous spectral energy distributions from a MWL monitoring, together with theoretical interpretations of these observations and possible implications on cosmic-ray acceleration.

Studi di modulazione solare dei raggi cosmici con l'esperimento PAMELA.

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Grazie alla sua lunga operatività in orbita e alla bassa soglia energetica, nell'ultimo decennio l'esperimento PAMELA ha prodotto misure di alta precisione dei flussi delle principali specie di raggi cosmici e della loro dipendenza temporale sotto alcune decine di GeV. Questi dati sono essenziali per la calibrazione di modelli per la propagazione e la modulazione dei raggi cosmici in Eliosfera. In questo intervento saranno presentati i flussi di idrogeno, di elio, degli elettroni, i rapporti idrogeno-elio e positroni-elettroni e relative evoluzioni temporali misurati da PAMELA tra 100 MeV/n e qualche decina di GeV/n dal 2006 al 2014, così come i flussi annuali di isotopi quali protoni, deutoni, elio-3 ed elio-4 al di sotto di 1 GeV/n. Verrà inoltre mostrato come queste misure, che coprono un intero ciclo solare dalla fase di minimo del 23° ciclo alla successiva fase di massimo del 24° con inversione di polarità del campo magnetico eliosferico, permettano in particolare di studiare l'effetto della dipendenza dal segno della carica nella modulazione solare e calibrare con maggiore precisione i parametri dei modelli di propagazione in Eliosfera.

Dati sintetici per la fisica degli eventi rari.

Gianvecchio A. (1) per la collaborazione CUORE
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Gli esperimenti che mirano alla scoperta di fenomeni rari condividono la necessità di isolare gli eventi del processo ricercato rispetto ad eventi di fondo. In questo scenario, ciò che presenterò tratta la generazione di dati sintetici per lo studio della risposta del rivelatore dell'esperimento CUORE. Questa nuova tecnica consiste in simulazioni che riproducono l'acquisizione del rivelatore tenendo conto di elementi di non idealità, quali rumore e forma dei segnali. L'obbiettivo è quello di poter riprodurre, in maniera naturale, la forma intrinseca, che devia da un profilo gaussiano, e la dipendenza della risoluzione dall'energia dei picchi nello spettro delle ampiezze. A tale proposito, ho inizialmente investigato l'impatto del pile-up sulla forma dei picchi, individuando deformazioni significative rispetto ad una risposta gaussiana. Di seguito, ho studiato l'effetto di impulsi con forma variabile sulla risoluzione evidenziando un allargamento dell'ordine di grandezza dei valori di CUORE. In conclusione, questo studio apre la strada all'isolamento dei fenomeni che contribuiscono alla formazione del picco; il che migliorerebbe la sensibilità finale di CUORE.

Measurement of the cosmic-ray electron and positron spectrum with the Calorimetric Electron Telescope on the International Space Station.

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The CALorimetric Electron Telescope (CALET), operating aboard the International Space Station (ISS) since October 2015, is an experiment dedicated to high-energy astroparticle physics. The primary scientific goal of the CALET mission is to perform a high-precision measurement of the inclusive spectrum of cosmic electrons and positrons (all-electron) up to the multi-TeV region, where the shape of the spectrum can indicate the presence of nearby cosmic-ray sources or dark matter signatures. The instrument, consisting of a charge detector, an imaging calorimeter and a total absorption calorimeter, has a total depth of about 30 radiation lengths with a fine shower-imaging capability. This design leads to an excellent energy resolution (a few % above 10 GeV) and an outstanding electrons over protons separation ($\sim 10^5$): thanks to these performances, the collaboration can finely investigate the shape of the total energy spectrum. In this contribution, the analysis procedure that leads to a precise measurement of the all-electron flux up to several TeV with the full statistics collected by the CALET experiment is presented and briefly discussed.

The atmospheric emission for CMB ground-based experiments.
Paris M., Mennella A.
Università Degli Studi di Milano
The CMB radiation is one of the most important observables to probe the very early stages of the Universe. This radiation represents the Universe only 380000 years after the Big Bang. The model of the Universe accepted by the whole scientific community relies on the Inflation Theory. This model predicts an expanding Universe as the result of a superluminal expansion that had happened during the very early stages of its life. The inflation theory also predicts the formation of Primordial Gravitational Waves that modified the metric imprinting a particular pattern on the polarization directions of the CMB's photons that were linearly polarized by the continuous Thomson scattering with the primordial plasma. The polarization signal is very faint, and the cosmological information coded into the large angular correlations suffers from significant spurious contribution of the systematic effects that are difficult to take under control. In this presentation, I am going to present the systematics spurious contribute introduced by the atmosphere for CMB ground-based observations, with the particular case of the Strip Telescope that will be held at the Tenerife Observatory in 2022.

The light component of cosmic-ray spectrum measured by DAMPE.
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(2) *Dipartimento di Matematica e Fisica, Università del Salento, Lecce e INFN, Sezione di Lecce*
The DArk Matter Particle Explorer (DAMPE) is a satellite-borne experiment promoted by the Chinese Academy of Sciences. Since its launch in December 2015, DAMPE has been stably collecting data with smooth and continuous operations. The scientific goals of the mission include the indirect search for dark matter, the study of the electron-positron spectrum and the analysis of the cosmic-nuclei flux with energies up to hundreds of TeV. In this work we present the energy spectra of protons and helium compared with the combined spectrum of light elements (p + He) as obtained by a third analysis.

La ricerca di correlazioni a lunga distanza con i telescopi del progetto EEE.
Pinto C., Collaborazione EEE
INFN e Università di Catania
La ricerca di correlazioni a lunga distanza tra sciami cosmici estesi è uno dei più ambiziosi obiettivi del progetto Extreme Energy Events (EEE). L'esistenza di tali eventi finora è stata solo ipotizzata teoricamente attraverso diversi meccanismi fisici, tra cui il cosiddetto effetto GZ, basato sulla fotodisintegrazione di un nucleo pesante primario nel campo solare, sembra essere il più interessante. Il tasso di conteggi atteso per questo genere di eventi è dell'ordine di alcuni eventi per anno, anche in caso di apparati sperimentali notevolmente estesi. Il progetto EEE consiste in una rete di 61 telescopi che permettono di tracciare i muoni cosmici, composti di tre Multigap Resistive Plate Chambers (MRPCs), capaci di ricostruire la direzione delle particelle cariche incidenti ed il tempo del loro arrivo. I telescopi della rete EEE sono dislocati lungo il territorio italiano e al CERN, rendendo di fatto l'esperimento

EEE particolarmente adatto alla ricerca di eventi rari. In questo contributo saranno descritte le strategie di analisi e presentati i recenti risultati ottenuti analizzando tutta la statistica raccolta in 10 anni di presa dati dei telescopi EEE.

System for on-Axis Neutrino Detection (SAND) at the DUNE Near Detector complex.

Vicenzi M.
Dipartimento di Fisica, Università di Genova e INFN, Sezione di Genova, Italia

The Deep Underground Neutrino Experiment (DUNE) Near Detector complex aims at constraining the systematic uncertainties for the long-baseline neutrino oscillation program by deconvolving the neutrino beam and cross-section models. SAND is the third near detector component, permanently placed on-axis, and it employs the 0.6 T superconducting magnet and electromagnetic calorimeter previously used at the KLOE experiment. The inner magnetized volume contains an upstream liquid-argon target (1 ton), actively instrumented with photodetectors to collect scintillation light, and a low-density target/tracker system to perform high-resolution momentum measurements. In this talk the liquid-argon detector and the tracker technology will be described as well as their performance for SAND primary goal of beam monitoring and neutrino flux measurement.

Test of the Archimedes prototype balance at the SAR-GRAV laboratories.

Pesenti L.
Dipartimento di Fisica, Università di Milano-Bicocca, Italia

In the framework of the Archimedes experiment, which aims to measure the interaction between vacuum fluctuations and gravity, a high-sensitivity prototype balance has been developed, which can be used as a tiltmeter when no weights are suspended to its ends. The tiltmeter has been first installed at the Virgo site, and then moved to the Sos-Enattos site, at the SAR-GRAV laboratories in Sardinia. This site, characterised by low seismic noise, allows sub-picoradian sensitivity to be achieved in the frequency region between 2 and 20 Hz, which is at the moment the best in the world.

Exploring new fitting strategies to improve the sensitivity of CUORE to neutrinoless double-beta decay of ^{130}Te.

Tomei C.
Dipartimento di Fisica, Università di Roma La Sapienza, Italia

CUORE is a bolometric detector for the search of neutrinoless double-beta decay of ^{130}Te hosted at LNGS. Since the start of the data taking in 2017, CUORE has reached an exposure of 1 tonne yr of TeO_2, the largest ever achieved by a cryogenic solid state detector. With such a large dataset available, it is possible to study non-uniformities of the background level over the complex array of 988 CUORE crystals. In this talk we explore whether it is possible to improve the CUORE sensitivity by a careful account of the background non-uniformities. We present preliminary results on a Bayesian analysis that includes such information using BAT (Bayesian Analysis Toolkit).

Quadratic gravity.

Rinaldi M.
University of Trento e Tifpa - INFN Trento

In this talk we discuss some recent advancements in the study of quadratic and scale-invariant gravity. We emphasise the importance that this model might have in the inflationary Universe but also in the formation of primordial black holes. Thus, we present a scale-invariant model of inflation and a possible mechanism for magnetogenesis, including observational predictions. We then explore the structure and the thermodynamical properties of black holes that might have formed at this epoch, since they differ significantly from the standard picture.

Modello di fondo dell'esperimento GERDA dopo l'upgrade.

Morella M.
Gran Sasso Science Institute e INFN, L'Aquila

L'esperimento GERDA ha come scopo la misura del doppio decadimento beta senza emissione di neutrini dell'isotopo 76 del germanio. Esso impiega dei rivelatori al germanio arricchito immersi in argon liquido, il quale agisce sia da liquido criogenico che da veto attivo attraverso la rivelazione della sua luce di scintillazione. Per la misura di questo raro fenomeno e per migliorare le strategie di radiopurezza in esperimenti futuri, è necessaria un'accurata conoscenza della quantità e della distribuzione degli eventi di fondo nelle componenti dell'apparato sperimentale. Nel mio contributo parlerò del modello di fondo in seguito a un upgrade dell'esperimento avvenuto nel 2018.

The Pierre Auger Observatory upgrade.

Convenga F., the Pierre Auger Collaboration
Karlsruher Institut für Technologie, KIT

The scientific results of the Pierre Auger Observatory have been many and of significant impact in cosmic ray physics. However, there are still many unknowns about the primary mass composition, the nature of the sources, and the underlying hadronic interactions. In this context, an upgrade of the Pierre Auger Observatory called "AugerPrime" is underway to obtain more detailed information regarding the mass composition and the origin of the high-energy flux suppression. The AugerPrime upgrade contains many improvements to the Observatory, including the installation of a new Surface Scintillator Detector (SSD) above each of the existing Water Cherenkov Detectors (WCDs), new surface detector stations electronics to process both WCD and SSD signals, the installation of the underground scintillator muon detector AMIGA, and the addition of sensors to each WCD to measure the radio waves generated by the extensive air showers. This talk will deal with AugerPrime, focusing on the installation and performance of the new electronics and SSDs.

Direct comparison of PEN and TPB wavelength shifters in a liquid-argon detector.

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Liquid-argon (LAr)-based detectors have many applications including direct dark matter searches and experiments investigating properties of neutrinos. The spectra of scintillation light from argon peaks at 128 nm. In order for the photo-sensors to efficiently detect this Vacuum UltraViolet (VUV) light, a wavelength shifter (WLS) is required. Currently, the most common WLS is Tetra-Phenyl Butadiene (TPB). Its application requires a vacuum evaporation process which is not trivial to scale up to the large-surface areas common in the upcoming generation of experiments. PolyEthylene Naphthalate (PEN) is a polymeric wavelength shifting film that is available in large footprints, and has recently been proposed as a scalable and inexpensive alternative to TPB for large LAr-based detectors. In the present work, we have compared the light yield (LY) obtained from two identical LAr detectors, housed simultaneously in the same LAr volume, one using PEN and the other using TPB. These measurements give a direct comparison of the relative efficiency between PEN and TPB in an environment that is representative of a large LAr experiment.

Proprietà spettrali broad-band della binaria con buco nero V404 Cyg durante l'outburst del 2015.

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L'accrescimento è un fenomeno astrofisico di grande importanza in quanto è in grado di liberare ingenti quantità di energia. Si osserva in svariati ambienti astrofisici come i sistemi binari, costituiti da un oggetto compatto e una stella compagna. Nella mia tesi prenderò in esame uno di questi oggetti: il sistema binario transiente V404-Cygni. Attraverso l'analisi spettrale della sorgente cercherò di capire quali processi fisici hanno luogo attorno a essa. La peculiarità di tale sistema è dovuta a rapidi cambiamenti di luminosità spiegabili grazie alla presenza di un assorbitore che circonda la sorgente in maniera non uniforme. Si pensa che i flussi più elevati corrispondano a emissioni che arrivano all'osservatore senza essere assorbite, mentre flussi più deboli sono rilevati quando la sorgente è parzialmente oscurata. Questa proprietà sembra replicare su piccola scala ciò che succede in alcuni Nuclei Galattici attivi (buchi neri super massicci situati al centro di altre galassie anch'essi soggetti al fenomeno dell'accrescimento); dunque capire la fisica delle emissioni di questa sorgente potrebbe aiutare a comprendere meglio quello che avviene in essi.

Sviluppo di calorimetri criogenici per la misura della forma spettrale del decadimento beta dell'indio-115.

Celi E.
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La forma spettrale dei decadimenti beta proibiti è di particolare interesse non solo per la fisica nucleare, ma comporta considerevoli implicazioni nel campo della fisica astroparticellare. Nella lista degli isotopi interessati l'indio-115 è uno dei più adatti ad essere studiati grazie all'alto Q-valore (~ 498 keV) e alla vita media (4.41×10^{14} yr) del suo decadimento. La nostra proposta è di usare un cristallo di ossido di indio come calorimetro criogenico per effettuare una misura ad alta precisione della forma dello spettro del decadimento beta. Questo è il primo passo per il progetto ACCESS (Array of Cryogenic Calorimeter to Evaluate Spectral Shapes). In questo contributo presenterò le linee guida del progetto e i risultati ottenuti con i test preliminari.

Rapid response to extraordinary events: The Gamma-ray Follow Up (GFU) platform for IceCube.

Boscolo Meneguolo C., Bernardini E., Mallamaci M.
Università di Padova

The IceCube discovery of an astrophysical flux of high-energy neutrinos is a milestone in multi-messenger astronomy. Time-integrated searches for point-like neutrino sources have failed so far because of large backgrounds and weak signals. IceCube observes the sky with full duty cycle, enabling us to search for transient neutrino emissions and alert the astrophysical community in the case of detection, aiming for the identification of an electromagnetic counterpart of rapidly fading sources. In this talk, the Gamma-ray Follow Up

(GFU) platform will be presented, which allows to generate and send alerts to the astrophysical community, as a response to the real-time identification and selection of good muon neutrino candidates.

Mitigation of non-axisymmetric optical aberrations in Advanced Virgo.

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The sensitivity and the operation of terrestrial gravitational interferometers are limited by noises and by optical aberrations. The absorption of power by the mirrors induces their thermal expansion and an increase of the optical path of the light. These effects cause a variation of the nominal optical configuration of the interferometer, worsening its performances. To mitigate these distortions a thermal compensation system (TCS) has been implemented in Advanced Virgo. TCS is designed to correct two kinds of optical aberrations: the axisymmetric and non-axisymmetric ones. The former are well known and have been compensated already in the previous observational runs. In view of the future observational run O5 (planned to start in 2025) an adaptive control of non-axisymmetric optical aberrations will be needed. The use of Deformable Mirrors (DM) has been studied as a possible solution. The great advantage of this system is that the applied correction is static and adaptive, so it does not introduce additional noise in the detector. The characterization of the DM and the preliminary actuation performances will be reported.

Coping with anomalous power absorptions in the Advanced Virgo core optics.

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Core optics are key elements in present and future gravitational waves interferometric detectors. Matching the requirements needed to reach the goal sensitivity for future observational runs is one of the biggest technological challenges in the field. During the last observational run, highly absorbing areas on the surfaces of the main optics of Advanced Virgo (AdV) and Advanced LIGO have been observed. These anomalous micron-scale absorbers produce distortions appearing as thermo-elastic deformations of the high-reflectivity mirrors surfaces that spoil the behavior of the detector. With the aim to understand and mitigate the effects of these anomalous absorption in the interferometer, a detailed and quantitative study of their characteristics has been carried out. The information about their position and fraction of absorbed power allows to put the basis for the development of an adaptive actuator, able to correct these aberrations in the AdV test masses. Here the analysis of AdV mirrors surfaces, the point absorbers identification and characterization, the corresponding thermo-elastic deformation and the results from a possible actuator for its compensation are presented.

Fabbricazione e misure di test per l'apparato di rivelazione dell'esperimento HOLMES.

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J. (5), Gallucci G. (4), Gard J. (5), Gatti F. (2)(4), Giachero A. (3), Hilton G. (5), Koester U. (8), Lusignoli M. (9), Mates J. (5), Maugeri E. (7), Nisi S. (6), Nucciotti A. (1)(3), Parodi L. (4), Pessina G. (3), Ragazzi S. (1)(3), Reintsema C. (5), Ribeiro-Gomes M. (10), Schmidt D. (5), Schumann D. (7), Siccardi F. (4), Swetz D. (5), Ullom J. (5), Vale L. (5)
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L'esperimento HOLMES fisserà un limite sulla massa del ν_e all'ordine dell'eV, studiando la cattura elettronica dell'^{163}Ho e le deformazioni all'end-point del suo spettro ($\sim$ 2.83 keV). I rivelatori adottati sono Transitions Edge Sensors (TES), sensibili termometri che, lavorando a temperature criogeniche, garantiscono tra le migliori prestazioni in quanto a risoluzione energetica. La produzione dei chip di TES per HOLMES richiede la messa a punto di procedure e strumenti opportuni, ma anche l'impiantazione della sorgente di Ho al loro interno. Questo intervento vuole raccogliere gli ultimi aggiornamenti in merito alla fabbricazione dei TES e alle successive misure di test eseguite. Prima della misura con l'olmio è infatti importante valutare risoluzione energetica e risposta temporale dei rivelatori esponendoli a diverse sorgenti esterne con raggi X di energia prossima a quelli dell'Ho. Nei mesi successivi all'impiantazione HOLMES, che ha come obiettivo ultimo la misura con un array da $\sim$ 1000 TES, potrà restituire i primi risultati (spettro calorimetrico e stima della sensibilità su m_{ν_e}) lavorando con chip da 64 pixel.

Validation test of photosensors for the DUNE experiment.

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The DUNE long-baseline neutrino oscillation experiment aims to provide precise measurements of oscillation parameters, determine the neutrino mass ordering and charge-pairing symmetry violation. The experiment will use a Near Detector and a Far Detector (FD) placed at a distance of 1300 km from the neutrino beam source. The FD complex will be composed of four giant Liquid Argon Time Projection Chambers. The first module will be a 14 kton single-phase LArTPC. The scintillation light emitted in neutrino interactions will be collected by a Photon Detection System based on Silicon Photomultipliers (SiPMs). About 300000 SiPMs will be necessary to instrument the PDS. In this contribution the characteristics of the light collection system will be described as well as the tests performed at cryogenic temperatures on SiPM samples to verify the compliance of their performances with the experiment requirements.

High-energy emission from radio-quiet pulsars: The case of PSR 1809-2332.

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Thanks to the Fermi Large Area Telescope (LAT) observations, our understanding of gamma-ray pulsars has dramatically improved. In particular, new results about the peculiarities of

these sources could provide new constraints on the magnetospheric emission models: for instance, the characteristic gamma-ray pulsars do not feature associated radio or X-ray pulsed emission. It is still unclear whether the lack of detection in some energy bands is related to observational limits rather than to the geometric configuration or to the emission processes at the source. PSR J1809-2332 is a radio-quiet pulsar first detected with Fermi-LAT in 2009. Even if an associated X-ray Chandra source exists, this pulsar seems to show no periodicity at these energies. We will present an updated study on the X-ray emission of PSR J1809-2332 and its associated pulsar wind nebula based on XMM-Newton observations, in order to better characterize this source and its high-energy emission.

Improving the sensitivity of LAr experiments to light dark matter with the Migdal effect.

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The search for dark matter (DM) weakly interacting massive particles with noble liquids has probed masses down and below a GeV/c^2, corresponding to an experimental threshold in direct detection experiments equivalent to a few ionization electrons. These experiments generically are insensitive to nuclear recoils with energy below the keV, corresponding to sub-GeV/c^2 dark matter scattering. The basic assumption for this kind of analysis is that the DM transfers energy to the nuclei via nuclear recoil. However, the sudden acceleration of a nucleus after a collision may lead to excitation and ionization of atomic electrons: this process is known as Migdal effect. In a recent work we examined both the Migdal effect and photon Bremsstrahlung from the nucleus in experiments exploiting liquid-argon (LAr) detectors. By means of a simulated experiment, called TEA-LAB, inspired on DarkSide-50, we show how including this effect allows us to extend the sensitivity of the experiment down to masses of 0.1 GeV/c^2.

Magnetic field screening in strong crossed electromagnetic fields.

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We consider crossed an electric and a magnetic field ($\vec{B} = B\hat{z}, \vec{E} = E\hat{y}$), with $E/B < 1$, in the presence of some initial number of $e^{\pm}$ pairs. We do not discuss here the mechanism of generation of these initial pairs. The electric field accelerates the pairs to high energies thereby radiating high-energy synchrotron photons. These photons interact with the magnetic field via magnetic pair production process (MPP), *i.e.*, $\gamma + B \to e^{+} + e^{-}$, producing additional pairs. We here show that the motion of all the pairs around the magnetic field lines generates a current that induces a magnetic field that shields the initial one. For instance, for an initial number of pairs $N_{\pm,0} = 10^{10}$, an initial magnetic field of 10^{12} G can be reduced of a few percent. The screen occurs in the short timescales $10^{-21} \leq t \leq 10^{-15}$ s, *i.e.*, before the particle acceleration timescale equals the synchrotron cooling timescale. Our results indicate that the screening of magnetic fields can be very relevant in some astrophysical systems such as pulsars and gamma-ray bursts.

Model-independent measurements of redshift-space distortions and magnification from harmonic-space power spectra.

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The project focusses on the harmonic-space analysis of the clustering of galaxy number counts, implementing a model-independent framework to measure the main contribution to the signal beyond Newtonian density fluctuations, namely redshift-space distortions and weak lensing magnification. By decomposing galaxy number density fluctuations into its three main components, we study how its harmonic-space power spectrum is able to retain information on each of the contributions separately. To this aim, we exploit redshift tomography, *i.e.* we slice the observed source redshift distribution into concentrical redshift shells and analyse auto and cross-bin correlations. Finally, we shall apply the formalism to synthetic datasets and provide constraints on the linear galaxy bias, the growth rate of matter fluctuations, and the magnification bias of the observed galaxy sample.

Medium-scale anisotropies in the arrival directions of UHECRs observed by the Pierre Auger Observatory.

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The Pierre Auger Observatory is the largest experiment dedicated to the study of UHECRs and it has made many important discoveries, such as the presence of a significant dipole distribution for data above 8 EeV, which does not point to the Galactic Center and thus confirms an extragalactic origin of UHECRs. This work concentrates on the study of the medium-scale anisotropies in the arrival directions of cosmic-ray data with energy above 32 EeV collected by the Auger Observatory up to 2020. The data is first submitted to a blind search and an autocorrelation test looking for clusters of events, then to a search for correlation with major astrophysical structures, *i.e.*, the Galactic Center, Galactic Plane and Supergalactic Plane. The distribution of the data is also correlated with a maximum-likelihood test to the expected flux from Starburst galaxies and AGNs and to the general distribution of matter in the local universe (2MASS). A structure-like analysis is performed on the region which presented the most significant excess in all the likelihood test, the Centaurus Region, which contains two prominent starburst galaxies and the closest AGN, Centaurus A.

Il campo gravitazionale di oggetti isolati in gravità quadratica.

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In Relatività Generale il campo gravitazionale di oggetti isolati, statici ed a simmetria sferica, è molto semplice: siano essi buchi neri, stelle ordinarie o stelle compatte, all'esterno sono descritti dalla metrica di Schwarzschild e caratterizzati dalla loro massa. La Relatività Generale non è però in grado di descrivere il comportamento della gravità a grandi energie, e molti approcci alla Gravità Quantistica concordano con l'aggiungere termini quadratici nei tensori di curvatura come prime correzioni all'azione di Einstein-Hilbert. Le soluzioni di questa teoria presentano deviazioni esponenzialmente soppresse dalla metrica di Schwarzschild a grandi distanze, e un variegato spettro di comportamenti vicino all'origine in relazione all'intensità di queste deviazioni. In questa comunicazione presenteremo come viene modificato il campo gravitazionale nel caso delle soluzioni più familiari, ovvero buchi neri e stelle compatte. Oltre a mostrare importanti differenze rispetto alle soluzioni classiche, il particolare modo in cui soluzioni diverse si discostano dalla metrica di Schwarzschild permette di distinguere la natura della soluzione da una pura osservazione gravitazionale.

NICE: An online application for glitches characterization in gravitational wave detectors.

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In LIGO and Virgo interferometers, during the validation of a gravitational wave event, it is necessary to extract the signal from a huge amount of non-Gaussian transient noises, called glitches. They have a typical time-frequency morphology, and the origin can be determined by studying coincidences with some auxiliary channels (*e.g.*, microphones, seismometers). With the increase in detection rate, due to the growing sensitivity of the interferometers, we created a fast and efficient noise analysis tool, the Noise Interface Catalogue Explorer (NICE). This is a web application for selecting glitches, making a first expositive distribution, and showing their morphology for the identification. This is particularly useful for low-latency analysis purposes, like the data quality alert to the astronomers for the electromagnetic counterpart observation. NICE contains integrated databases, collecting the glitches metadata, and provides a descending workflow that leads from the selection of the desired glitches to the deeper analysis of the single transient noise. We present the NICE facilities and the results applied to Virgo unclassified and simulated glitches.

Intrinsic gravitational modes sustained by black hole collapsing binaries.

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Intrinsic Gravitational Modes (IGM) involving electromagnetic-field fluctuations are found that are sustained by the time-dependent three-dimensional gravitational field of black hole binaries when their collapse is approached. These "disk-rippling" modes, emerging from a plasma disk structure surrounding a binary, have ballooning amplitude profiles in the vertical direction (referring to the binary angular momentum vector) and rotate mainly with a frequency of twice the binary rotation frequency within the limited region where the Newtonian gravity modulation is valid. Modes with considerably higher frequencies can be sustained by the modulated gravitational potential through the coupling of modes of this kind whose frequencies differ by twice the binary rotation frequency. Relevant mode-particle resonances can provide a means to transfer energy from high- to low-energy populations (a process evidenced by laboratories experiments) and offer an explanation for the absence of detectable high-energy radiation emission as the observed collapse of black hole binaries is approached.

Cyclical generation of reconnected magnetic fields by electron pressure gradients.

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The theoretical basis for the cyclical generation of macroscopic reconnected magnetic fields in low collisionality plasma regimes is formulated. The relevant process is sustained by the “thermal” energy of the electron population.In particular, an oscillatory mode propagating along and across a confining magnetic field is identified that involves the magnetic reconnection region where the ratio of the longitudinal ($\propto D^e_\|$) to transverse electron thermal conductivity ($\propto D^e_\perp$) is relatively large. A periodic exchange of reconnected magnetic field energy with electron thermal energy is sustained within a region that remains significant even when the magnetic field configuration from which the mode can emerge involves large-scale distances. The mode growth rate depends on the particle density gradient (aligned with the electron temperature gradient) and the relevant particle diffusion coefficient. A different magnetic reconnection process driven by the plasma pressure gradient was identified explaining the origin of the observed sawtooth oscillations of magnetically confined plasmas.

The iron spectrum measured with CALET on the International Space Station.

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The Calorimetric Electron Telescope, in operation on the International Space Station since 2015, is able to identify particle charge from proton to iron and above, to accurately reconstruct tracks and to measure the energy with a lead tungstate homogeneous calorimeter. One of the scientific objectives is to measure the energy spectra of cosmic rays, to shed light on their acceleration and propagation in the Galaxy. After five years of observation, a precise measurement of the iron spectrum is now available in the interval of kinetic energy per nucleon from 10 GeV/n to 2 TeV/n. A description of the analysis and details on systematic uncertainties will be illustrated.

Stellemoti nelle millisecond pulsar ed emissione di onde gravitazionali.

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Nonostante finora siano state rilevate solo onde gravitazionali (OG) transitorie prodotte da eventi catastrofici, si ritiene che dovrebbero esserci anche sorgenti continue di OG all’interno della nostra galassia; per esempio, stelle di neutroni in accrescimento, nelle quali le forze centrifughe possono essere così forti da romperne la crosta (stellemoto), producendo un momento quadrupolare responsabile dell’emissione continua di OG. Presentiamo qui un modello newtoniano per SN comprimibili, non magnetizzate e autogravitanti. A seconda degli scenari forniti dalle diverse equazioni di stato, troviamo che la massima ellitticità indotta da uno stellemoto varia da 10^{-9} a 10^{-5}. Per le stelle in accrescimento, la frequenza di equilibrio corrispondente risulta in buon accordo con le osservazioni e, per tutti gli scenari, inferiore alla frequenza di rotazione massima osservata di 716.36 Hz. Infine, discutiamo i possibili vincoli osservativi sul limite superiore dell’ellitticità delle pulsar in accrescimento.

Rivelazione di segnali gravitazionali provenienti da pulsar tramite algoritmi di machine learning.

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La rivelazione delle onde gravitazionali è stato uno dei maggiori successi della fisica contemporanea. Finora abbiamo rivelato solo segnali gravitazionali transienti provenienti da coalescenze di oggetti compatti, ma ci aspettiamo di osservare nei prossimi anni segnali continui e periodici. Le pulsar, ad esempio, possono emettere onde di questa natura. L'ampiezza di questi segnali è molto ridotta: per rivelarli sono necessari grandi tempi di integrazione, e analizzare grandi quantità di dati può diventare un compito arduo. Una possibile soluzione consiste nell'utilizzare algoritmi di apprendimento automatico, i quali hanno dimostrato di essere una rapida ed efficiente alternativa agli approcci classici. Il segnale proveniente da una pulsar è modulato sia a causa del rallentamento intrinseco della sorgente, sia a causa della modulazione Doppler provocata dai moti terrestri. In questa comunicazione presenteremo un metodo che utilizza una rete neurale convolutiva per individuare la frequenza del segnale emesso da una pulsar, sfruttando la peculiare forma attesa per queste sorgenti.

The reconstruction of charged tracks within the new Time Projection Chambers of the T2K Upgraded Experiment at J-PARC.

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The T2K Collaboration is developing new gas-based Time Projection Chamber (TPC) detectors to be exploited in the "near" neutrino detector located in the J-PARC laboratory (Tokai, Japan). The design of the new TPCs, which will enable the study of the particles generated at large angles by the neutrino interactions, includes a significant active volume defined by rectangular cross-section Field Cages with lightweight composite material walls and amplification and readout of the primary ionization electrons by means of MicroMegas sensors. In this talk I will present the first performance results obtained by exposing a prototype of the new detector to an electron test beam and to cosmic rays, and I will highlight the challenges we are facing in terms of developing new track reconstruction algorithms.

Sviluppo di pipeline per la rivelazione di GRB con CTA.

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Il Cherenkov Telescope Array (CTA) sarà fondamentale, durante i prossimi decenni, per l'osservazione del cielo nei raggi gamma. Una classe di sorgenti molto interessanti in questa banda sono i Gamma Ray Burst (GRB), transienti elettromagnetici che rilasciano, in tempi molto brevi, un'energia compresa tra 10^{51} e 10^{54} erg. Recentemente una componente di altissima energia ($E > 100$ GeV) è stata osservata, dai telescopi MAGIC e H.E.S.S., in associazione con l'afterglow di alcuni GRB. Si tratta di una componente fondamentale per lo studio dei meccanismi di emissione e accelerazione in atto nella sorgente e sarà oggetto di studio di CTA. Sulla base di popolazioni sintetiche di GRB, sono in corso alcuni studi che si pongono come obiettivo quello di determinare il numero di sorgenti che potranno essere osservate, tenendo conto anche dell'assorbimento da parte dell'Extragalactic Background Light (EBL). Questo lavoro, attualmente in fase preliminare, ha lo scopo di determinare la visibilità dei GRB, attraverso il metodo di analisi On/Off, sfruttando uno dei tool costruiti per CTA (ctools) per simulazioni ed analisi.

The design of the beamline for the ENUBET experiment.

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The ENUBET project aims at reducing the flux-related systematics on a narrow-band neutrino beam by monitoring the associated charged leptons in an instrumented decay tunnel. A key element of the project is the design of a transfer line with conventional magnets that maximizes the yield of K^+ and π^+, while minimizing the total length to reduce meson decays in the non-instrumented region. In order to limit particle rates on the tunnel instrumentation, a high level of collimation is needed. At the same time a fine tuning of the shielding and the collimators is required to minimize any beam-induced background in the decay region. The transfer line is optimized with TRANSPORT and G4beamline for 8.5 GeV/c mesons with a momentum bite of 10%. This contribution reports details on the current beamline with an improved proton target design. Highlights of a full GEANT4 simulation of the setup in terms of particle yields and neutrino fluxes at the far detector will be shown, together with doses estimation through a FLUKA simulation. Studies on an alternative beamline with a broad momentum range (4, 6, 8.5 GeV/c), that could enhance the physics reach of the facility, are also discussed.

The HEPD-02 detector onboard the CSES-02 satellite.

Ricci E., on behalf of the Limadou Collaboration
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The China Seismo-Electromagnetic Satellite (CSES) is a mission devoted to the observation of Earth from space. Its main focus is the study of phenomena connected to earthquakes. Among the payloads, the Italian Limadou Collaboration is in charge of the High Energy Particle Detector (HEPD), designed for electrons and protons in the MeV energy range. The HEPD is the first detector specifically designed to investigate a possible correlation between particle bursts and earthquakes. After the successful experience of the HEPD-01 detector onboard the CSES-01 satellite, launched in February 2018 and currently in operation, the Limadou Collaboration is now working at the HEPD-02 detector design and assembly for the new satellite mission CSES-02 planned for late 2022. The general structure of the new detector is the same as that of the first one, with some major upgrades aimed at optimising the physics performance of the apparatus and, in particular, a brand new tracker that will be realised with Monlithic Active Pixel Sensors (MAPS), at their first use in space. This contribution will describe the upgrade of the detector and the expected performance characterised with a Monte Carlo simulation.

The Advanced Surveyor of Transient Events and Nuclear Astrophysics (ASTENA).

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The Advanced Surveyor of Transient Events and Nuclear Astrophysics (ASTENA) is a new high-energy mission concept that has been proposed to the ESA call for ideas for its new long-term programme "Voyage 2050". The ASTENA mission includes two instruments: 1) an array of Wide Field Monitors with Imaging, Spectroscopy and polarimetric capabilities (WFM-IS), with a large effective area and a broad energy passband (2 keV–20 MeV), and 2) a broad-band (50–700 keV) Narrow Field Telescope (NFT) with focusing capabilities based on the use of an advanced Laue lens with unprecedented sensitivity and angular resolution. Thanks to the increased sensitivity with respect to state-of-the-art soft gamma telescopes in the MeV and sub-MeV energy band, ASTENA will enable the study of the so far uncovered population of low-luminosity GRBs and will allow to detect or improve existing detections with unprecedented angular resolution of gamma-ray lines of nuclear origin or from pair annihilation. In this contribution we will present the science motivation, the instrument description, the simulations to predict the telescope performance and the current technological developments.

INAF - Catania Solar Telescope contribution to the ESA - Space Weather Service Network.

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The increasing technological development requires more attention to the Space Weather (SW) monitoring and to predict the state of the Sun and of the interplanetary environment, including Earth's magnetosphere, ionosphere and thermosphere. In fact, severe SW events can affect spaceborne and ground-based infrastructures thereby endangering human health and safety. In this context, the acquisition system of INAF - Catania Solar Telescope has been recently upgraded in order to improve its contribution to the ESA's Space Weather Service Network, by the provision of SW products and services through the ESA Portal, which represents the main asset for SW in Europe. For many years INAF-OACT has provided full-disc images of the photosphere and chromosphere acquired by its Solar Telescope, together with a detailed characterization of the sunspot groups. These data are daily published in near real time in the portal. We describe the main products provided by the INAF-OACT and, as a showcase of the observational capabilities of the revamped Catania Solar Telescope, we report the results of a B5.4-class flare occurred on December 7th, 2020, simultaneously observed by the IRIS and SDO satellites.

Long GRB afterglow from radio to X-rays in the binary-driven hypernova scenario.

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The binary-driven hypernova model uses as the progenitor of energetic, long GRBs, a binary composed of a carbon-oxygen (CO) star that undergoes supernova (SN), creating a massive accretion process onto a companion neutron star (NS). The SN forms at its center a newborn NS, while the NS binary companion, by accretion of part of the SN ejecta, reaches the critical mass, collapsing and forming a black hole (BH). The rest of the SN ejecta escape from the binary, expanding at mildly relativistic velocity. We show that the ejecta, being threaded by the magnetic field lines of the newborn NS at its center, produces synchrotron radiation, further powered by the pulsar activity of such an NS. This process generates distinct multi-wavelength emissions from the radio to the X-rays confirmed by hundreds of GRB afterglows. The analytic, closed-form solution of the kinetic equation of the electrons producing this synchrotron emission is also presented. All this allows the determination of the newborn NS properties such as its spin and the strength of its magnetic field, as well as its multi-polar structure.

Preliminary results on cosmic Li, Be and B with the DAMPE experiment.

PARENTI A., DI SANTO M., KYRATZIS D., SILVERI L. ON BEHALF OF THE DAMPE COLLABORATION

Gran Sasso Science Institute, L'Aquila and INFN - Laboratori Nazionali del Gran Sasso, Italia

The space-based DAMPE (DArk Matter Particle Explorer) detector was successfully launched in December 2015 and has been taking data ever since. One of its goals is to precisely measure high-energy galactic cosmic rays (CRs). Investigating the spectrum of cosmic lithium, beryllium and boron, so-called secondary nuclei, is of fundamental importance to better understand CR propagation in the Galaxy as well as the origin of the flux hardening observed in primary CRs. Current analysis results concerning the cosmic Li, Be and B nuclei will be presented and discussed.

The Gd-water plant of the XENONnT neutron veto.

SELVI M., FOR THE XENON COLLABORATION

INFN Bologna

The XENONnT experiment is currently under commissioning at LNGS. One of its novel subsystems is the so-called "neutron veto", aimed at reducing the background from radiogenic neutrons by tagging them in a suited water Cerenkov detector. A key ingredient is the doping of water with gadolinium, the element with the highest neutron capture efficiency, in the form of Gd-sulphate. In this communication, we will present the details of the plan to mix Gd inside water and to purify the Gd-water solution to keep large water transparency.

Metodi di machine learning per la caratterizzazione di rumori transienti nei rivelatori di onde gravitazionali.

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I rivelatori attuali di onde gravitazionali come Advanced LIGO e Advanced Virgo sono soggetti a vari tipi di rumore, sia di natura strumentale che ambientale. In particolare, alcuni rapidi transienti di rumore, noti come "glitch", possono influire sulla qualità dei dati e risultare simili a segnali gravitazionali di natura astrofisica. È quindi fondamentale poter riconoscere questi segnali transienti di rumore, in modo da ridurre il loro impatto sulla ricerca di segnali astrofisici, ed essere in grado di raggrupparli in famiglie dalle caratteristiche comuni, per poi studiarne l'origine. Analisi basate sul machine learning risultano essere molto promettenti per raggiungere questi scopi. In particolare, reti neurali convolutive si dimostrano essere in grado di poter riconoscere immagini di spettrogrammi di diverse famiglie di glitch con una notevole precisione. In questo lavoro presenteremo la possibilità di usare reti neurali convolutive per serie temporali contenenti rumore transiente, in modo da ridurre il tempo necessario per l'analisi dei segnali.

IBIS 2.0: Enabling new observations of small-scale plasma processes in the solar atmosphere.

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The IBIS Interferometric BIdimensional Spectrometer, disassembled from the US Dunn Solar Telescope in 2019, is undergoing a significant hardware and software upgrade in light of its new installation as IBIS 2.0 at the Vacuum Tower Telescope in the Canary Islands in 2022. We present the instrumental characteristics and the design of the refurbished instrument. IBIS 2.0 will allow acquiring new spectropolarimetric observations of the solar atmosphere at high spatial, spectral and temporal resolution in coordination with telescopes onboard the Solar Orbiter, Bepi-Colombo, and SOLAR-C missions and other ground-based instruments. We also describe the future steps towards the operation of IBIS 2.0 as a key resource for the studies of magnetohydrodynamics and plasma physics in the solar atmosphere.

GRB-SNe connection within the binary-driven hypernova (BdHN) model.

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ICRANet and INAF

It is accepted that some long GRBs are associated to a special type of SN Ic. Our approach, the binary-driven hypernova (BdHN), assumes all long GRBs originate in binary new-Neutron Stars (NS) originating from a Co-core and a NS companion. The trigger of the event is signed by the collapse of the CO-core undergoing a SN explosion and creating a new-NS in the presence of the binary NS companion. Consequently, the evolution of the BdHN is based on the interplay of the SN explosion, the new-NS and the companion NS. The quantity characterizing the different outlook is the binary distance between the Co-core undergoing SN and the binary companion NS. Besides the difference between these subclasses, which cannot be denied, is that all of them originate from the onset of a SN, genereating a new-NS in the presence of a companoion NS. This work addresses the SN fate in the BdHN model and the possibility of observing the optical emission from the SN. We report the 25 observations of the SN occurring in different BdHN types. Finally, within the BdHN model, we explain why the optical peak luminosity of SNe are identical, independent of the their isotropic gamma energy spanning for ~ 8 order of magnitude.

Experimental Maxwell-Boltzmann neutron spectrum determination with thermal temperature of 28 keV for Maxwellian Averaged Cross-Section (MACS) calculations.

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The experimental measurement of the neutron capture cross-sections is an actively working task, since it is an essential element in the stellar reaction rates calculations and, thus, the possibility of reproducing the observed abundance of the elements in the universe. The

Maxwellian-Averaged Cross-Section (MACS) is the quantity needed for the calculation of the stellar reaction rate. Before any MACS measurement, a characterized neutron beam with a stellar spectrum is mandatory, and this is the main purpose of this work. The $^{7}\mathrm{Li}(\mathrm{p,n})^{7}\mathrm{Be}$ nuclear reaction was employed as neutron source. A method based on the idea of shaping the proton beam energy to shape the neutron beam spectrum was used to produce a MBNS. For that, an initial proton energy of 3170 keV and a 51 μm thickness aluminum (Al) foil, as proton energy shaper, were employed. Differential angular neutron energy distribution from 0 to 90 degrees in steps of 10° were measured to obtain the 0°–90° integrated neutron spectra, over a flight path of 50 cm. The emitted neutron energy spectrum was obtained applying the conversion method using the response matrix of the employed Li-glass detector.

Polarization signatures during the X1.6 flare observed in NOAA 12192.

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The X1.6 flare observed on October 22, 2014 (SOL2014-10-22T14:28) was among the strongest flares occurred in the magnetically complex, great active region NOAA 12192. It was a confined flare, without an accompanying CME, despite the large amount of released energy. In our work we attempt to deepen our understanding of the magnetic field configuration of the AR 12192. We analyzed the polarization signatures during the flare using spectropolarimetric data acquired by the IBIS/DST instrument along the photospheric Fe I 617.3 nm and the chromospheric Ca II 854.2 nm lines in a time interval immediately following the peak of the X1.6 flare. The results obtained provided evidence of significant changes in the magnetic field configuration during the analyzed time interval.

Commissioning and first results of the XENONnT Neutron Veto.

Mancuso A.
Università di Bologna

The XENONnT experiment at the Laboratori Nazionali del Gran Sasso (LNGS) is currently under commissioning: the detector and all the subsystems are monitored and calibrated in view of the first Science Run. The Neutron Veto novel subsystem, installed in 2020, aims to tag the radiogenic neutrons from the detector materials. It is made of 120 high-QE low-radioactivity photomultiplier tubes (8″ Hamamatsu R5912), installed in water inside a high light collection volume delimited by ePTFE reflector panels around the cryostat. This allows to detect the products of the neutron capture through the emitted Cherenkov light. The water will be eventually doped with Gd to increase the neutron detection efficiency. In this communication, we describe the steps and the results of the commissioning and calibrations of the Neutron Veto, in the current phase with pure water.

Intrinsic gravitational acoustic modes sustained by (GR) gravitational wave emitters.

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Modes with considerably higher frequencies than those of the emitted Gravitational Waves by collapsing binaries can be sustained by the modulated gravitational potential associated with binaries. These modes depend on a significant electron temperature of the plasma disk structures from which they emerge. A nonlinear coupling of modes of this kind, their frequencies differing by twice the binary rotation frequency, is involved. When the disk structures are immersed in a stationary magnetic field, another class of modes can emerge and extend considered the range of process resulting from relevant mode-particle resonant interactions.

Caratterizzazione e ottimizzazione del modello ingegneristico del sistema di trigger del rivelatore HEPD-02 dell'esperimento CSES-Limadou.

Mese M. per la Collaborazione CSES-Limadou
Università degli studi di Napoli Federico II e Istituto Nazionale di Fisica Nucleare

Il progetto CSES-Limadou prevede la realizzazione di una costellazione di satelliti, equipaggiati con diversi rivelatori, che consentono di monitorare alcune perturbazioni ionosferiche potenzialmente correlate con il verificarsi di terremoti sulla superficie terrestre. Il primo satellite è stato lanciato il 2 Febbraio 2018 e un secondo è in fase di sviluppo. Il lancio di quest'ultimo è previsto per il mese di Marzo del 2022. Fra i rivelatori presenti sul satellite, HEPD consente di rivelare elettroni e protoni in range energetici che vanno da 3 a 100 MeV per gli elettroni e da 35 a 250 MeV per i protoni. In questo contributo saranno descritte le misure effettuate sul modello ingegneristico della scheda che ospita l'elettronica di front-end del calorimetro e di trigger dello strumento. Il lavoro ha consentito l'ottimizzazione del progetto, in vista dello sviluppo del modello di volo che verrà utilizzato sul secondo satellite.

Measurement of the energy spectrum of cosmic iron nuclei with DAMPE.

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DAMPE (Dark Matter Particle Explorer) is a calorimetric-type, satellite-borne detector for the observations of high-energy electrons, gamma-rays, and cosmic-ray nuclei. Using five years data recorded with DAMPE from January 1, 2016 to December 31, 2020, we can measure the spectrum of iron nuclei in a wide energy range. Detailed studies of the fragmentation of iron in the detector have been performed using Monte Carlo simulations. Preliminary results of the ongoing analysis will be shown and discussed.

GRB 180720B: A BDHNI prototype.

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GRB 180720B, observed by Fermi-GBM, with redshift $z = 0.653$, isotropic energy $E_{iso} = 5.92 \times 10^{53}$ erg, and X-ray afterglow observed by the Swift-XRT, is classified as a Binary-driven Hypernova I (BdHN I). BdHN I are long GRBs with a binary progenitor composed of a Co-core and a neutron star (NS) companion with orbital period ~ 5 min. The gravitational collapse of the Co-core generates a supernova (SN) and a new NS (νNS) at its center. The SN accretion onto the NS triggers its gravitational collapse forming a black hole (BH). An electrodynamical process near the BH horizon leads to the long-lasting GeV emission powered by the BH rotational energy: we determine the BH mass and spin. The νNS via its pulsar-like emission and fallback accretion injects energy into the magnetized SN ejecta generating, by synchroton, the X-ray afterglow powered by by the νNS rotational energy, we evaluate the νNS spin. The emission observed by the High-Energy Stereoscopic System (H.E.S.S.), at 100–440 GeV, of total energy 2.4×10^{50} erg, is here powered by a "glitch" event that suddenly injects relativistic electrons into the νNS magnetosphere during its slowing down phase.

Performance of the CYGNO Experiment prototype.

RIGGIO C. PER LA COLLABORAZIONE CYGNO
Sapienza Università di Roma

The Cygno Collaboration is working at the development of a gaseous Time Projection Chamber (TPC) with optical readout, operated at atmospheric pressure and ambient temperature for the study of rare events as Weakly Interactive Massive Particles (WIMPs) or neutrinos interactions. The use of a light nucleus as the helium one, together with the very high sensitivity offered by the optical readout, allows to study in details interactions with energy releases even below 10 keV. The set of information provided by the TPC approach (released energy, position, length and direction of recoils) allows, in the same energy range, to obtain a rejection of the background due to photon interactions larger than 99%. In this presentation we will show the results of R&D ongoing and the performance of the ultimate prototype with a sensitive volume of 50 litres representing the ultimate step before the final demonstrator of 1 cubic meter that will be installed at Gran Sasso Laboratories.

A spectral algorithm for numerical simulations of gravitational fields.

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Neutron stars and black holes are spectacular compact objects and, despite years of study, their dynamics are not completely understood yet. Recently, several gravitational signals have been detected by the interferometers, testifying to the extreme interaction of the above astrophysical objects, as suggested by numerical relativity. For this reason, the numerical approach becomes a valid investigation tool, which allows inspecting inaccessible regions. We propose a novel spectral technique in order to simulate extreme gravitational events, in vacuum spacetimes. We developed the Spectral-FIltered Numerical Gravity codE (SFINGE), an efficient model based on a Cartesian-Fourier decomposition, accompanied by filtering techniques. The code has been validated via standard gravitational testbeds, verifying its high accuracy and stability. Then we simulate singular spacetimes, such as the Schwarzschild black hole, the head-on collision, and finally the evolution of two binary black holes during their final coalescence stage, with the relative production of the gravitational signal.

Caratterizzazione della risposta di calorimetri criogenici a sorgenti alfa.

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CUORE è un esperimento che ha come scopo principale la ricerca del doppio decadimento beta senza emissione di neutrini ($0\nu\beta\beta$) il cui rivelatore è costituito da un insieme di 988 cristalli di TeO_2 operanti a temperature criogeniche. CUPID si colloca tra gli esperimenti di prossima generazione per la ricerca del $0\nu\beta\beta$ ed utilizzerà cristalli di Li_2MoO_4 per integrare le tecniche bolometriche attualmente utilizzate da CUORE con la rivelazione della luce emessa dal rivelatore stesso per consentire l'identificazione del tipo di particelle interagenti. Presso il laboratorio di criogenia dell'Università Milano Bicocca è stato possibile studiare e confrontare le non-linearità nella risposta dei cristalli di TeO_2 con gli innovativi cristalli di Li_2MoO_4 tramite l'utilizzo di una sorgente alfa superficiale nota. Gli studi effettuati hanno consentito di effettuare una caratterizzazione della risposta di questi rivelatori a diverse temperature in un range energetico tra 0.5 MeV e 10 MeV e per diversi tipi di particelle (gamma/elettroni e alfa).

Sezione IV
Geofisica e fisica dell'ambiente

Comunicazioni

Comparison of climate data records of temperature, humidity and wind speed.

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Observational data records are influenced by instrumental effects which may erode their reliability for climate applications. Among in-situ measurement techniques, radiosounding balloons are widely used for the study of climate changes in the atmosphere. Several climate studies use radiosounding time series of temperature, relative humidity and wind homogenized at mandatory pressure levels. In this work, a comparison among existing homogenized radiosonde datasets with satellite climate data records and atmospheric reanalysis is presented for the period since 1978. The study of trends at different pressure levels reveals a good agreement between the reanalysis and existing radiosounding homogenized datasets. For relative humidity, the discrepancies among the datasets are more significant. A focus on one of the most recently released datasets, named RHARM (Radiosounding HARMonization), shows its capability to reduce the differences with the reanalysis especially in the northern hemisphere for temperature and relative humidity. RHARM also improves the agreement with satellite climate data records, such as MSU (Microwave Sounding Unit) with Aura/MLS (Microwave Limb Sounder).

Linking the topside ionosphere effective scale height to the plasma ambipolar diffusion theory.

Pignalberi A., Pezzopane M.
INGV

Empirical models of the ionosphere describe the topside ionosphere through different analytical functions, but all of them depend on a parameter called effective scale height driving the distribution of the plasma with height. This parameter is deduced empirically from electron density measurements but does not have any physical meaning. In this work, we mathematically link the empirical scale height to that theoretically deduced from the plasma ambipolar diffusion theory and apply the obtained formalism to demonstrate a possible connection between the vertical gradient of the scale height (obtained by COSMIC satellites) and the electron temperature (obtained by ESA Swarm satellites).

Testing gas dispersion modelling: A case study at La Soufrière volcano (Guadeloupe, Lesser Antilles).

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This study aimed to validate the modelling of gas dispersal at La Soufrière de Guadeloupe volcano. We focused on the distribution of CO_2 and H_2S discharged from the active fumaroles at the summit, using the measurements of continuous gas concentrations collected during March-April 2017. We implemented the open-source Eulerian code DISGAS-2.0 for passive gas dispersion coupled with the mass consistent Diagnostic Wind Model, using local wind measurements and the ECMWF-ERA5 reanalysis data. Our results indicated the potential usefulness of DISGAS-2.0 as a tool for reproducing the fumarolic degassing and to assess (gas) hazard in any other volcanic contexts.

Radiografia Muonica applicata ai vulcani: Studio della parte sommitale del Vesuvio nell'esperimento MURAVES.

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La radiografia muonica permette di investigare l'interno di oggetti di grandi dimensioni, misurando il grado di assorbimento dei muoni cosmici da cui vengono naturalmente investiti. Questa metodologia è stata ed è ampiamente sfruttata per studiare la distribuzione di massa all'interno di vulcani, con l'obiettivo di evidenziare la presenza di strutture conduttive, utili alla simulazione delle possibili dinamiche eruttive. L'esperimento MURAVES (MUon RAdiography of Mt. VESuvius) intende ottenere una radiografia muonica della parte sommitale del Vesuvio, uno dei vulcani attivi più pericolosi al mondo, utilizzando un sistema di tre odoscopi per muoni costituiti da scintillatori plastici accoppiati a SiPM. Si vuole comunicare lo stato dell'acquisizione dati, operativa dall'estate 2019, illustrandone le prime interpretazioni e presentare inoltre i progressi ottenuti nell'elaborazione di una dettagliata simulazione dell'esperimento.

Inquinamento Termico dalla climatizzazione estiva.

Mazzocchi A.

Melegnano, MI

La climatizzazione estiva degli edifici (CE) altera il modo naturale in cui massa ed energia del H_2O atmosferico si distribuiscono tra Atmosfera e Idrosfera. Estate 2016: CE, consumando 2066,67 TWh elettrici, estromise da Atmosfera 12,76 Gt Vapore Acqueo a temperatura ambiente avendone dissociato 8643,09 TWh Entalpia da 12,76 Gt Condensa a 21°C, così che, da CE, 8643,09 TWh Entalpia convertiti in 8643,09 TWh Calore Sensibile e uniti ad equivalente termico di 2066,67 TWh Lavoro, s'immettessero in Atmosfera e 12,76 Gt Condensa a 21°C confluissero in Idrosfera tramite le fognature.

Satellite observations and modelling of hydrogen cyanide in the Earth's atmosphere.

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Hydrogen cyanide (HCN) is one of the most abundant cyanides present in the global atmosphere, and is a tracer of biomass burning, especially for peatland wildfires. In this work we present observations of HCN during the 2015 Indonesian peatland fires from the IASI (Infrared Atmospheric Sounding Interferometer) satellite instrument. HCN variability has also been investigated using an adapted version of the three-dimensional (3-D) chemical transport model (CTM) TOMCAT. Here we compare model outputs with HCN profiles measured by the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) and FTIR ground-based instruments in the NDACC (Network for the Detection of Atmospheric Composition Change) network.

Dalla EE alla Necessità di Gravitazione Idrodinamica, e quel che ne consegue.

SCALERA G.
INGV - Istituto Nazionale di Geofisica e Vulcanologia - Roma

È necessario per la expanding Earth un meccanismo idrodinamico di gravitazione, che è già sotteso alla formulazione newtoniana del campo gravitazionale, la quale È solo una descrizione fenomenologica incompleta della realtà fisica. Il principio di moto inerziale e la costanza della massa dei corpi risultano essere solo buone approssimazioni. Relazioni e parametri che legano il mondo "idrodinamico" alla nostra descrizione newtoniana vengono esplicitate combinando Scienze della Terra e Astrofisica. Questa visione del mondo fisico non necessita né della relatività ristretta né della generale in quanto il fluido impalpabile preposto al meccanismo gravitativo ($\rho \approx 10^{-24}$kg/m^3) costituisce un sistema di riferimento medio.

Environmental magnetics properties of cave sediments at Gran Dolina in the archaeological site of Sierra de Atapuerca (Burgos, Spain).

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It is already accepted in the literature that some magnetic properties can furnish an environmental significance. In particular, rock magnetic analyses allowed us to determine changes in grain size, composition and concentration, all characteristics that are influenced by climatic conditions. In this study, we focused in one of the most important archaeo- and paleontological site of Lower to Middle Pleistocene in Europe: Sierra de Atapuerca. We added a magnetic proxy in the study for understanding the climatic - paleoenvironmental conditions

at the time the earliest hominins began to migrate into Europe, whose remains were found in Gran Dolina cave, the area of our analysis.

The Electric Field Detector (EFD-02) on board CSES-02 satellite.

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The China Seismo-Electromagnetic Satellite (CSES) mission, successfully operative since 2017, monitors the dynamics of the top-side ionospheric electromagnetic field, plasma and particle distribution, with the use of 9 dedicated instruments. The electric field detector EFD-02, scheduled to fly on board the CSES-02 satellite, will measure the electric field components over a wide-band (DC−3.7MHz) and with high sensitivity of about 1μ V/m in the ULF band. EFD-02 will measure the differences of potential between different pairs of probes installed at the tips of four booms deployed from the satellite after injection in the LEO orbit. Compared to the previous detectors on board missions CSES-01 and Demeter, EFD-02 has a better organized subdivision of acquired signals into 5 bands (ULF, ELF, VLF, VLFe, HF) and a higher sampling frequency, allowing to observe more thoroughly the variation of the electric field due to perturbations from solar, seismic and anthropic phenomena. The launch is scheduled by the end of 2022 with an expected lifetime of 6 years.

Stime probabilistiche della pericolosità vulcanica nell'ambito del Centro di Eccellenza Europeo per l'HPC nelle scienze della Terra Solida ChEESE.

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Per i vulcani attivi, la conoscenza della probabilità di eruzione e delle aree potenzialmente esposte ad hazard vulcanici diventa un'informazione preziosa per coloro che hanno la responsabilità di definire i piani di emergenza, sia nel breve che nel lungo periodo. La modellazione della complessità dei fenomeni vulcanici richiede una combinazione di modelli fisici e statistici, nonché l'uso di sistemi di calcolo ad alte prestazioni (HPC). Per questo motivo, abbiamo creato codici e flussi di lavoro altamente efficienti in grado di riprodurre i processi vulcanici e stimare il rischio associato al trasporto del tefra utilizzando dati di monitoraggio, statistici e meteorologici. Come applicazione, abbiamo generato mappe di pericolosità per Campi Flegrei, Italia e Jan Mayen, Norvegia.

Machine learning approach for mapping lava flows from space.

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Estimating the area and volume of erupted lava is both a crucial component of volcano monitoring and a powerful tool for investigating lava flow behavior. Here, we aim to develop a machine learning approach based on the Google Earth Engine platform to map lava flow solely using freely available and open source data from space-borne instruments. We propose a generalized approach, in which different images are used to train the model and new images to test it. This method was used during the 2021 Etna eruption for mapping lava flows in near-real-time as new images became available.

Thermal gradient and Covid-19 spread.

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The heavy spread of the COVID-19 pandemic worries humanity. We discuss how specific weather factors are responsible for COVID-19 transmission. We analyse the incidence of COVID-19 as a function of latitude and in particular on thermal gradients during the morning "up", and in the afternoon "down", and other factors that justify the spread of the pandemic around the world. The pandemic peaks are around - 25 (°) and 50 (°) which are disjoint from only temperature.

Modelling seismic attenuation across Italy and the Tyrrhenian basin.

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Seismic attenuation imaging marks areas of high scattering and absorption within the continental crust. In this study, we investigate the Italian peninsula and the Tyrrhenian Sea, which is the ideal region to explore the potential of attenuation imaging in a mixed continental-oceanic crust. In these structural settings, we show that the combined results of simulations based on radiative-transfer and wave equation model complex wave attenuation, crustal reverberations and energy leakage in the mantle. The discrimination of the average stochastic properties of the crust from crustal reverberations provides the forward model to image oceanic basins, submerged continental crust, and magmatism.

Simulations of gravitoelastic correlations for the Sardinian candidate site of the Einstein Telescope.

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Gravity fluctuations produced by ambient seismic fields are predicted to limit the sensitivity of the next generation, gravitational wave detector Einstein Telescope at frequencies below 20 Hz. The detector will be hosted in an underground infrastructure to reduce seismic disturbances and associated gravity fluctuations. Additional mitigation might be required by monitoring the seismic field and using the data to estimate the associated gravity fluctuations and to subtract the estimate from the detector data, a technique called coherent noise cancelation. In this paper, we present a calculation of correlations between surface displacement of a seismic field and the associated gravitational fluctuations using the spectral element SPECFEM3D Cartesian software. The model takes into account the local topography at a candidate site of the Einstein Telescope at Sardinia. This paper is a first demonstration of SPECFEM3D's capabilities to provide estimates of gravitoelastic correlations, which are required for an optimized deployment of seismometers for gravity noise cancelation.

Persistent scatterer (PS) interferometry for landslides monitoring and statistical analysis on time-series: application to Santo Stefano d'Aveto (Liguria, Italy).

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We used Persistent Scatterer (PS) Interferometry, a powerful tool for monitoring landslides, to investigate the S. Stefano d'Aveto landslide (Liguria, Italy) over the period 2015-2021. By processing Sentinel-1A images sampled every 12 days, for both Ascending and Descending orbits, our results reveal vertical motion of -6.4 to 4.4 mm/y and E-W displacement of -38 to -2.32 mm/y, with an increase in velocity since 2018. Three families of PS (similarity > 98%) were identified through a cross-correlation analysis that divide the landslide in three main sectors. Furthermore, the spectral analysis of the amplitude highlighted a peak equivalent to a periodicity of 330 days.

A magnetic approach for understanding the impact of Covid-19 lockdown on PM10 in Rome, Italy.

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An extensive survey of the magnetic properties of PM10 daily filters from selected air monitoring stations in Rome and Latium Region was conducted for outlining the impact of lockdown (13 march – 18 may, 2020) on atmospheric particulate matter, through the comparison with daily filters collected after the end of the strictest measures. Magnetic measurements highlighted persisting high concentration of magnetic minerals in the daily PM filters of busy roads from Rome during lockdown. Nevertheless, their concentration increased after the lockdown and, while the average PM concentration remained the same, the average magnetic susceptibility almost doubled. In rural background stations there was no difference between lockdown and post lockdown, for both magnetic susceptibility and PM concentration. Non-exhaust PM arising from brakes dominated the magnetic fraction: fuel exhausts or natural sources emerged in rural or lower traffic settlings. Magnetic measurements were successful at understanding the impact of lockdown measures on the abundance and composition of PM10 traffic related dusts, giving a valuable contribution to the complex debate about the effects of lockdown on PM10.

Revisione Formula Risonanze di Schumann.

Valli F.
ISPRA

La formula usata oggi (maggio 2021) sulle Risonanze di Schumann non descrive (ne tiene conto) delle frequenze osservate minori di 6 Hz. Una causa è dovuta alla piccola ampiezza dei segnali. Un'altra agli strumenti usati. Si propone un'analisi critica della fisica del fenomeno e la revisione della formula.

Retrieval of volcanic ash cloud properties using msg-seviri and machine learning techniques.

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Volcanic ash clouds are a major hazard to population centers and can cause widespread disruption to aviation operations. Here we propose an innovative machine learning (ML) algorithm to classify the images acquired by the sensor SEVIRI (onboard MSG geostazionary satellite) in different objects, identifying volcanic and weather clouds, and the underlying surfaces. The results obtained during the 2021 Etna eruption with the ML procedure were compared with the consolidated procedure based on an RGB channels combination in the visible (VIS) spectral range. The ash volcanic cloud is correctly identified by both the models and the results indicate a good agreement.

Dissipation of field-aligned currents in the high-latitude ionosphere.

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The interaction between plasma of solar origin and the Earth's magnetosphere-ionosphere (MI) system is at the base of a chain of phenomena that may be relevant for Space Weather. Among them, the MI coupling plays a fundamental role, as it allows energy and momentum to be exchanged and provides a mechanism able to modify the energy budget of the ionosphere. This coupling is mainly realized by means of field-aligned currents that connect the magnetosphere with the high-latitude ionosphere. Thus, understanding the dissipation of these currents in the ionosphere may help to clarify their contribution to the energetic budget and to shed light on some physical processes still unclear. Our study takes advantage of 6 years of *in situ* data at 1 Hz from the Swarm constellation to investigate the large-scale features of dissipation of field-aligned currents in the topside ionosphere at high latitudes.The North-South asymmetry in the dissipation of field-aligned currents is also investigated. *This work is supported by the Italian National Program for Antarctic Research under contract N. PNRA18 00289-SPIRiT.*

Spectroscopic characterization of the stability of differently aged natural snow.

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The extent, persistence and evolution of snow coverage are relevant to climatology, water runoff estimate and avalanche forecast. The morphology of snow grains, from fresh, to compact, to icy, sensitively depends on environment parameters such as Sun irradiation, temperature, humidity and it affects the physical properties of the snowpack. Snowpack stability is tested coupling tapping tests to observation of snow grain morphology along a vertical depth profile through the snowpack thickness. We analysed in the lab different kinds of snow between -5.5 °C and -0.5 °C, approaching the melting temperature. We observe consistent changes in the relative intensity of the OH-Stretching band (2800 – 3700 cm^{-1}) in snow samples with different specific surface area (SSA), depending on their morphology and average grain size. The modifications of Density Functional Theory simulated Raman

spectra of a model ice slab and its surfaces agree with experiments. We carried out a field campaign during a Winter season (Aosta Valley, Italy), recording in situ Raman spectra along depth profiles of a snowpack made of several accumulated seasonal snow layers. We observe qualitative differences in the features of the OH-Stretching band of spectra collected from compact and respectively low-density layers with different relative stability.

Contributo per un protocollo di misure del gas radon in camera chiusa.

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La Direttiva Europea 2013/59/EURATOM, recepita in Italia dal D.Lgs n. 101/2020, stabilisce le norme di sicurezza in ambito radioprotezionistico, tra cui il controllo della concentrazione di attività di gas radon indoor ed il contributo dell'esalazione dei materiali da costruzione. Al momento non è disponibile un unico protocollo di misura dell'esalazione del gas radon. A tal motivo, in questo contributo viene presentato un protocollo con i relativi risultati di misure di materiali da costruzione effettuate in camera chiusa. Il protocollo proposto è stato applicato in condizioni sperimentali indipendenti, in particolare in Italia ed in Ecuador. La qualità del confronto indica la bontà del protocollo seguito.

Proton energy spectra of energetic storm particle events and relation with shock parameters and turbulence.

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The proton energy spectra of 23 Energetic Storm Particle events, occurring either in association with (16 events) or in absence of (7 events) Solar Energetic Particles, are investigated by using data from particle instruments aboard STEREO A in the energy range from 84.1 keV to 100 MeV. For the SEP events at quasi-perpendicular shocks, the Weibull distribution provides good fits to the spectra, over the whole energy range for some events, and only at high energies for the others, being lower energies explained by the power law predicted by the DSA. Instead, the SEP spectra at quasi-parallel shocks are better reproduced by a double power law. In the cases non associated with SEPs, an Ellison-Ramaty form fits the observed spectra. Moreover, a significant correlation of the downstream turbulence level is found with the Weibull parameters for quasi-perpendicular shocks, and with the proton peak value in the intermediate energy range 4-6 MeV for all the 16 shocks. Our results suggest that the downstream turbulence is a relevant factor in particle acceleration and that stochastic acceleration can be a plausible mechanism for re-acceleration at interplanetary shocks.

Accuracy of hmF2 estimations using ionograms validated parameters, compared to ISR measurements at Millstone Hill.

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Several empirical formulations have been proposed over time, to estimate the fundamental ionospheric parameter hmF2 as a function of MUF(3000)F2, foF2, and foE. The first formulation proposed was due to Shimazaki (1955), it is particularly simple, and still finds application in different contexts, such as the studies on the ionospheric long-term trend. Among other more accurate formulations, the most used is the one obtained by Bilitza et al. (1979), included in the IRI model. These formulations are often fed with values provided by global models. In this work, a series of hmF2 values is obtained from the two relationships described above using input values manually scaled from ionograms recorded in the Millstone Hill ionospheric station, with the intention to evaluate their accuracy when updated with validated data, rather than modeled ones. This is done by comparing the values of hmF2 with those obtained simultaneously with independent measurements from the Incoherent Scatter Radar installed in the same location. The database considered consists of ∼9060 measurements, thus allowing the evaluation of the results as a function of different heliogeophysical conditions.

Caratterizzazione di nebulizzatori per bio-aerosol per applicazioni in camere di simulazione atmosferica.

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ChAMBRe (Chamber for Aerosol Modelling e Bio-aerosol Research) è una camera di simulazione atmosferica tramite cui sarà possibile studiare, in condizioni controllate, come condizioni e composizione atmosferica (tipologia e concentrazione di specie gassose e particolato atmosferico) influenzino la vitalità e la capacità di proliferazione/dispersione dei batteri. L'accuratezza delle procedure sperimentali deve essere spinta a livelli inusuali in ambito microbiologico. In questo quadro, verrà presentato lo studio delle prestazioni di tre generatori di bio-aerosol disponibili presso ChAMBRe (Collison, BLAM e SLAG, CH TECHNOLOGIES) in termini di efficienza e riproducibilità di aerosolizzazione dei batteri. La caratterizzazione è stata eseguita con due ceppi batterici modello, *E. coli* e *B. Subtilis* e include l'uso non convenzionale di uno spettrometro per bio-aerosol (WIBS-NEO) per seguire l'andamento temporale di concentrazione e distribuzione dimensionale del bio-aerosol all'interno della camera. I risultati della caratterizzazione saranno presentati con un focus sull'impostazione sperimentale e sull'analisi dei dati WIBS.

A digital holographic technique for studying mineral dust content in ice cores

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We present the results of the characterization of micrometric dust particles suspended in meltwater from Antarctic ice cores by a holographic method. Deriving information about particle shapes is critical to determine the intrinsic optical properties of dust, which are of great importance to increase the knowledge about aerosols and their contribution to radiative transfer through the atmosphere. To this end, our instrument includes a collimated laser beam, a microscope objective, and a digital camera, wereby we obtain several optical and geometrical parameters through a multiparametric single-particle approach. By numerically reconstructing the interference pattern of the scattered field with the trans-illuminating field, we retrieve the particle shape, projected on a plane orthogonal to the optical axis, in addition to the extinction cross-section. Here we present a quantitative analysis paying a special attention to the shape of the particles, which consistently exhibit a considerable non-sphericity, whereby we can differentiate particles of comparable size. The results are in accordance with Coulter Counter measurements, that represents the state-of-art of ice core dust sizing.

AI-based spectral windows phasor approach to retrieve solar-induced fluorescence spectra at top-of-canopy and at photosystem level.

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The Solar-induced fluorescence (SIF) is a crucial remote sensing indicator to monitor the vegetation health. The SIF retrieval algorithms exploit canopy reflectance (Rapp) in high-spectral resolution at the atmospheric O_2 bands to quantify canopy SIF (SIFtoc). Here, we propose a new phasor-based retrieval algorithm to consistently retrieve SIFtoc, SIF at photosystem level (SIFpho) and canopy biophysical variables (Leaf Area Index, Chlorophyll Content, absorbed Photosynthetic Active Radiation, SIF Quantum Yield). In particular, Rapp spectra are Discrete Fourier transformed on consecutive spectrally resolved complex planes, where a supervised Machine Learning algorithm, trained with atmosphere-canopy radiative transfer (RT) model, is employed to estimate the investigated variables. The results reached by our method on RT simulations (error $< 3\%$) and field spectroscopy measurements collected during a long-term campaign on natural vegetation prove that our approach paves the way to new important perspectives: the joint retrieval of canopy biophysical variables and SIFtoc permitted to fully derive SIFpho and Quantum Yield which are better indicators of vegetation activity.

Extreme value theory approach for rainfall daily data of Basilicata.

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Global warming influences many aspects of climate. It produces higher temperatures than expected, or it can give rise to extreme precipitation phenomena. All these events are classified as extreme events. In this work, we present the analysis of the daily rainfall of Basilicata. We investigated these data using the extreme events theory (EVT). In particular we use the Generalize Pareto Distribution (GPD) approach to analyze the dataset. We produced for 12 stations of Basilicata the diagnostic plot that characterizes the GPD approach. We see from the results that the model is in agreement with the data, and we also present the return level plot that allows us to do a forecasting of the rainfall. Finally, we did a spatial map of the return level from which we can see that the extreme rainfall are concentrated in the south-east side of the region, with a clear separation with respect to the north-west side. Moreover, the comparison between the empirical and theoretical maps highlights an anomalous behavior in the central part of the region, where the extreme precipitation recorded is significantly higher than that predicted by the model.

Stochastic 0-dimensional BFM model: Effect of temperature fluctuations on the dynamics of the biogeochemical properties in a marine ecosystem.

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We present a new stochastic model, based on a 0-dimensional version of the well known biogeochemical flux model (BFM), which allows to take into account the temperature random fluctuations present in natural systems and therefore to describe more realistically the dynamics of real marine ecosystems. The study presents a detailed analysis of the effects of randomly varying temperature on the lower trophic levels of the food web and ocean biogeochemical processes. More in detail, the temperature is described as a stochastic process driven by an additive self-correlated Gaussian noise. Varying both correlation time and intensity of the noise source, the predominance of different plankton populations is observed, with regimes shifted towards the coexistence or the exclusion of some populations. Finally a Fourier analysis carried out on the time series of the plankton populations shows how the ecosystem responses to the seasonal driving for different values of the noise intensity.

Optical Properties of Airborne dust in Antarctica

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OPTAIR is a multidisciplinary project to study the optical properties of airborne particles at Concordia Station, on the East Antarctic plateau, to assess the relationship among the optical properties of particles suspended in air and deposited by the snow. Data are put in correlation with LIDAR measurements, with the aim to assess the impact on past and present climate. A permanent instrument has been installed in November 2018, producing data to feed the models describing radiation transfer through the Earth's atmosphere, an open issue for what concerns the effects of dust. Preliminary data from the Antarctic season 2019 will be presented, with clear evidence of non-spherical shapes and remarkable changes in size and optical properties across the year. Some events, mainly observed during the Antarctic night, show peculiar optical properties of dust and remarkable abundances, thus showing the need of high time resolution to assess the effective impact of dust on radiative transfer.

Long-term solar wind reconstruction via geomagnetic indices and Ca II K index.

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Long-term solar wind time series constitute an important tool for assessing how it varies on decennial time-scales as well as to evaluate its effects on the Earth magnetosphere. Although direct measurements of solar wind parameters are available only starting from 1964, this lack of data can be overcome by using longer dataset as solar wind proxies. In this work, after a calibration process, we used both Ap-index and Ca II K index measurements to reconstruct solar wind near-Earth properties. This reconstruction allows to analyze long-term solar wind variations up to the beginning of 1900, hence covering more than one century.

Inquinamento Luminoso e promozione del territorio: il cielo della Valle Grana.

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La regione piemonte nel 2018 si èdotata di una legge per l'abbattimento dell'inquinamento luminoso tra le migliori in italia. La mancata applicazione prevede ovviamente ammende eppure nel 2019 si sono riscontrate varie tentate violazioni. Anche nella Valle Grana in provincia di Cuneo, dove si può ancora godere di un cielo quasi del tutto incontaminato (Inquinamento Luminoso: Scala Bortle 2). Da un confronto con le associazioni di appassionati e la cittadinanza si è scelto la strada di coinvolgere la popolazione nella promozione della Valle e la valorizzazione del cielo anziché perseguire la via sanzionatoria, con la realizzazione di un case-study per l'International Council on Monuments and Sites (ICOMOS).

Past and future scenarios of conservation conditions of paper collections in three historic libraries in Italy.

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The conservation of paper collections in historic libraries depends on the environmental stress over time. In fact, chemical deterioration is among the major threats of paper collections deterioration as cellulose hydrolysis is greatly dependent on air temperature. The indoor climate within historic buildings without air conditioning systems is the result of the interaction between the building envelope and the outdoor climate. The indoor/outdoor climate measurements collected in three historic libraries located in Milan, Udine and Rome (Italy) were used to assess the buffering effect of their building envelopes. In addition, the climate-induced chemical risk for paper collections was studied through a dose-response function based on cellulose hydrolysis. The indoor climate conditions in the historic libraries in recent past, near and far future were simulated using the ERA5-Land dataset provided by Copernicus Climate Change Service. Hence, the damage risk for paper collections associated to the indoor climate scenarios was compared to the one induced by the current indoor conditions, allowing to investigate the effects of the possible future climate change on library conservation.

On Markovian features of magnetic field fluctuations in the inner heliosphere.

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In the framework of statistical time series analysis of complex dynamics we present a multi-scale characterization of solar wind turbulence by using Parker Solar-Probe (PSP) magnetic field observations. The data analysis, based on the Markov-process theory, is meant to estimate the Kramers-Moyal coefficients associated with the measured magnetic field fluctuations. In fact, when the scale-to-scale dynamics can be successfully described as a Markov process, first- and second-order Kramers-Moyal coefficients provide a complete description of the dynamics as a Langevin stochastic process. The analysis is carried out on magnetic field observations gathered by PSP in one of its encounters with the Sun. By computing

the conditional probability density functions of the magnetic field fluctuations, we tested the Markovian hypothesis verifying the validity of the Chapman-Kolmogorov equation in the inertial range and the kinetic one. An attempt to interpret the turbulent magnetic-field fluctuations in terms of Langevin processes with drift and diffusion terms defined by the first- and second-order Kramers-Moyal coefficients is discussed.

Stress inversion in gelatin: A mechanical-statistical approach to eruptive vent location forecasts tested on analog models.

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The uncertain location of future eruptive vents makes assessing volcanic hazard in regions of distributed volcanism challenging. This can be due to scarce and spatially sparse past vents, which undermines the ability of data-driven approaches in forecasting future vent locations. Here we employ analog models to test a statistical-mechanical strategy for the forecast of such locations. We stress a gelatin block laterally and with surface excavations, and observe air-filled crack trajectories. Then, we compare their surface arrivals to the ones predicted by deterministic simulations, and we use a Monte Carlo approach to sample the distributions of parameters describing the state of stress of the gelatin block. Although the method does not constrain individual stress parameters well, it effectively retrieves their ratio even with limited numbers of data. This leads to successful forecasts for the arrival points of subsequent cracks.

Machine learning analysis of a local seismic network in Mt. Amiata (Italy).

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Since March 2016 a small network of 11 seismic stations, deployed by Istituto Nazionale di Geofisica e Vulcanologia recorded about 1000 earthquakes in the southern part of Mt. Amiata. The continuous seismic waveforms are reprocessed with phase recognition pickers based on machine learning (ML) algorithms trained with global datasets of local earthquakes to get a more comprehensive earthquake catalog. This new catalog is compared with the already available events picked and located manually to assess the performance of ML based analysis. The manually detected earthquakes are then used to assemble a dataset suitable for ML analysis. In a later stage, we investigate how the automatic detection performance could be enhanced further with specific training of the ML pickers with data coming from INGV network (INSTANCE dataset) and from the local network itself.

Ionospheric Turbulence: A Challenge for GPS Loss of Lock Understanding.

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Our society is becoming increasingly dependent on Global Navigation Satellite Systems (GNSS), such as the global positioning system (GPS), GLONASS and GALILEO. These systems provide an efficient response to the needs of positioning on our planet and are also used by many infrastructures and applications for timing and synchronization. One of the natural factors that most contribute to the malfunction of these systems, leading to a degradation of their performance, accuracy and reliability, is represented by the ionospheric irregularities, i.e., plasma density variations that may affect the electromagnetic signals propagating through them. We use electron density data recorded on board the ESA's Swarm constellation to assess the possible dependence of the loss of lock of GPS signals on a specific typology of ionospheric irregularities and, thereby, the origin of one of the large space weather effects on the GNSS systems and users. We show that ionospheric irregularities characterized by a turbulent nature and extremely high-density fluctuations can lead to malfunctions of GNSS, thus paving the way for new prediction approaches of their adverse effects.

Studio di particelle di soot in ChAMBRe, la camera di simulazione atmosferica.

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Gli aerosol carboniosi, tra cui la componente *soot*, hanno impatti importanti, e non del tutto compresi, sia sul clima che sulla salute: esperimenti in condizioni controllate ma realistiche sono necessari per approfondire singoli processi. Il primo passo è la produzione controllata di *soot*, ottenuta collegando un Mini-Inverted Soot Generator (MISG) alla camera di simulazione atmosferica ChAMBRe. In una serie di misure il MISG è stato alimentato alternativamente con etilene o propano, variando il rapporto combustibile-ossigeno. Gli aerosol generati con il MISG sono stati caratterizzati in tempo reale in termini di distribuzione dimensionale, composti gassosi associati, proprietà ottiche. Il particolato prodotto è stato anche raccolto su filtri e successivamente sottoposto ad analisi ottica e termo-ottica. L'analisi ottica consente la determinazione non distruttiva del coefficiente di assorbimento a diverse lunghezze d'onda, l'analisi termo-ottica fornisce le concentrazioni di carbonio totale e delle frazioni elementare ed organico. Alla conferenza saranno presentati i risultati e il loro impatto nelle successive fasi sperimentali.

Trattamento dei segnali degli strainmeter ad alta precisione installati in pozzi profondi all'Etna per finalità di sorveglianza vulcanica in real time e di early warning.

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Lo studio dei processi deformativi del terrenoè importante per la caratterizzazione delle sorgenti di deformazione e per il monitoraggio vulcanico. A questo scopo, i dilatometri in pozzo profondi rappresentano un valido strumento per acquisire misure di deformazione volumetrica dell'edificio vulcanico con elevata precisione. I segnali di strain sono di solito affetti da disturbi dovuti alla pressione atmosferica e alle maree terrestri. Per evidenziare le variazioni di strain dovute all'attività vulcanica, occorre stimare e filtrare queste componenti perturbative del segnale misurato. In questo lavoro descriviamo l'implementazione di tecniche di filtraggio del segnale di strain acquisito dalla stazione di Monte Ruvolo della rete dilatometrica dell'INGV installata sull'Etna. Lo scopo innovativo dello studio è stato quello di implementare il segnale di strain, registrato e filtrato, in un contesto di monitoraggio in *near real-time* per finalità di sorveglianza, che si svolge presso la di Sala Operativa dell'INGV, e per applicazioni di *early-warning*.

Caratterizzazione di dosimetri a termoluminescenza per dosimetria ambientale ad alta quota nell'ambito del progetto SAMADHA.

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La componente dovuta ai raggi cosmici secondari in atmosfera è una sorgente di radiazioni che contribuisce all'esposizione terrestre. La posizione geografica, la quota, la latitudine, l'attività solare e la variabilità del campo geomagnetico influenzano il contributo alla dose ambientale. Il progetto INFN SAMADHA (*South Atlantic Magnetic Anomaly Dosimetry at High Altitude*) ha l'obiettivo di monitorare la regione sottostante la *South Atlantic Anomaly*, che si estende su parte dell'Oceano Atlantico e del Sud America, dove il campo magnetico ha i valori più bassi del pianeta. Il gruppo di radioattività ambientale del Dipartimento di Fisica e Sezione INFN di Napoli ha il compito di testare e preparare i dosimetri a termoluminescenza (TLD) da esporre presso i laboratori di alta quota dei Monti Famatina in Argentina e di Chacaltava in Bolivia. 40 TLD-600 e 40 TLD-700 sono stati caratterizzati in energia e in dose. Combinando le risposte dei due tipi di TLD è possibile rivelare i neutroni termici che, alle quote di interesse per l'uomo, incidono sul rischio radiologico a causa dell'elevato "fattore di peso della radiazione, Q". Verranno presentati i risultati preliminari ottenuti.

Sezione V
Biofisica e fisica medica

Comunicazioni

Precise control of optical and electrical parameters in 3D modulation of $GABA_A$ receptors in cerebellar granule cells in culture.

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The caged molecule RuBi-GABA allows investigating neuronal transmission in precise cell regions. GABA, covalently bound to the cage RuBi, cannot interact with its receptors on the plasma membrane. After linear and non-linear photoactivation, GABA is released with high control in time and space. Using this approach, coupling it with the patch-clamp technique, we evaluated GABAA receptors' modulation. We analyzed the biological response affected by crucial physical parameters as photoactivation laser power, exposure time, and the uncaging point distance on the X, Y, Z axes. Our goal was to understand how these parameters conditioned biological behavior and, possibly, minimize their effects.

Nanophysics evolution for new medical applications.

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University of Oslo
Nanophysics brings together multiple fields of physics and science to determine the structural, electronic, optical, and thermal behavior of nanomaterials in the range of 1–100 nm dimensions, electrical and thermal conductivity, the forces between nanoscale objects, and the transition between classical and quantum behavior. The nanophysics is halfway between the size scales of quantum mechanics and macroscopic physics governed by the laws of Newton and Einstein. The correct definition of nanophysics is the physics of structures and artefacts with dimensions in the nanometer range or of phenomena occurring in nanoseconds. Modern physical methods whose fundamentals are developed in physics laboratories have become critically important in nanoscience for medical applications and diagnostics, such as in oncology.

Saccharide amorphous matrices: Effects of protein/sugar ratio on water.

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Saccharides protect biostructures against adverse conditions mainly by preventing large-scale motions leading to unfolding. The efficiency of this mechanism strongly depends on hydration and sugar/protein ratio and it is higher in trehalose than in other sugars. We report an Infrared Spectroscopy study on dry amorphous matrices of the disaccharides trehalose, maltose, sucrose and lactose, and the trisaccharide raffinose, with and without Myoglobin, at different sugar/protein ratios. To inspect matrix properties we analyse the Water Association Band, and carefully decompose it into sub-bands, since their relative population has been shown to effectively probe water structure and dynamics in different matrices. The analysis is extended to investigate the structure of protein-sugar-water samples: several classes of water molecules can be identified in the protein and sugar environment and their relative population is dependent on the type of sugar and on the sugar/protein ratio. This gives relevant information on how the molecular interplay between residual waters, sugar and protein molecules affect the biopreserving properties of saccharides matrices.

A study on early-fixed x-ray exposed neuroblastoma cells by means of FT-IR microspectroscopy.

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FT-IR microspectroscopy has been usefully applied in the analysis of the complex biological processes occurring during X-rays radiation-cell interaction. Generally, these works are focused on the study of the changes occurring in cells when they are fixed immediately after the irradiation or 24 and 48 hours later. In the present paper, changes taking place in the first hours after the irradiation are examined for obtaining information on the processes related to this time frame. X-ray irradiation of SH-SY5Y cells was performed at room temperature, after X-ray exposure, some cell samples were immediately fixed and others were allowed to recover for some hours and then fixed. In the spectra of unexposed SH-SY5Y neuroblastoma cells, several bands related to the contributions of the cell constituents are present. Spectra obtained for differently treated samples show changes in bands positions and intensity that are indicative of modifications in DNA conformation and in protein secondary structure. The present results support that FT-IR is a powerful tool for detecting and studying X-ray-induced effects in human cells.

Caratterizzazione con raggi x di un sensore in diamante con struttura 3D.

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Gli sviluppi della radioterapia hanno introdotto nuove sfide per i dosimetri che caratterizzano i fasci terapeutici, quali rapidità della risposta e ottima risoluzione spaziale. Il diamante presenta qualità promettenti per tali applicazioni trattandosi di un materiale tessuto equivalente, resistente al danno da radiazione e con basse correnti di buio che consentono di avere un buon rapporto segnale/rumore. In questo lavoro si studia un dispositivo costruito su un substrato in diamante sintetico policristallino, su questo si realizzano percorsi conduttivi sia all'interno del volume sensibile che sulla superficie per ottenere elettrodi trasformando il diamante in grafite usando fasci laser impulsati. Anche le connessioni verso il sistema di acquisizione si realizzano direttamente su aree grafitizzate, ottenendo così un dispositivo "all-carbon" ed evitando l'introduzione di materiale ad alto Z. Tali miglioramenti portano a minori tensioni di polarizzazione, minori tempi di risposta e migliore risoluzione spaziale. Il sensore, esposto ad un fascio di raggi X, ha dimostrato buona velocità di risposta, ottima linearità e indipendenza della risposta dal rateo di dose.

Modification of zebrafish samples by physical stresses.

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By electromagnetic stresses, zebrafish (Danio rerio) embryos were subjected to static, low frequency magnetic and radio frequencies fields. Embryos were exposed to static, very low frequency, low frequency, very high frequency and ultra-high frequency field irradiations. The field intensities were 40 mT, 40 mT, 470 μT, 240 nT and 240 nT, respectively. Untreated embryos were used as control and their survival was 60%. Survival of zebrafish larvae at 5 days after exposure to magnetic fields and radiofrequencies reached up to 80%. Our results show that the exposure to the different irradiations induces significant alterations of body pigmentation.

Modelling electrostatic interactions and solvation in chromatin: From the single nucleosome towards the chromatin fibre.

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Chromatin is a protein-DNA found in the nuclei of eukaryotic cells. It reinforces the DNA and its topology tunes gene expression. We study chromatin compaction from an electrostatic perspective. We examine the effect of the histone tails and propose a methodology to connect electrostatics to structural and functional features of protein-DNA systems. We investigate the electrostatic origins of effects such as DNA unwrapping, and histone tail truncation. We present a comprehensive study of electrostatic interactions between nucleosome pairs, providing a cohesive description of nucleosome electrostatics in the chromatin fibre, combining information on the energetics of different positions of nucleosomes.

A combined MD and DFT study on mercaptobenzamides inhibitors for HIV NCp7 protein.

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The action of the mercaptobenzamides (MB) class of molecules on the HIV nucleocapsid protein (NCp7), a zinc finger protein, is an issue of relatively recent research interest, with the aim to develop a new class of effective and well-tolerated HIV antivirals, able to overcome virus mutations. MB molecules are easily and cheaply synthesized, and show the ability to unfold the HIV zinc finger region, thus impeding effective viral replication. This effect is not fully understood, and moreover is highly modulated by the precise composition of MB aromatic ring and chain, a fact yet to be elucidated. We also sampled the different equilibrium configuration of the NCp7 protein in the biological environment, in order to highlight what specific structure is involved in the MB potential antiviral effect. Our approach to the problem is to adopt a combination of classical Molecular Dynamics (MD) and quantum *ab initio* DFT techniques. Our results allowed us to analyse with atomistic resolution the action mechanism of MB molecules on NCp7, with respect to the role played by each MB functional group and NCp7 equilibrium structure.

Inhibition of protein-protein interactions in cysteine biosynthetic pathway: A SPR and fluorescence spectroscopy study.

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Cyteine biosynthetic pathway is a promising target for the development of new antibacterials. The interaction between serine acetyltransferase (SAT) and O-acetylserine sulfhydrilase (OASS-A), the two enzymes forming the Cysteine Synthase (CS) complex, regulates cysteine homeostasis. Since complex formation implies the insertion of SAT C-terminal sequence into OASS-A active site, we tested whether a recently developed inhibitor of OASS-A exhibited any effect on CS stability. Through surface plasmon resonance and fluorescence spectroscopy we demonstrated that this is indeed the case. The inhibitor destabilizes CS from both *Salmonella Typhimurium* and *Escherichia coli*, indicating a potential broad-spectrum activity of this candidate antimicrobial compound.

Effetti dell'acetone e del DMSO sulla risposta dosimetrica di gel di Fricke: Verso nuove matrici idrogeliche.

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In questo contributo vengono presentati i risultati di varie misure su dosimetri a gel di Fricke realizzati con matrici sintetiche di alcool-polivinilico e GTA al variare della concentrazione di acetone e DMSO. Questi due solventi organici posso essere utilizzati per disperdere additivi organici in matrice. Misure di rilassometria-NMR, AFM, assorbanza-ottica, swelling, water-loss e di elasticità sono state condotte al fine di evidenziare come questi solventi posso influenzare le proprietà meccano-elastiche. I campioni sono stati anche irradiati tramite una sorgente di cesio-137 per sondare possibili influenze sulla risposta dosimetrica. È stato possibile trovare la migliore quantità di solvente da utilizzare senza alterarne significativamente la risposta dosimetrica.

A preliminary study on the prototype of PRAGUE detector, a device designed to acquire the Percentage Depth-Dose distribution of proton beams.

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The PRAGUE (Proton RAnGe measure Using silicon carbidE) project regards the realization of a detector made up of 60 new generation silicon carbide (SiC) devices (sensitive area of 15×5 mm^2 and active thickness of 10 μm) placed in a stack configuration. SiC devices, thanks to their high radiation hardness, their linear response with the energy and their independence from the dose rate of the incident radiation, are suitable for the characterization of hadron beams, even at high intensity. PRAGUE is designed to measure, in real time and with a high longitudinal spatial resolution (up to 30 μm in water), the Percentage Depth-Dose (PDD) distribution curves of 30–150 MeV proton beam. Starting from PDD, it will be possible to determine with very high precision, the range of the beam and the energy spectrum of the incident proton beam through an unfolding procedure. A prototype made of three detectors has been realized and characterized. The electronic chain used for the readout of the detector is based on the use of the chip TERA08 and it is designed to be able to answer correctly with both pulsed and continuous particle beams.

A bit stickier, a bit slower, a lot stiffer: Specific vs. nonspecific binding of Gal4 to DNA.

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Transcription factors regulate gene activity by binding specific regions of DNA thanks to a subtle interplay of specific and nonspecific interactions. We exploit Reflective Phantom Interface (RPI), a label-free biosensor based on optical reflectivity, to investigate the binding of the gene regulator Gal4 to double-stranded DNA fragments containing or not its consensus sequence. The combined analysis of RPI curves for specific and nonspecific binding provides interaction strength and kinetics and their dependence on temperature and ionic strength. We find that the free energy gap between specific and nonspecific binding of Gal4 is of the order of 1 kcal/mol only, and that binding to the cognate site is markedly slower. By performing all-atom molecular dynamics simulations of Gal4-DNA interactions, we find that the small energy gap emerges from a strong enthalpy-entropy compensation. Indeed, the binding of Gal4 to its specific sequence entails bending of DNA and a striking conformational freezing of the protein, which could be instrumental in the biological function of Gal4.

Unusually fast bis-histidyl coordination in a plant hemoglobin.

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The recently identified non-symbiotic hemoglobin gene MtGlb1-2 of the legume *Medicago truncatula* possesses unique properties as it generates four alternative splice forms encoding proteins with one or two heme domains. We investigated the ligand binding kinetics of MtGlb1-2.1 and MtGlb1-2.4, bearing one and two hemes, respectively. Unexpectedly, the overall time-course of ligand rebinding followed by ns laser flash photolysis and a hybrid fs-ps pump-probe setup was unusually fast. Most photodissociated ligands are rebound geminately within a few nanoseconds, but the very peculiar kinetic feature is that the rate constants for ligation and deligation of distal histidine to the heme are the highest reported for any plant or vertebrate globin. The combination of microscopic rates results in unusually high overall ligand binding rate constants, a fact that contributes to explain at the mechanistic level the extremely high reactivity of these proteins toward the physiological ligands oxygen, nitric oxide and nitrite.

Probing the role of the CD loop-D-helix unit in murine neuroglobin.

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We have produced a variant of neuroglobin (Ngb CDless), where the CDloop- and the D-helix were excised, directly joining the C and E helices. The CDless variant retained bis-His hexacoordination and we investigated the role of the CDloop-D-helix unit in controlling CO binding and structural dynamics by an integrative approach based on X-ray crystallography, laser flash photolysis, resonance Raman, and molecular dynamics simulations. Rapid mixing and laser-flash photolysis showed that ligand affinity was unchanged with respect to the wild-type protein, albeit with increased on and off constants for heme iron hexacoordination by the distal His64. Accordingly, resonance Raman spectroscopy highlighted a more open distal pocket in the CO complex, that, in agreement with MD simulations, likely involves His64 swinging inwards and outwards of the distal heme pocket. Ngb CDless displays a more rigid overall structure with respect to the wild type abolishing the structural dynamics of the CDloop-D-helix hypothesized to mediate its signaling role, and retains ligand binding control by distal His64.

Direct detection of 5 MeV protons by flexible thin-film devices based on organic semiconductors.

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The direct detection of 5 MeV protons by flexible organic thin film devices is here reported for the first time. Mechanical flexibility, portability, low cost of fabrication and human tissue equivalence are important properties which make this technology an excellent candidate for the development of wearable proton dosimeters to be employed in several areas such as in the medical field (*i.e.*, during proton therapy treatments). Moreover, exploiting the coupling between the organic semiconductor and the plastic substrate, this class of detectors offers the unique possibility to operate them both in real-time mode and in integration mode. In fact, while the energy absorbed from the proton beam by the organic semiconductor is registered by an instantaneous increase of current, the energy released in the plastic substrate generates an accumulation of trapped charges which induces an increase of the device conductivity proportionally to the total dose absorbed by the system. This allows to measure simultaneously and independently the instantaneous and the cumulative dose absorbed by the device recording two different information regarding the irradiation condition of the sensing system.

Nucleoplasmic reticulum role investigated by super-resolution microscopy.

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Genome expression and chromatin organization maintenance are fundamental to ensure the healthy state of cells. Modification in chromatin architecture and thus in gene expression can lead to different pathologies including cancer. In the context of chromatin organization, an important role is carried out by the Nucleoplasmic Reticulum (NR). This is an extension of the endoplasmic reticulum within the cell nucleus and it consists of a dynamic network of nuclear envelope invaginations. NR role is still unclear, but it is known that it is involved in different cellular processes such as DNA replication, transcription, and repair by interacting and anchoring chromatin itself. In our work, we aim to exploit super-resolution microscopy techniques to investigate the nanoscale spatial organization of NR and chromatin structure first in fixed, then in live cells. The final aim is to characterize the functional role of NR in regulating and organizing fundamental cell processes.

Radiofotoluminescenza visibile di centri di colore in cristalli di fluoruro di litio irraggiati con una sorgente di riferimento ^{60}Co nell'intervallo di dose (1–20) Gy

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È stata studiata la risposta spettrale in radiofotoluminescenza visibile dei centri di colore F_2 ed F_3^+ in cristalli di fluoruro di litio nominalmente puri, formatisi per irraggiamento con radiazione gamma del ^{60}Co nell'intervallo di dose (1–20) Gy. Sotto opportuno pompaggio laser a 445 nm, la fotoluminescenza dei centri F_3^+ ha subito una drastica diminuzione nei primi secondi, mentre quella dei centri F_2 è rimasta costante nel tempo. Il segnale di fotoluminescenza dei centri F_2, integrato in un intervallo spettrale di ampiezza 50 nm attorno al picco di emissione a 670 nm, ha mostrato un comportamento lineare in funzione della dose assorbita, con un buon rapporto segnale-rumore. I risultati confermano quelli di nostre precedenti indagini con altre radiazioni ionizzanti, dimostrando la potenziale applicazione di tali cristalli come dosimetri passivi a lettura ottica per radioterapia.

An automated tool to estimate chromatin compaction in stained nuclei.

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Chromatin arrangement undergoes various structural changes during the entire cell life. The spatial arrangement of the chromatin within the nucleus is not random, indeed is related to the silencing/activation of chromosomal territories. How the chromatin architecture varies during cellular processes is still partially unknown. Here an automatic tool to quantify chromatin compaction from 3D fluorescence microscope images is presented. In order to separate the nucleus of interest both from the background and from the other nuclei that may be present in the field of view, a neural network can be trained. Different morphological measures and statistical analysis on fluorescent intensities are computed on the region of interest. Furthermore the nucleus can be clustered thus identifying different compactness regions. By providing a parameter-free and automatic numerical quantification of chromatin compaction, this workflow opens the way for biologists to study how chromatin structures form and the behaviour in various cellular processes, from physiological to pathological ones.

Including volume effects in biological treatment plan optimization for carbon ion therapy

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We describe a way to include biologically based objectives in inverse planning optimization for carbon ion therapy, beyond voxel-dose–based criteria already implemented in TRiP98, the GSI research planning software. The aim is to account for volume effects —tissue architecture dependent response to damage— using the concept of Generalized Equivalent Uniform Dose (gEUD). gEUD is a power law including the volume effect (VE) parameter a to convert an heterogeneous dose distribution into a uniform dose associated with a same biological effect. The gEUD-based optimization allows to control the whole DVH shape of OAR with a single objective by adjusting the prescribed gEUD_0 and a, reducing the volume receiving dose levels close to the mean dose when $a = 1$, while close to the maximum dose for $a \gg 1$. This can lead to a reduction in NTCP for a tissue with large VE, like the parotid. We studied the role of gEUD_0 and a with different algorithms; we compared dose-/gEUD-based optimization in the chordoma case, obtaining the same target coverage, similar DVHs for OARs with small VE and at the same time decreasing the mean dose received by the closest parotid, thus reducing its NTCP by a factor 2.3.

NMR characterization of lanthanide-based MRI contrast agents.

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The NMR relaxation efficiency, or relaxivity, reflects the ability of a substance to change locally the relaxation times of tissues, varying therefore the contrast in Magnetic Resonance Imaging (MRI) acquisitions. The Nuclear Magnetic Resonance Dispersion (NMRD) profiles express the longitudinal and transverse relaxivities as a function of the resonance frequency. NMRD profiles of different lanthanide complexes (composed by a macrocyclic ligand and a lanthanide paramagnetic center) of interest for possible implementation as MRI contrast agents (CA) at high fields, were acquired up to 16 T (700 MHz) and analyzed on the basis of the Solomon-Bloembergen-Morgan theory (SBM).

^{52g}Mn production routes for multi-modal imaging applications.

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The radionuclide ^{52g}Mn is of significant medical interest for the innovative PET-MRI multi-modal imaging technique. In this study we compare its standard cyclotron production route $^{nat}\mathrm{Cr}(p,x)^{52g}\mathrm{Mn}$ with the alternative reaction $^{nat}\mathrm{V}(\alpha,x)^{52g}\mathrm{Mn}$. The theoretical calculations are performed by a suitable tuning of the nuclear level density parameters of the TALYS reaction code, with the aim to obtain a good agreement with the experimental cross sections. The production route with ^{nat}V results in a more favorable radionuclidic purity than with ^{nat}Cr. Dosimetric studies are performed to establish the time frame in which ^{52g}Mn can be used with an acceptable dose to the patient.

A feasibility study of deep seated tumor treatments combining flash effect and very high energy electron beams.

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Although in recent decades, technological advances have improved the efficacy of Radiation Therapy (RT) cancer treatment, the RT is still limited by normal tissue complications. In this respect, the specific interactions of charged particles with matter can help in sparing the healthy tissues. Very High Energy Electron (VHEE) beams have been explored in the past as they have enough energy to reach deep seated tumours. However, the availability of VHEE and other charged particles in the clinic has been hampered by the size, complexity, and ultimately high cost of the beam production system. recently, C- and X-band linacs demonstrated the capability of reaching the required gradients and thus triggered a novel interest in VHEE treatment feasibility. We have developed a VHEE Treatment Planning System combining an accurate Monte Carlo simulation with a simple modelling of the FLASH effect. The results obtained in few selected cases, demonstrate that FLASH therapy with VHEE beams of 70–130 MeV is competitive with standard RT and could allow a better sparing of the healthy tissues. The impact on deep-seated tumors will be discussed also in view of the results obtained with proton beams.

DSC unveils new aspects of extracellular vesicles mixing with model membranes.

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Extracellular Vesicles (EVs) are the main intercellular communication system. They are widely studied as vectors for therapeutic or diagnostic applications, and have a crucial role in cancer and neurodegenerative pathologies diffusion. Previous AFM and SANS analyses revealed a strong interaction of Umbilical Cord Mesenchymal Stem Cells EVs with the phase borders of model membrane protruding domains. To deepen EVs to cell internalization mechanisms, we performed DSC measurements on EVs mixed with model membranes of variable complex composition. DSC thermograms from unilamellar phospholipid vesicles show two transition peaks, interpreted as separate contributions from the two leaflets of the membrane bilayer. EVs effect is stronger on the lipids residing in the inner leaflet of the target membrane, having a higher packing parameter with respect to the outer layer lipids. The corresponding peak melting temperature and associated enthalpy are increased, indicating that EVs components impose to target phospholipids a lower mobility. Our results contribute to the description of EVs mixing mechanisms, having implications on the EVs interaction routes modulation in a therapeutic view.

New methods for an optimal theranostic radioisotope production at the Bern medical cyclotron.

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Radioisotopes for theranostics are essential for nuclear medicine developments. Their production using solid target stations is challenging and new instruments and methods are needed. A research program is ongoing at the 18 MeV Bern medical cyclotron, equipped with a solid target station (STS) and a 6 m long Beam Transfer Line (BTL) which brings the beam into a separate bunker. New methods to assess the beam energy and the production cross sections were conceived together with a novel specific coin to bombard compressed 6 mm diameter powder pellets. The STS is equipped with a pneumatic transfer system to deliver the irradiated target. The EoB-activity is assessed with a CdZnTe (CZT) detector. To minimize the dose to the personnel, a mechanical transfer system was developed to load the target station. To optimize the irradiation procedure, an ultra-compact active irradiation system based on a novel magnetic lens and two-dimensional beam detectors was recently installed in the cyclotron. Results on Er-165, Tb-155, Ga-68, Cu-61, Cu-64, Sc-43, Sc-44 and Sc-47 production are presented, with particular emphasis on the results obtained with the new irradiation system.

Investigating nanoscale chromatin alterations involved in neuroblastoma transformation by optical nanoscopy.

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Chromatin organization is a well-orchestrated mechanism involved in cellular physiology and the onset of many diseases. Neuroblastoma (NB) is the most common extracranial solid tumor in childhood and is characterized by remarkable heterogeneity. Despite several advancements that have been done, the molecular mechanisms involved in NB are still partially unknown. The aim of the project is to characterize changes in chromatin nanoscale architecture correlated with NB transformation. We employed NB cells genetically engineered to overexpress the non-coding RNA NDM29 which promotes differentiation of tumor cells. Previous studies have shown that NDM29 can restore the expression of DNA damage repair genes whose expression is reduced in NB cells. Thus, we will investigate chromatin architecture in the whole nucleus and in chromosome territories and specific genes as a function of NB malignant transformation by using Stimulation Emission Depletion (STED) Microscopy. The goal of this project is to unveil whether NB-associated chromatin alteration locates in correspondence of specific territories or genes and paving the way towards new prognostic and therapeutic approaches.

Alterations of chromatin organization investigated by confocal microscopy.
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Oncogenes can induce DNA damage by interfering with fundamental processes such as DNA transcription and replication. Here we use the U937-PR9 cell line, an *in vitro* model of Acute Promyelocytic Leukemia (APL), which allows us to selectively activate the expression of the PML-RARα oncogene and to analyze its effects on the spatiotemporal organization of functional nuclear processes. We perform high-resolution confocal microscopy on dual-color images and we take advantage of Image Cross-Correlation Spectroscopy (ICCS) to quantify alterations in the spatial organization of replication and transcription sites. In addition, Proximity Ligation Assay (PLA) is carried out to monitor alterations in proximity at a sub-diffraction spatial scale < 40 nm. Our approach is complementary to the currently growing amount of data collected by high-throughput techniques.

Study of the linearity in spinal cord fMRI signal.
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fMRI techniques are widely exploited for the study of brain activation, however, their application on spinal cord is still an object of study as the features of the functional contrast are

still partially unknown. In this framework, we focused on characterizing the human spinal cord fMRI signal in response to a graded motor task. This study is aimed at assessing the relationship between the hemodynamic response and the intensity of the inducing task, in a broad range of isometric force levels. 80 human spinal cord fMRI have been acquired during a controlled motor task with a neurovascular coil array, on a 3T scanner (Achieva Philips Medical Systems). We found congruent task-related fMRI responses, with positive signal changes mostly detected at C4-C7 vertebral levels. The functional response amplitude was roughly a linear function of the applied force, but divergences from linearity were observed. This parametric dependence indirectly confirms the physiological origin of the functional response in the human spinal cord and will help the design and analysis of spinal cord fMRI studies.

Activity measurements of ^{64}Cu sample activated by 14 MeV neutron beam.

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A new activity measurement system based on two large volume NaI(Tl) $5'' \times 5''$ cylindrical detectors, placed at 180°, was built at ENEA-INMRI. FLUKA Monte Carlo simulations were developed for the new system. It was used for the activity determination of a solid Cu-64 sample activated by the ENEA FNG 14 MeV neutron beam. The $^{64}\mathrm{Zn(n,p)}^{64}\mathrm{Cu}$ reaction was studied using both natural and enriched zinc target. A radiochemical analysis of the activated sample was performed at the ENEA-NMLNWM to separate Cu-64 from Zn target and prepare a Cu-64 liquid solution. The separation efficiency was tested by comparing the Cu-64 activity of the solid sample with the one of the liquid solution measured by the TDCR (Triple-to-Double Coincidence Ratio) technique at ENEA-INMRI. The experiment opened interesting perspectives in short-lived radionuclides production, used in nuclear medicine, by 14 MeV neutron beam. Cu-64 is, in fact, an emerging theranostic radionuclide currently produced by cyclotrons, using very expensive Ni-64 targets. By the achieved results a prediction on Cu-64 production with a high-brilliance 14 MeV neutron source, named Sorgentina-RF and under construction at ENEA, was made.

Multiparametric real-time analysis of physiological and metabolic signals from wearables.

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Wearable technology combined with novel digital acquisition approaches has added a whole new dimension in the healthcare system allowing the real-time continuous monitoring of human-body physiology and metabolism. They can be used in daily activities for fitness monitoring and, more importantly, for diagnosis and therapy management of patients suffering from chronic illnesses. Here we present a combined approach to contextually analyze multiple time datastreams, relying on LSTM and CNN neural networks.

Caratterizzazione dosimetrica del Gafchromic® XR-QA2 tramite misure di colore.

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I film Gafchromic® XR-QA2 sono utilizzati in ambito radiodiagnostico per l'elevata risoluzione spaziale e la possibilità di ottenere distribuzioni superficiali di dose. Il loro utilizzo richiede la calibrazione della risposta in termini di variazione della densità ottica (DO) in funzione della dose e la caratterizzazione soprattutto in termini di dipendenza energetica ed angolare. Viene presentato uno studio metodologico basato sul confronto tra due diverse procedure per la valutazione della dose utilizzando film irradiati in aria con un tomografo TC Revolution EVO presso Humanitas - Istituto Clinico Catanese (HICC). La procedura di routine, basata sulle immagini acquisite con uno scanner Epson-10000XL (metodo standard) è stata confrontata con i dati ottenuti con uno spettrofotometro Konica Minolta CM-2600d (metodo spettrofotometrico). Le variazioni di DO ottenute con il metodo standard sono state correlate alla variazione delle coordinate cromatiche nel sistema CIELAB. I risultati ottenuti sono confrontabili nell'ambito delle incertezze associate ad entrambi i metodi ed evidenziano le potenzialità del metodo spettrofotometrico in ambito dosimetrico.

Analisi preliminari sulle conseguenze neurocognitive di Long COVID.

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Abbiamo confrontato un gruppo di 12 pazienti affetti da Long COVID, ovvero con almeno due sintomi riferiti e obiettività neurologiche negative che persistono da più di 12 settimane dalla negativizzazione, con un gruppo di soggetti sani. I soggetti sono stati studiati con risonanza magnetica e test neuropsicologici. In particolare, abbiamo acquisito un protocollo RM standard associato ad immagini volumetriche T1, BOLD resting state, perfusione mediante Arterial Spin Labeling (ASL), Susceptibility Weighted Imaging (SWI) e Diffusion Tensor Imaging (DTI). I test neuropsicologici indagavano i domini attentivi, esecutivi, di memoria visuo-spaziale e verbale con l'aggiunta di scale psicometriche volte a testare la presenza di ansia, depressione e stress post-traumatico. Le analisi statistiche sono state fatte con SPSS 27™, VBM8, SPM 12, FSL 6, SYNGO.VIA VB40A™. Non sono state rilevate alterazioni morfofunzionali significative nel gruppo di pazienti nè alterazioni dei network cerebrali nonostante l'evidenza ai test neuropsicologici di disturbi esecutivi e presenza di sintomatologia stress correlabile.

High dose rate irradiations simulations and measurements at the TIFPA-INFN x-ray station.

Di Ruzza B.
TIFPA-INFN

The TIFPA-INFN center is equipped with a 3 kW tungsten anode x-ray irradiation station used for biological and biophysics irradiations on cells and radiation damage studies on silicon sensors. Since in recent years the importance for high dose rate irradiations is emerging, not only for solid state silicon radiation damage studies but primarily for flash irradiation activities on cells for oncological studies, it is becoming mandatory to explore the limits of the irradiation stations. In this talk the station spectrum simulation realized with the spekpy python code for different operative station configurations and the corresponding dose rate measurements realized with a PTW FarmerChamber will be described.

$4\pi\gamma$ activity measurements of ^{64}Cu produced by ^{65}Cu(n, 2n)^{64}Cu with 14 MeV neutron beam.

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The high-efficiency $4\pi\gamma$-integral counting method, available at ENEA-INMRI and based on a large-volume well-type NaI(Tl) $5'' \times 5''$ detector, was used for direct activity measurement of a ^{64}Cu solid sample activated by the 14 MeV neutron beam of the ENEA FNG facility. A Fluka Monte Carlo code was used to simulate the experimental set-up. This allowed to study the ^{65}Cu(n, 2n)^{64}Cu reaction with both natural and enriched copper targets. An accurate analysis of the irradiated samples for the impurities, activated by the neutron beam and estimated by MCNP and FISPACT-II code, was also performed by means of the ENEA-INMRI high-energy resolution HPGe detector, traceable to the ^{64}Cu standard here maintained. The achieved results, carried out under high metrological level conditions, allowed to make predictions for a ^{64}Cu production by the studied reactions using a higher brilliance 14 MeV neutron source, named Sorgentina-RF and under construction at ENEA. The overall experiment opened an interesting alternative to obtain ^{64}Cu, a teranostic radionuclide of increasing interest in Nuclear Medicine and produced using expensive nichel targets by proton-induced reactions in biomedical cyclotrons.

^{161}Gd spectroscopy after (n, γ) reactions on a target of very highisotopic purity.

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The ^{161}Gd nucleus has been investigated using thermal neutron-induced reactions on a highly isotopically pure target. Its gamma decay has been measured with the FIPPS γ-ray spectrometer at the Institut Laue Langevin in Grenoble (France). Via the analysis of multiple γ-ray coincidence data, the complex excitation spectrum of this nucleus and its decay pattern have been significantly extended, allowing to obtain information on its structure. This information is also important for the understanding of the structure of surrounding nuclei in the region of deformation around $A = 160$. ^{161}Gd is also very relevant in connection with the production, via beta-decay, of ^{161}Tb, a promising nucleus for targeted radionuclide therapies. An estimate of the production rate of ^{161}Tb, obtained from the measurement of the reaction cross-section of ^{161}Gd, will also be discussed.

Interaction of alpha-synuclein with the internal and external leaflet of the lipid membranes.

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Alpha-synuclein, a peptide involved in Parkinson's disease, is present in both the inner (cytosol) and extracellular space. Both the endogenous and exogenous components seem to have a role in the neurodegenerative process typical of the disorder. The cell membrane has an asymmetric structure, *i.e.*, the lipid compositions of the inner and outer leaflet are different. We prepared supported lipid bilayers (SLBs) with two different compositions that mimic the composition of the inner and the outer leaflet of the neuronal membrane, respectively. We studied the interaction between alpha-synuclein and these two types of SLBs, to reveal the possible destabilization induced by pathological peptides. It is known that the diffusion of lipids is affected by the presence of the supporting rigid substrate. We proposed an alternative approach, making the peptides interact with liposomes in solution, forming a planer bilayer after this interaction. We characterized the membranes before and after the interaction with alpha-synuclein by atomic force microscope, quartz micro-balance and fluorescence techniques.

Un approccio biofisico e psicoacustico per un udito artificiale.

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Si propone uno studio del sistema uditivo mirato allo sviluppo di un udito artificiale integrando l'esperienza ed i modelli realizzati seguendo diversi approcci. Gli elementi fisici e psicoacustici verranno considerati e studiati, integrando le informazioni ottenute da diversi modelli ed utilizzando le diverse metodiche di analisi dei segnali complessi, si confronteranno i segnali simulati con segnali reali prodotti dal sistema uditivo (emissioni otoacustiche). Infine, si ritiene che l'approccio intensimetrico possa essere utilizzato sia per la registrazione delle emissioni otoacoustiche che per l'identificazione della direzione di provenienza del suono nel sistema integrato, sfruttando le caratteristiche vettoriali del campo acustico.

Multimodal approach to study human epiphysis by x-ray tomography and histology.

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Calcium deposits are a common occurrence in the human pineal gland (PG). They are progressively accumulated in PG tissue with age and are not usually considered as pathology. However, with aging and neurodegenerative diseases the calcium deposits can reduce the number of functioning pinealocytes and therefore melatonin secretion. In this framework we have studied the morphological structure of human PGs with different extent of intrapineal calcifications using X-ray phase contrast tomography (XPCT), laboratory X-ray micro-computed tomography, and histology. We proposed and tested a new processing data analysis pipeline to better correlate the results. These experimental and data analysis approaches would provide new opportunities for the understanding of the formation mechanisms of PG calcifications and lesions.

Characterization of cardiac variability to quantify psychophysical stress.

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The Heart Rate Variability (HRV), the time intervals between consecutive heartbeats, is a parameter that, by reflecting the autonomic response of the nervous system, allows to characterize psychophysical states. Since HR signals are complex and non-stationary time series, non-linear techniques are adopted for the analysis of such signals. These techniques are sufficiently sensitive to reveal changes in sympathetic and parasympathetic activity during physical or normal daily life activity. Specifically, we found that Poincaré diagrams and the analysis of recurrence (RQA), applied to HR time series detected by wearable devices, allow a fast, ready-to-achieve and quantitative assessment of stress.

Extracellular vesicles as modulators of biomechanical properties in cells.

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Extracellular vesicles (EVs) mediated communication has been recently receiving a growing attention for its role in the development of cancer metastasis. EVs are small vesicles exchanged among cells and, owing to their biologically active content, EVs promote tumour-induced immune suppression, metastasis and angiogenesis, and constitute a potential target in cancer therapy. Yet, their role in priming the premetastatic niche and helping the spreading of cancer cells is still debated. Here we focused on the effects of EVs on the biomechanical properties of target cells, since it is recognized that the biomechanical properties play a

crucial role during metastatic spreading. To this purpose, we isolated and thoroughly characterized metastatic breast cancer (MBC) cell derived EVs. Then, we tested their ability to model the pre-metastatic niche by analyzing the biomechanical changes induced by EVs uptake on recipient cells through AFM-based nanoindentation and immunofluorescence measurements. Our results indicate that MBC-derived small extracellular vesicles can actively induce cellular proliferation, stiffness, cytoskeleton, nuclear and motility rearrangements.

Combining enhanced sampling simulations and deep learning dimensionality reduction for the study of intrinsically disordered proteins.

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A novel computational approach to the investigation of Intrinsically Disordered Proteins (IDP) is designed and applied to the study of the Heat Shock Protein B8 (HSPB8) and its pathologically relevant K141E point mutation. The protein functionality stems from its Intrinsically Disordered Regions (IDRs), lacking a fixed 3D structure, and whose dynamics imbalance can lead to neurodegenerative diseases. At present, no experimental 3D structure of HSPB8 has been resolved. In this work, we propose a new computational workflow for the study of IDRs that combines Homology Modelling, Enhanced Sampling Molecular Dynamics Simulations based on state-of-the-art force fields, and EncoderMap, namely a dimensionality reduction Neural Network Variational Autoencoder. The final aim is to compare the outcomes with available Optical Tweezers experiments. Preliminary results show that the most relevant protein conformations obtained from the EncoderMap plots have the potential to shed light on the different structural functionality of wt HSPB8 and its pathologic K141E mutant.

In silico validation of MCID tool for voxel dosimetry applied to ^{90}Y radioembolization of liver malignancies.

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The aim of this work was the validation of MCID platform for internal dosimetry, which allows a personalized treatment planning starting from patient-specific images and direct Monte Carlo (MC) simulations. Absorbed dose for different computational phantoms, calculated with MC and with conventional MIRD methods at both organ and voxel level were compared, obtaining differences of about 0.3% and within 3%, respectively, whereas differences increased (up to 14%) introducing tissue heterogeneities in phantoms. This study validated a platform for fast implementation of a personalized MC simulation and points out the relevance of dishomogeneities in the dosimetric evaluation.

Sezione VI
Fisica applicata, acceleratori e beni culturali

Comunicazioni

Rivelatori di gamma e neutroni per il monitoraggio di rifiuti radioattivi nel progetto MICADO.

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Nell'ambito del progetto MICADO (Measurement and Instrumentation for Cleaning And Decommissioning Operations), abbiamo realizzato e caratterizzato una serie di rivelatori per gamma e neutroni economici, compatti, robusti e affidabili. Tali rivelatori vanno posizionati intorno ai fusti di scorie radioattive, nei siti di stoccaggio, per un monitoraggio in tempo reale. Il sensore di gamma consiste in 80 cm di fibra ottica scintillante accoppiata agli estremi a fotosensori SiPM; il sensore di neutroni è un rivelatore al silicio di 3×3 cm^2 tra due strati sottili di ^{6}LiF. Saranno presentati i rivelatori e i risultati dei test di caratterizzazione con sorgenti radioattive effettuati in laboratorio.

Anode materials based on doped iron oxides for Na-ion storage.

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Advances in renewable energy sources (RESs) are enabling greater access to electricity in poorer Countries. However, the intermittent nature and availability of RESs require efficient electrochemical energy storage devices (EESDs) for their integration into smart grids. On turns, this makes the development of cost-effective, high-performance materials a key point for both more mature and emergent EESDs, such as sodium-ion batteries (SIBs). Iron (III) oxides (α-Fe_2O_3 and γ-Fe_2O_3) that store Na^+ ions through conversion reaction exhibit high theoretical capacities, but low conductivity limits their performance as anode materials in rechargeable SIBs. This contribution demonstrates that doping with tetravalent impurities is a viable strategy to enhance their conductive and electrochemical properties. Regardless of the synthetic route, doped Fe_2O_3-based anodes exhibit improved rate capability and specific capacity with respect to the undoped ones. In SIBs, Fe_2O_3@rGO and Fe_2O_3 : Ti@rGO composites produced by solvothermal method deliver 33 and 63 mAh/g at C rate, respectively; whereas electrospun Fe_2O_3, Fe_2O_3 : Si and Fe_2O_3 : Ge nanofibers deliver 25, 120 and 143 mAh/g at 2C rate, respectively.

High-precision kaonic atoms measurements at the DAΦNE collider: The SIDDHARTA-2 experiment.

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The SIDDHARTA-2 Collaboration is getting ready to perform the first ever kaonic deuterium measurement at the DAΦNE Collider of the LNF-INFN. The high-precision measurement of the kaonic deuterium is going to be performed with a dedicated experimental setup, specially realized for this purpose, containing dedicated X-rays detectors and veto and trigger systems. The contribution will present in detail the SIDDHARTA-2 setup and the first results collected at the DAΦNE Collider in preparation for the kaonic deuterium measurement.

Self-referenced optical-frequency comb based on low-noise Yb:CALGO femtosecond laser system.

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We report on the design, realization and characterization of a compact optical-frequency comb operating in the wavelength range from 670 to 1500 nm, based on a diode-pumped low-noise Yb:CALGO amplified ultrafast laser system. Both the carrier envelope offset and repetition rate frequencies are phase-locked to reference synthesizers providing a long-term fractional frequency stability of 7×10–13 at 100 s integration time. A complete characterization of the comb in terms of phase noise, frequency stability, and optical beating against a single-frequency oscillator Nd:YAG laser is presented. At SIF 2021 Conference we will report on our experimental results, showing the excellent properties of the Yb:CALGO comb.

High-resolution direct-comb spectrometer at 2.4 μm.

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We present the first implementation of a direct-comb spectrometer capable of resolving the single-comb mode of a 200 MHz pulse repetition rate Cr:ZnSe mode-locked laser at 2.4 μm. The spectrometer is based on the combination of a scanning Fabry-Pérot micro-cavity resonator with a Finesse of 15000 and a diffraction reflecting grating. We demonstrate its application in high-precision spectroscopy of acetylene at 2.4 μm, over 3 THz bandwidth sampled at 200 MHz and with a frequency resolution of 100 kHz limited only by the comb mode linewidth.

Resistive plate chamber technology for *in vivo* beam range verification in hadron therapy.

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Nowadays, more than ever, attention is focused on cancer treatment techniques in order to improve them. Hadron therapy is one of the most promising modern techniques, where, instead of gamma- and X-rays used in conventional brachytherapy, hadronic particles such as protons and heavy ions offer us a unique benefit such as high accuracy in delivering the local dose distribution in the target tumor volume while minimizing the overspill of radiation on healthy tissue. In this project Monte Carlo simulations are discussed for *in vivo* beam range verification using detection of secondary gammas and Resistive Plate Chamber technology.

● The development of energy-selective neutron transmission for applied-physics investigations.

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Energy-selective neutron transmission provides unique and insightful information over a variety of systems of applied and industrial interest. An increased use of this experimental technique has been accompanied by a boost in the development of instrumentation, data analysis and modelling at the ISIS Facility in the UK, available for user access. We will present recent examples of such research activity including the study of molecular catalysis in hydrogen-storage materials; the selection of shielding materials for radiation protection in hospitals and research centres; and the characterization of the neutron attenuation in biological materials for application to boron neutron capture therapy.

● È possibile definire una legge per la conduttanza ottica in analogia a quella elettrica e termica?

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L'esperienza acquisita sulla caratterizzazione ottica dei concentratori solari ha dimostrato che l'uso di un irraggiamento di tipo Lambertiano è molto efficace per risalire alle loro proprietà di collezione ottica. L'idea di applicare questo irraggiamento, con divergenza angolare di 90° e luce non polarizzata, ad entrambi i terminali ottici di questi sistemi ci porta a definire una semplice legge per la conduttanza ottica, che può essere espressa nella forma: flusso netto che attraversa il sistema ottico = conduttanza ottica Lambertiana (OLC) * differenza di radianza ai suoi capi, in analogia alle leggi di conduttanza elettrica e termica. La OLC, a sua volta, risulta espressa come il prodotto della étendue per la trasmittanza Lambertiana, e quindi ha per dimensioni (m^2*sr). Questa legge si applica ai sistemi per i quali è valido il principio della reversibilità ottica, e la grandezza OLC non dipende dalla direzione del flusso. Conduttanze ottiche simulate sono riportate per alcuni semplici sistemi a simmetria cilindrica, come i concentratori solari "senza immagine", i coni di luce e i tunnel solari, in funzione della riflettività di superficie.

● Influence of Rogowski coil linear slit on sub-ns current pulses.

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Due to the application of new biophysical stresses by electromagnetic fast pulses, Rogowski coils are designed for linear structure. The device is intended as a transmission line with a small slit to lead the flow of primary current. The slit forms a stray capacitor and an inductor. The slit dimensions influence the attenuation factor. We present the theory and the experimental results.

Multiple target system for muons production.

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A new idea of muon accelerator, called Low EMittance Muon Accelerator (LEMMA) and based on the muon production via the reaction $e^+e^- \to \mu^+\mu^-$ by a ~ 45 GeV positron beam impinging on a fixed target, has been proposed in the last years. In this scheme muons are produced almost at rest in the center-of-mass system, but have a high Lorentz boost ($\gamma > 200$) and long lifetime; moreover, thanks to the low emittance, the cooling in space phase is not needed. This production method presents several challenges and its feasibility is currently under study. In particular, the target must tolerate the energy deposited by very intense positron beam fluxes. Therefore, the choice of the target is a trade-off between maximization of the production rate and minimization of the emittance increase due to multiple scattering. Previous studies have shown that solid targets made of light materials (like beryllium and carbon) could be a solution. Preliminary results regarding deposited energy in the targets, muon production and beam energy losing, based on Geant4 simulations of several configurations and target shapes are presented.

Radioactivity, radiological risk, heavy metals contamination and minerals content assessment in flour samples.

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Flour investigation is of great interest due to its high consumption for nutritional purposes. In this study, eleven types of flour (five samples for each one), coming from large retailers and employed by people for different cooking food purposes, were investigated through High Purity Germanium (HPGe) Gamma Spectrometry, in order to estimate natural (K-40) and anthropogenic (Cs-137) radioisotopes specific activity and thus to assess the radiological risk due to the flour ingestion (for the age category higher than 17 years). Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Emission Spectroscopy (ICP-OES) were also employed, in order to evaluate any possible heavy metals contamination, the minerals composition, and to perform multivariate statistical analysis to deduce the flour authenticity through a correlation to the botanical origin, according to the elements concentrations.

INFN-CHNet at work: X-ray fluorescence analyses on works of art at the CCR "La Venaria Reale".

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INFN-CHNet, the network of the Italian National Institute for Nuclear Physics (INFN) devoted to Cultural Heritage, has the mission to develop instruments and methods for application to the heritage science field. Within this network, a Macro X-Ray Fluorescence (MA-XRF) scanner was realised for both elemental imaging and spectroscopy. It has been used for a number of applications, such as paintings, ceramics, mosaics and manuscripts. As an example, some measurements conducted at the Centro di Conservazione e Restauro "La Venaria Reale" will be presented. Furthermore, general aspects of the analysis with the MA-XRF scanner will be discussed.

Optical and colorimetric characterization of Fricke gel dosimeters prepared with XO and MTB.

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Radiochromic Fricke gels dosimeters (FGs) are well-known tools in radiation dosimetry. FGs were prepared using a matrix based on poly(vinyl-alcohol) and loaded with Xylenol-Orange and Methylthymol-Blue. The samples were irradiated with γ-rays and the consequent color changes were investigated by using spectrophotometry and colorimetry techniques. Starting from the measurement of the transmittance spectra, an analysis of the color of the dosimeters was carried out considering the CIELAB color space considering different illuminants. The study suggested that colorimetric analysis, combined with the spectrophotometric one, can be a useful tool for characterizing the gels in view of a standardization of Fricke gel dosimetry.

Il ruolo dello Xylenol-Orange e del Ferro-Ammonio-Solfato nella risposta dosimetrica di gel di Fricke a base di PVA-GTA.

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In questo contributo vengono presentati i risultati di misure di assorbanza ottica su dosimetri a gel di Fricke realizzati con matrici sintetiche di Alcool-Polivinilico e Glutaraldeide (PVA-

GTA-FGs) al variare della concentrazione di Ferro-Ammonio-Solfato e Xylenol-Orange (protagonisti del funzionamento di questi dosimetri). L'idea progettuale di questo lavoro nasce dalla constatazione che, nei lavori reperibili in letteratura sulla dosimetria con FGs, i diversi gruppi di ricerca non seguono un protocollo di preparazione standardizzato. L'ottimizzazione della ricetta di fabbricazione dei PVA-GTA-FGs, unita ai miglioramenti apportati dalla matrice sintetica, ha permesso di massimizzare la sensibilità della risposta ottica e minimizzare la perdita dell'informazione dosimetrica spaziale e temporale.

Substrate-enhanced photoluminescence of colour centres in lithium fluoride film-based detectors for soft X-rays.

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Radiation imaging detectors based on polycrystalline lithium fluoride (LiF) films thermally evaporated, in controlled experimental conditions, on four substrates —glass, Si(100) and Al thin films grown on glass and Si(100)— were irradiated with soft X-rays from a laser plasma source. After irradiation, the visible photoluminescence (PL) signal emitted by the radiation-induced F_2 and F_3^+ colour centres was investigated by optical spectroscopy, conventional and confocal fluorescence microscopy. A PL enhancement is observed which depends on the substrate reflectivity in the visible spectral range and on the LiF film thickness.

The role of coating in magnetite core-shell nanoparticles studied with ^{1}H-NMR relaxometry.

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A ^{1}H-NMR relaxometry study on superparamagnetic iron-oxide magnetic nanoparticles (MNP) dispersed in aqueous media is presented in this communication. Two series of iron oxides systems (with core diameter $\sim$ 9 nm and $\sim$ 4 nm, respectively) coated with different polymers (2,3-Dimercaptosuccinic acid, 3-aminopropyl phosphonic acid and Polyacrylic Acid) were used. A structural and morpho-dimensional characterization of the nanosystems is being conducted flanked by magnetic measurements. For studying the fundamental physical mechanisms of nuclear relaxation, NMR-D profiles of longitudinal and transversal relaxivity, r_1 and r_2, have been measured at room temperature. The NMR-D curves have confirmed the nature of the involved physical mechanism: at low frequencies the nuclear relaxation enhancement is led by the Neel correlation time while at higher frequencies the Curie relaxation mechanism dominates. Further several speculations on the effect of the different coatings on the nuclear relaxation efficiency are presented.

Displacement damage induced by electrons in CMOS Single-Photon Avalanche Diodes.

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This work investigated the degradation induced to 150-nm Single-Photon Avalanche Diodes (SPADs) by 2 MeV electrons. The great relevance of studying radiation damage on SPADs comes from their wide use in many areas that include high radiation fields, such as space applications or high-energy physics. In this work, the radiation-induced damage effects were investigated through a Dark Count Rate (DCR) behavior analysis. Different architectures of CMOS SPADs, both in terms of structural parameters and geometrical configuration, were tested. Despite electrons being light particles, the work was focused on Displacement Damage, which has been slightly investigated in literature for these particles. Displacement Damage results in reticular defects that lead to a DCR increase by mostly thermal causes in most linear-region operating devices; the study revealed an interesting behavior of DCR as a function both of absorbed dose and applied voltage, suggesting a strong relevance of tunneling contribution to noise in a peculiar way for Geiger-Mode devices such as SPADs, alongside the thermal one.

Cryogenic vacuum behavior of porous materials of interest for future accelerators.

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The properties of vacuum components at cryogenic temperature represent a crucial aspect to assure accelerator's best performances. These are not only intrinsic to each surface but also to the residual gas physisorbed on the walls and to the many interactions such surfaces will undergo during operation. Here we report on our study about the effects induced by temperature fluctuations and electron irradiation on a class of porous materials which are potential candidates of future accelerators. The results will be useful to predict the gas quantity delivered in cryogenic vacuum from porous surfaces.

Il progetto REMIX: Research on Emerging Medical radIonuclides from the X-sections.

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Lo scopo del progetto REMIX è studiare la produzione con acceleratori di Sc-47 ed alcuni radionuclidi del terbio: Tb-149, Tb-152, Tb-155 e Tb-161. Tali radionuclidi hanno caratteristiche ideali per essere utilizzati nella teranostica di diversi tumori, dato che possono svolgere un'azione sia diagnostica che terapeutica. Il progetto REMIX, finanziato dall'INFN per gli anni 2021–2023 e svolto all'interno del programma di ricerca LARAMED presso i Laboratori Nazionali di Legnaro, vede la collaborazione di varie sezioni (LNL, PD, PV e MI) e la collaborazione dell'Ospedale Sacro Cuore Don Calabria (Negrar, VR) e dell'Istituto Oncologico Veneto (IOV). L'obiettivo è la misura presso il centro di ricerca ARRONAX (Nantes, Francia) di diverse sezioni d'urto, del confronto dei dati sperimentali con i risultati della modellistica nucleare e del calcolo della dose per alcuni radiofarmaci, considerando le radiazioni emesse sia dal radionuclide di riferimento che dagli eventuali isotopi contaminanti.

Compact Raman setup to measure natural gas composition.

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It is here presented a multi-gas analyzer using Raman spectroscopy for the in-line measurement of composition and heating value of natural gas. The system consists of: 1) a high-power lighting-grade multimode laser diode; 2) a gas cell rated for operation up to 7 bar pressure; 3) a custom-designed lens-based f/2.8 spectrometer with a CMOS camera as high-sensitivity and low-noise focal-plane array. The system is intended to be operated in a wide range of temperatures, from −20 °C to 50 °C. The use of a multimode laser diode gives Raman spectra that are broadened and drifting with temperature. Custom image processing and fitting software cope for these effects and give gas composition once calibration spectra have been acquired. The method has been validated against the single components (such as methane and other alkanes, nitrogen, oxygen, carbon dioxide, hydrogen) and tested with certified gas mixtures simulating the concentration levels commonly found during field operation on natural gas. The method can be considered as a competitor of most available non-analytical techniques for the determination of the heating value and complementary to gaschromatography.

Il progetto europeo BLEMAB: La radiografia muonica come strumento di *imaging* in ambito industriale.

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La radiografia muonica è una tecnica di *imaging* non invasiva che permette, attraverso misure di assorbimento di muoni cosmici, di ottenere immagini tridimensionali della struttura interna di volumi materiali molto estesi. Il progetto Europeo BLEMAB propone l'applicazione della tecnica nell'ambito della siderurgia per il monitoraggio di altiforni all'interno di acciaierie. Lo scopo è l'osservazione, mediante la misura delle densità, dello sviluppo geometrico della "zona coesiva", regione dell'altoforno particolarmente importante per i processi di fusione dei minerali e per le prestazioni dell'altoforno stesso. Nella presentazione verranno descritti il progetto, l'apparato sperimentale e i primi risultati ottenuti con simulazioni preliminari.

IoT in environmental physics.

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A great variety of new board and devices are today available oriented to the IoT, corresponding to a number of combinations of microcontrollers, sensors, connection, interfaces, together with embedded programming strategies, communication protocols and the world of cloud computing. Such a "new age of measurement" is producing engineered solutions in a number of application fields, but it is also making the concept of measure a main feature of physics, important to a wider audience. IoT is making observation no more a domain of research & academic world: makers and DIYers are developing recipes used for didactical purposes, in teaching labs and in research in several domains of applied physics, including enviromental physics. In this work a review of papers on the use of IoT in applied physics is given, which includes main features and issues emerging in collected recipes.

A feasibility study of tomato fruit quality assessment and traceability by X-ray fluorescence spectrometry and statistical analysis.

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X-ray fluorescence (XRF) measurements were performed on dried tomato samples by using a portable XRF spectrometer. The purpose of this study is to establish a protocol for *in situ* analysis in order to provide a fast and reliable technique for quality assessment and traceability of Protected Geographical Indication (PGI) products. Experimental data were extensively studied by using Principal Component Analysis (PCA) and Cluster Analysis. Moreover, a comparison of the obtained XRF results with a semi-quantitative ICP-MS analysis was also performed. The perspectives to apply the implemented procedures in order to disentangle tomato lots produced in different geographical areas will be discussed.

Flexible microelectrode array based on conducting polymers for neural recording and stimulation.

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Flexible microelectrode arrays placed on the surface of the brain cortex are promising tools for treating neurological deficits and restoring lost functionalities. Modern microfabrication techniques offer great possibilities to achieve high spatial and temporal resolution, but the device performances are ultimately determined by the material chosen as the biotic/abiotic interface. The conductive polymer poly(3,4-ethylenedioxythiophene) doped with polystyrene sulfonate (PEDOT:PSS) is a favorable material to use for this scope, due to its biocompatibility, long-term stability, and large charge injection capacity. Our research aims to realize an optimized device with flexible mechanical properties and low-impedance electrodes enabling efficient recording and stimulation of neural activity during chronic *in vivo* experiments.

Graphene suspended on Ge micro-crystals for photodetection applications.

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Ge-on-Si micro-crystals grown on Si-patterned substrates can be used as absorbing elements for photodetection in the near-infrared. In such microstructures light confinement effects, due to crystal faceting and pattern periodicity, enhance light absorption as compared to conventional epitaxial layers. The challenge in realizing this type of devices is the formation of a top transparent contact suspended on the microcrystals array. Graphene can be used as a suspended contact that can adapt to the 3D morphology of the microcrystals, ensuring the formation of an electrically continuous layer. The fabricated devices feature a responsivity exceeding that of planar devices with comparable thickness.

Studio delle proprietà elettro-chimiche del suolo sottoposto a riscaldamento e irraggiamento X.

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I microorganismi presenti nei suoli rappresentano, grazie al loro potenziale redox, una fonte naturale di energia. Sono stati studiati diversi campioni di suolo: alcuni riscaldati a una temperatura di 150 °C, altri sottoposti a irraggiamento X (10 MeV). L'effetto del riscaldamento e dell'irraggiamento dei campioni è stato correlato, tramite due elettrodi inseriti al loro interno, alla tensione misurata (V_{out}). La V_{out} è diminuita del 90% dopo 30 ore di riscaldamento e ha subito una lieve diminuzione all'aumentare della dose assorbita. L'attività enzimatica ha mostrato un forte decremento dopo 1 h di riscaldamento ma non ha mostrato variazioni nei campioni irraggiati. Alla luce dei risultati ottenuti la conversione dell'attività chemo-elettrica del suolo è attribuibile prevalentemente alla carica batterica.

Diagnostic of alpha particles by proton-boron fusion reaction in plasma.

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The "neutronless" proton-boron fusion reaction B(p,α)2α, may allow some important applications such as the building of an ultra-clean nuclear-fusion reactor as well as the use of the produced alpha particles in cancer treatments. Recent results have proven that it is possible to trigger the pB reaction in a plasma environment as that generated in the laser interaction with a boron-rich polymeric target. Moreover, the development of innovative diagnostic methodologies for protons and alpha particle detection is needed. The reaction was studied in a dedicated experiment performed at PALS (Prague Asterix Laser System, Prague, CZ) in October 2020 where a 600 J, 300 ps laser interacted with specially designed boron-doped targets. The goal of the experiment was the reconstruction of the energy and angular distribution of α particles generated in the proton-boron reaction in plasmas using different detectors (CR39, Thomson parabola and solid-state detectors in time-of-flight mode) placed at different angles. Preliminary results will be presented and discussed.

Room-temperature ferroelectric switching of spin-to-charge conversion in GeTe.

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The increasing demand for computational power density is currently provided by the downscaling of the CMOS technology. Since this challenge is approaching a physical limit, a paradigm shift is requested to beyond-CMOS platforms. A breakthrough might come from the exploitation of the spin degree of freedom. In this framework, ferroelectric Rashba semiconductors (FERSC) offer the possibility to achieve the electric control of the spin in semiconductors, thanks to the interplay between ferroelectricity and giant Rashba effect. Here we demonstrate the ferroelectric switching of spin-to-charge conversion at room temperature in the epitaxial Rashba germanium telluride semiconductor. The result paves the way to non-volatile in-memory computing devices based on spin, in a silicon-compatible semiconducting platform.

Quantum communication in Florence: Recent achievements and future perspectives.

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The Quantum Communication research group of the National Institute of Optics (INO-CNR) is based in Florence (Italy), in close cooperation with DTU Fotonik (Denmark). Additional laboratories are located at University of Florence and in the Area Science Park of Trieste. The main topic of our research is quantum key distribution (QKD). Conversely to standard cryptography, QKD has the unmatched benefit of not being affected by the future advances in both classical and quantum computing, and thus it is today the sole technology able to guarantee a trusted security in authentication procedures and sensitive data handling. Our recent achievements include the first Italian field trial of a QKD setup, performed over an installed fiber-optics link in the Florence metropolitan area, paving the way towards the future Italian Quantum Backbone. Another field trial of QKD was performed in a public demonstration in Trieste, during the closing ceremony of the EuroScience Open Forum (ESOF 2020), at the presence of the Italian Prime Minister. Finally, our group is collaborating with the new CNR spin-off company, QTI, with the aim to produce and commercialize quantum communication architectures.

An innovative method for spatial mode shifting in an actively frequency-stabilized optical cavity for dual-color X-rays generation.

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We report on an innovative method to shift the transversal position of the focal point of a 4-mirror bow-tie optical cavity by properly rotating its curved mirrors by PZT actuators. This method allows moving the cavity focus of 135 μm in 50 ms, keeping it frequency stabilized. We propose to use this technique to generate 2-color X-rays via Inverse Compton Scattering (ICS). Indeed, in ICS facilities, arranging two high-finesse cavities with different collision angle with an electron beam allows generating different energy X-rays just by switching the two focal points onto the electrons trajectory. At SIF Congress we will expose our method and results in detail.

^{1}H NMR study of the local spin dynamics and magnetic anisotropy in monodispersed ferrite nanoparticles with variable size.

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We investigated the spin dynamics and magnetic anisotropy of maghemite-based magnetic nanoparticles, with a diameter ranging between 3 and 12 nm. The dependence of the anisotropy energy barrier at high applied fields has been investigated by means of AC susceptibility. Relaxometric properties have been studied at two NMR frequencies, 21 MHz and 58 MHz (corresponding to applied static fields $H = 5$ and 14 kOe, respectively), and the temperature dependence of NMR spectra, line-width (FWHM) and spin-lattice relaxation time for all samples have been singled out. As the temperature decreases, a rich phenomenology can be observed; particularly molecular motions and/or hyperfine magnetic field fluctuations slow down, giving rise to significant enhancements of the proton spin lattice relaxation rates.

Polarization control with semiconductor nanowires in silicon photonics waveguides.

Kaplan A.E., per la Collaborazione Quantep
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Silicon photonics has drastically changed the field of photonics in the last 15 years. Thanks to the standard Silicon On Insulator (SOI) platform, submicron waveguides can be fabricated, permitting the realization of very complex optical circuits, capable of performing a variety of functionalities, such as light modulation, switching, multiplexing, etc. Although silicon photonics is considered a mature technology, several functionalities are still hindered or resulted to be difficult to be performed using this technological platform. These are mainly related to the advanced control of the polarization states and nonlinear operations. A possible way to overcome such limitation is related to the use of nano and quantum materials, that have the potential to add unique functionalities to the SOI platform. We present a numerical simulation campaign that explores the use of nanowires as a semiconductor medium to control the polarization of a light beam traveling in a standard SOI waveguide. We study different polarization states and changes that a waveguide-confined light beam experiences, when it interacts with nanowires integrated in the SOI technology.

Studio di un sistema pianta-terreno come sensore UV.

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Le piante sono naturalmente sensibili alla radiazione Ultra-Violetta (UV) cui sono esposte. Questo principio può essere sfruttato per costruire dei veri e propri sensori UV viventi: green, non tossici, autoalimentati e poco costosi. Lo studio presentato ha l'obiettivo di valutare le potenzialità di un sistema composto da una pianta particolarmente sensibile alla radiazione UV (*Dimorphotheca ecklonis*) e da due elettrodi impiantati nel suo terreno. L'obiettivo è il potenziale utilizzo come sensore sfruttando la conversione dei processi di ossido-riduzione indotti da tale radiazione in un segnale elettrico misurabile. I risultati ottenuti hanno mostrato che la differenza di potenziale misurata ai capi degli elettrodi è proporzionale all'irradianza della sorgente UV utilizzata. Dai valori ottenuti è stato possibile stimare una risoluzione di circa 0.13 mW/cm^2 e una sensibilità di circa 6.6 mV/(mW/cm^2).

Differential correlation plenoptic imaging.

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Correlation Plenoptic Imaging (CPI) is capable of extracting plenoptic information out of the light coming from a scene. It does so by exploiting correlations of light detected on two spatially resolving sensors. The availability of plenoptic information enables improvements in the depth of focus (DOF) of the output images, compared to standard imaging, and allows the user to reconstruct the 3D scene and refocus relevant details in post-processing, all with a single shot. CPI has been shown to enable wider DOF extension and improved 3D reconstruction with respect to conventional plenoptic systems, retaining the diffraction-limited resolution typical of non-plenoptic apparata. Like other correlation imaging techniques, CPI suffers from degradation of the image quality with highly transmissive samples. Here, we propose a differential approach, Differential CPI (DCPI) aimed at taming the effects of high transmissivity on the noise, akin to one already applied to Ghost Imaging. DCPI is shown to improve visibility when imaging sparse and binary objects in a microscopy context with chaotic illumination and is expected to be even more convenient when using entangled photons.

Measurements of ^{16}O fragmentation cross-sections on C target with the FOOT apparatus.

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In particle therapy (PT) nuclear interactions of the beam with the patient's body causes fragmentation of both the projectile and target nuclei. In treatments with protons, target fragmentation generates short-range secondary particles, that may deposit a non-negligible dose in the entry channel. On the other hand, in treatments with ions, such as C, the main concern is represented by the long-range fragments produced by projectile fragmentation, reaching healthy tissues beyond the tumour region. Fragmentation processes need to be taken into account when planning a PT treatment to keep the dose accuracy within the recommended 3% of tolerance level. The evaluation of the impact that these processes have on the released dose is very limited by the lack of data, especially for the fragmentation cross-sections. The FOOT (FragmentatiOn Of Target) Collaboration designed an experiment aiming at the measurement of the relevant differential cross-sections. In this contribution, an overview of the FOOT experiment, including the detector design and the expected performances will be discussed. In addition, preliminary results on data of a 400 MeV/u ^{16}O beam impinging on a carbon target will be presented.

Caratterizzazione delle tecniche di doratura e dei pigmenti pittorici di tavole dipinte del XIV-XV secolo mediante la tecnica di imaging MA-XRF.

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L'imaging macro-XRF (MA-XRF) è una tecnica ben consolidata nell'analisi non distruttiva di campioni con composizione chimica eterogenea lungo la superficie. Essa è largamente indicata per lo studio di dipinti storici fornendo le immagini degli elementi chimici che caratterizzano gli strati pittorici e come questi sono distribuiti sul supporto. Le immagini elementali consentono lo studio dei materiali originali impiegati dall'artista, le tecniche pittoriche, il processo creativo, la presenza eventuale di restauri. Inoltre, è possibile valutare lo stato di conservazione delle opere e in molti casi risolvere questioni legate all'autenticità. In questo lavoro, verrà presentato lo studio condotto su tavole dipinte di iconografia sacra cristiana del XIV e XV secolo d.C. custodite presso la Galleria di Palazzo Bellomo di Siracusa (Italia) e sottoposte per la prima volta ad analisi scientifiche per le quali la MA-XRF è stata operata *in situ* impiegando lo scanner LANDIS-X, sviluppato dal XRAYLab dell'ISPC-CNR e dei LNS-INFN di Catania al fine di caratterizzarne la tavolozza dei pigmenti, la tecnica esecutiva con particolare attenzione alle tecniche di doratura e al processo creativo.

The AISHa ion source at INFN-LNS.

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The Advanced Ion Source for Hadrontherapy (AISHa) is an ECR ion source operating at 18 GHz, developed with the aim of producing high-intensity and low-emittance highly charged ion beams for hadrontherapy purposes. Its hybrid magnetic system consists of a permanent Halbach-type hexapole and of four superconducting coils. The transport line is equipped with an Emittance Measurement Unit, a Faraday Cup and a beam viewers system. Due to its unique peculiarity, AISHa is a suitable/reliable choice for different applications. Within the INSpIRIT project (funded by the Lombardy region) and in collaboration with CNAO, the development of metal beams is planned for radiobiological purposes. Within the IONS project, funded by INFN, AISHa will be used as a test bench for an innovative active plasma chamber designed to increase plasma confinement and to refine techniques of non-invasive plasma diagnostics, such as Optical Emission Spectroscopy (OES), to correlate plasma and beam parameters. Finally, as part of the DRIFT Collaboration, a dedicated setup is under realization to provide impinging beams and detection systems for target production in nuclear physics experiments.

Coupling PLD-grown isotopically enriched boron with semiconductor and scintillator detectors.

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We present the first year activities carried out in the frame of the BoLAS-NEXT INFN experiment. Aim of the experiment is to fully exploit the use of ^{10}B conversion layers deposited by the laser ablation technique for thermal neutron detection. The strategies developed for the improvement of detection efficiency, such as the set-up of sandwich geometries employing the simultaneous use of two large-area Si detectors, will be presented discussing the advantages in terms of gamma background discrimination. The preliminary results obtained in the deposition of ^{10}B film on polymeric scintillators such as polysiloxane will be also given.

Verso il primo fascio continuo di positronio.

Toso V. per la Collaborazione QUPLAS
POLIMI e INFN

Si propone un metodo innovativo per la produzione di un fascio continuo di “positronio” (Ps) (lo stato legato elettrone/positrone). Tale studio si colloca nell’ambito dell’esperimento QUPLAS, che ha recentemente realizzato la prima misura di interferometria di singole particelle di antimateria, utilizzando un fascio di positroni. Il Ps a differenza del positrone è elettricamente neutro, per questo la sua accelerazione e guida in un fascio è estremamente complessa. Oltre a questo, si tratta di un sistema instabile che è soggetto ad annichilazione in fotoni con una breve vita media (142 ns nel caso del ortho-Ps). Per superare tali problematiche è conveniente utilizzare lo ione negativo del Ps (Ps^-, due elettroni e un positrone), che può essere più facilmente guidato. Una volta raggiunta la traiettoria desiderata, si propone di utilizzare un fascio laser continuo d’alta potenza per rimuovere un elettrone ed ottenere il Ps. A differenza di altri fasci di positronio sviluppati in regime pulsato, in questa presentazione verrà mostrato il setup sperimentale sviluppato per realizzare un fascio continuo e le simulazioni dell'accelerazione e guida del Ps^-.

Sorgenti a gas-puff per microscopia in trasmissione di campioni biologici.

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Negli ultimi decenni sono stati compiuti notevoli sforzi al fine di migliorare la risoluzione spaziale in microscopia. L'utilizzo di sorgenti compatte basate sulla produzione di radiazione nel campo dei Soft X-Rays (SXR) e degli Extreme Ultra-Violet (EUV) ha permesso di superare i limiti imposti da grandi facility (quali, ad esempio, la loro complessità e dispendiosa manutenzione, nonché la necessità di prenotare turni di misura in adeguato anticipo). In particolare, le sorgenti a doppio flusso di gas, denominate "gas-puff" e sviluppate presso la Military University of Technology (Varsavia, Polonia) rappresentano un valido strumento per la microscopia a trasmissione, permettendo di ottenere una risoluzione spaziale nanometrica di gran lunga superiore a quella ottenibile coi microscopi ottici tradizionali. Tali sorgenti consentono la generazione efficiente di plasma evitando la creazione di "debris" e fornendo un numero di fotoni ottimale per l'imaging. In questa relazione verranno presentati due sistemi ottimizzati per la microscopia in SXR ed EUV, con particolare risalto ai risultati ottenuti osservando diversi campioni biologici.

Rock magnetism methodologies for fine arts and cultural heritage.

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Rock magnetism analyses were applied to two different research lines aimed at the preservation and characterization of fine arts. The first study consisted in the magnetic biomonitoring of Villa Farnesina, Rome, one of the finest historical buildings of the Italian Renaissance, with its frescoed interiors and the magnificent gardens facing Lungotevere. The sources and the spatial distribution of the airborne particles emitted by vehicles were inferred from the magnetic properties of the leaves collected from the trees along the roadway and inside the gardens of the Villa, integrated with those carried by the lichens transplanted also inside the frescoed halls. Brake abrasion from vehicles was the main source of the bioaccumulated particles, whose concentration depends on the distance from the road. Rock magnetism was also applied to the identification of pigments in fine arts, through their magnetic properties related to Fe-oxides and hydroxides. The magnetic susceptibility, its temperature dependence and the hysteresis properties indicated distinctive proportions of hematite and maghemite as the main magnetic carriers, with promising and original applications in cultural heritage.

Thermal neutron cross-sections of amino acids from average contributions of functional groups.

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The experimental thermal neutron cross-sections of the twenty proteinogenic amino acids have been measured over the incident-neutron energy range spanning from 1 meV to 10 keV and data have been interpreted using the multi-phonon expansion based on first-principles calculations. The scattering cross-section, dominated by the incoherent inelastic contribution from the hydrogen atoms, can be rationalized in terms of the average contributions of different functional groups, thus neglecting their correlation. These results can be used for modelling the total neutron cross-sections of complex organic systems like proteins, muscles, or human tissues from a limited number of starting input functions. This simplification is of crucial importance for fine tuning of transport simulations used in medical applications, including boron neutron capture therapy as well as secondary neutrons emission induced during proton therapy. Moreover, the parametrized neutron cross-sections allow a better treatment of neutron scattering experiments, providing detailed sample self-attenuation corrections for a variety of biological and soft-matter systems.

Caratterizzazione della sorgente di radiazione nell'estremo ultravioletto a scarica elettrica in gas dell'ENEA, tramite rivelatori a diamante prodotti dall'Università di Roma Tor Vergata.

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In questa comunicazione viene descritta la sorgente di radiazione nell'estremo ultravioletto (EUV) a scarica elettrica in gas (tipicamente Xe) operante nel Centro ENEA di Frascati. La sorgente emette impulsi di radiazione EUV di 100 ns di durata, nell'intervallo spettrale 10–18 nm di lunghezza d'onda. L'energia per impulso è di circa 35 mJ/sr ad una frequenza di ripetizione di 10 Hz. Si riportano, inoltre, i risultati ottenuti utilizzando dei rivelatori a diamante monocristallino di alta purezza, prodotti tramite CVD su un substrato di diamante sintetico HPHT, dal Dip. di Ingegneria Industriale dell'Università "Tor Vergata". La configurazione dei contatti elettrici nei dispositivi utilizzati è di tipo interdigitato, particolarmente adatta all'utilizzo per misure veloci. Grazie alla velocità di risposta di questi rivelatori, è stato possibile caratterizzare, molto più efficacemente rispetto all'uso di rivelatori PIN diode al silicio, il veloce picco di emissione EUV (7 ns FWHM), sovraimposto all'impulso principale. Questo veloce picco di emissione avviene in corrispondenza dell'istante di massimi compressione radiale e riscaldamento della colonna di plasma.

Characterization of pulsed-laser deposited diamond-like carbon films for micro-pattern gas detectors.

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We present the activities carried out in the frame of the FTM-NEXT INFN experiment. Aim of the experiment is to obtain hydrogen-free diamond-like carbon (DLC) films, as active layers for new micro-pattern gas detectors devices, by means of the pulsed-laser deposition (PLD) method. In order to obtain DLC coatings, over large areas (2 cm $\times$ 2 cm), with spatial homogeneity, adhesion to the substrate and typical surface resistivity values in the range of 1–100 Mohm/sq, growth conditions had to be optimized. We have analyzed different films obtained by means electron microscopy, electron diffraction, electrical transport characterization and scanning tunneling spectroscopy. In addition, we discuss how the different deposition parameters influenced the characteristics of the DLC films.

Microscopy identification of microplastics by spectral and lifetime phasor analysis.

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In the last years, microplastics pollution has raised as a worldwide environmental problem. The increasing daily use and release of plastics into the environment have led to the accumulation of fragmented microplastics, with potentially awful consequences for the environment, and animal and human health. The detection and identification of microplastics are of utmost importance, but available methods are still limited. Here we report the capability of fluorescence microscopy in the identification of different microplastics in the aquatic environment. A new approach based on phasor analysis of solvatochromic dyes (Nile Red and dimethylamino-nitrostilbene) is presented. Significant differences have been observed in the fluorescence lifetimes and emission spectra of the analysed microplastics thus providing useful fingerprints for the identification of fragments from different types of plastics. We also show that phasor analysis constitutes a fast, robust, and straightforward method for mapping and identifying different microplastics within the same sample in an aquatic environment.

Ultimi sviluppi sui rivelatori veloci al silicio UFSD.

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La mia presentazione riguarderà gli Ultra-Fast Silicon Detectors (UFSD), un particolare tipo di sensori al silicio basati sulla tecnologia dei Low-Gain Avalance Diodes (LGAD). A differenza dei rivelatori al silicio tradizionali, nei sensori LGAD le cariche primarie vengono moltiplicate grazie ad un layer di guadagno, generando un segnale più ampio rispetto ad un classico rivelatore al silicio senza guadagno, e aumentandone di molto il rapporto segnale/rumore. I rivelatori UFSD sono progettati per effettuare misure di tempo con una risoluzione temporale di alcune decine di picosecondi, questo grazie alle caratteristiche degli LGAD unite ad uno spessore ridotto, dell'ordine dei 50 μm. Presenterò le caratteristiche dei sensori UFSD e le principali misure effettuate sulle ultime produzioni. In particolare, si studieranno la resistenza alle radiazioni e l'uniformità di produzione su sensori di grandi dimensioni, in vista dell'utilizzo di sensori UFSD per la costruzione del MIP Timing Detector (MTD) per la Fase 2 del rivelatore CMS.

Low-power programmable integrated photonic circuits fabricated by femtosecond laser micromachining.

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Photonic integrated circuits (PICs) are steadily becoming an established technology with a wide range of applications in communications, sensing and analog signal processing. PICs manipulate light signals using waveguides, directional couplers and phase shifters as building blocks. Recently there has been growing interest in fully reconfigurable PICs, which can be programmed to perform any linear transformation on the input signal. Femtosecond Laser Micromachining (FLM) is a versatile fabrication technology that allows rapid and cost-effective fabrication of PICs. Reconfigurability in FLM PICs is implemented by means of thermal phase shifters, which provide optical signal modulation without added signal loss. Until recently only few thermal shifters could be fabricated on the same chip due to their high power dissipation and thermal crosstalk. This limitation can be overcome with the introduction of isolation structures fabricated via FLM, which provide a more than ten-fold reduction in dissipated power with negligible crosstalk, allowing us to fabricate fully programmable PICs with tens of thermal shifters integrated on the same device.

Characterization of ^{nat}Pd- and ^{110}Pd-irradiated samples at the LENA TRIGA Mk II research reactor.

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Within the ISOLPHARM_EIRA project two different irradiation experiments, at the LENA TRIGA Mk II research reactor, are planned in order to evaluate the ^{111}Ag yield. In this communication we show the results of these experiments and the comparison with the Monte Carlo estimates.

Sviluppo di elettronica di lettura per rivelatori di radiazioni basati su film sottili di semiconduttori organici.

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Il progetto FORTRESS si dedica allo sviluppo di rivelatori di radiazioni ionizzanti (raggi X e gamma) basati su film sottili di semiconduttori organici. Il sistema integrato consiste in una matrice 2D leggera e flessibile di sensori di radiazione, con una elettronica di lettura dedicata. Tra le applicazioni previste per questi rivelatori, vi sono il controllo in tempo reale delle dosi e la riduzione del rischio associato ai trattamenti di radioterapia e medicina nucleare e il monitor di fascio per tubi a raggi X utilizzati in ambito medicale. In questa comunicazione è presentato lo sviluppo di un circuito elettronico, compatto ed economico, per l'amplificazione e digitalizzazione dei piccoli segnali in corrente, tipicamente dell'ordine dei 10–100 pA, prodotti dai sensori utilizzati. Il sistema integrato è completato da un modulo wireless per la trasmissione dei dati e il controllo da remoto.

Correlation plenoptic microscopy.

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We present a novel approach to three-dimensional optical microscopy, named correlation plenoptic microscopy (CPM). Along the line of correlation plenoptic imaging, CPM exploits correlations of intensity fluctuations, intrinsic in chaotic light, to retrieve both spatial and angular information about the sample, thus enabling both enhancing the depth of field (DOF) and performing scanning-free 3D reconstruction, while maintaining diffraction limited resolution. We present results obtained with both three-dimensional phantoms and biological samples, demonstrating that CPM enables improving the resolution by a factor of 4, for a given DOF. We also compare the results obtained by conventional CPM with the ones obtained by performing angular measurements in the Fourier plane of the objective lens, where spatial filtering is performed for edge enhancement.

TXRF/GIRXF high precision laboratory setup with high-flux monochromatic sources for archeometric applications.

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LANDIS XRAYlab is developing an instrument for experiments near total reflection conditions, that enhances the signal form the first few nanometers while suppressing the contribution from the bulk of the sample. By changing the angle of incidence around the critical angle (grazing incidence conditions), the depth profile of surface coatings can be directly probed, making this method particularly suited for the study of thin surface layers found in many archaeological artifacts. Since both the critical angle for total reflection and the penetration depth at a given angle of incidence are dependent upon the incident energy, high-precision TXRF and GIRXF are traditionally implemented within synchrotrons (where highly monochromatic X-ray beams with little to no divergence are available), while table-top instruments are limited by both the directionality and monochromaticity of the incident beams. Thanks to the recent integration of highly monochromatizing optics into compact X-ray tubes for laboratory applications, such compromises are no longer necessary. In this work, we present the characterization of a monochromatic laboratory self-assembled set up for TXRF and GIXRF measurements.

Transmission electron microscopy for the analysis of defects induced in graphene oxide by ion irradiation.

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Sheets of oxidized graphene (GO) assume a static, non-flat configuration, with apparently random out-of-plane microscopic deformations, in which the surface normal varies by several degrees. As is well known, the irradiation of oxidized graphene with ionic beams causes the removal of the functional oxygen groups from the sheet. This process does not improve the flatness of the sheet, on the contrary, it increases deformation in a dose-dependent manner. The electron diffraction, in particular, highlights these deformations through the enlargement of the spots. This enlargement involves both the direction normal to the reciprocal lattice vectors and the parallel one. The first deformation is related to the non-planarity of the surface, the second to the strain caused by the rearrangement of the deformed lattice. Such structures indicate that there are a large number of different orientations present within the electron beam with a diameter of less than one micron and that the normal to the surface of the sheet must vary in all directions. This is the result of a microscopic roughness within the sheets. The progressive deformation of the spots depends on the absorbed dose.

Investigation on siloxane scintillators response to proton beams as related to dosimetry in proton therapy.

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In this presentation, we show the results of irradiation of siloxane scintillators, produced using different polysiloxane matrices, under proton beams with energy of 5 MeV at the Labec facility and 37 MeV at the TIFPA facility. The chemical nature of these sensors can be assimilated to human tissue. Therefore, aiming at preserving healthy tissue during a proton-therapy stage, the study of scintillation light output of these materials upon irradiation with proton beams of different energy, flux and fluence is highly attractive. The detection limit, the linearity and the stability of the sensors response as a function of the dose rate is measured and compared with the behavior of the plastic scintillator EJ-212. Considering the cutting-edge technology aimed at the production of flexible organic photoconverters, described in the FIRE project funded by the V-th commission of INFN, the possibility to achieve a fully flexible device composed of scintillator and photoconverter might open the way to a myriad of crucial application fields (nuclear medicine, workers surveillance in critical environments and homeland security).

InnovaTron: An innovative industrial high-intensity cyclotron for large-scale production of medical radioisotopes.

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A research project is ongoing at IBA to design an innovative compact high-intensity self-extracting cyclotron for large-scale production of medical radioisotopes. The project, named InnovaTron, has received funding from the EU H2020 Marie Sklodowska-Curie Actions - Individual Fellowship programme. In the self-extracting cyclotron, proton beams are extracted without any active device. Although encouraging results were obtained with the prototype in 2001, InnovaTron will improve the magnet design and the beam optics of the self-extracting cyclotron by means of innovative technological solutions. An overview on the InnovaTron project will be presented together with the first simulation results.

A characterization of a novel composite detector with neutron and gamma discrimination capabilities.

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In this presentation we will show the results of the irradiation tests with gamma and neutron calibration sources of a novel composite scintillator, built by adding a lithium tetraborate layer between two inorganic scintillators CsI(Tl). The first, $^{6}Li_2{}^{10}B_4O_7$, is selected to be sensitive for neutrons, the CsI(Tl) for gamma. In fact, new inorganic scintillators have been discovered in recent times, with neutron and gamma-ray detection capabilities, like CLLB. However, the size is relatively small and the cost of a new scintillator is relatively high compared to traditional scintillators, such as CsI(Tl). Recently, significant progress in the development of organic scintillators with neutron and gamma sensitivity has also been achieved. The great advantage is they have low production costs, but, on the other hand, they have low detection and low photopeak efficiencies due to the low Z and low density of their constituents. Thus, the presented detector can be well suited for applications where the energy resolution for the gamma-ray detector is crucial together with the discrimination between neutron and gamma. Tests with comparative readouts, PMT and SiPM, will also be presented.

A characterization of large-volume plastic scintillator with different SIPM configurations.

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The present study is part of the DRAGON project, funded by INFN-E. The Dragon (Drone for RAdiation detection of Gammas and Neutrons) project aims to design and develop an Unmanned Aerial Vehicle (UAV) equipped with a detection system able to identify radioactive materials spread over a wide area or located in a specific position for environmental and accident monitoring. The presentation will be focused on the characterization of the radioactivity counter. We will present a comparative test of the response of small- and large-size plastic scintillators coupled to different readout devices (several SiPM configurations and a standard PMT). The tested plastic scintillators are the EJ-276 and EJ-276G (green fluorescence), provided with pulse-shape discriminating (PSD) capability, of 1 ″ and 3 ″ diameters. Different SiPM matrixes have been used, with different configurations, coupled with a custom-made fast preamplifier. The results will be given in terms of energy resolution and neutron/gamma discrimination capabilities.

Investigation of the photoelectrochemical transduction at the organic-semiconductor/water interface.

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Exposure to light efficiently generates excitons in organic semiconductors. Our aim is to transduce this energy into biochemical processes that will induce therapeutic effects leading to cardiac cell regeneration. To do so an electrochemical transduction has to be invoked: this can be a capacitive mechanism or a faradaic mechanism. In the former a transient electrical field is generated inducing ionic displacement currents, whereas in the latter a photoactivated electrochemical redox reaction generate new active species at the interface. It has been shown that emergent electrochemical species such as reactive oxygen species, interacting specifically with extracellular components or ion channels, play a pivotal role in triggering cardiac cells regeneration. Here we investigate different organic semiconductor photoelectrodes that show both a photocapacitive and a photofaradaic response, examining the processes that lead to the photovoltage formation, and showing how this builds up as a consequence of photofaradaic charge transfer.

TRAMM: A novel device for electron emittance measurement.

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In modern accelerator facilities, such as Free Electron Lasers (FELs) and Energy Recovery Linacs (ERLs), high bunch charge, ultra-low emittance electron beams are becoming an absolute requirement. High quantum efficiency photocathodes, depending on the recipe and deposition technique, are relatively easy to achieve. Nonetheless, researchers still struggle to produce materials that combine high QE with low thermal emittance. Usually, we measure emittance with several devices (beam sampling, pepper pot, or solenoid scan) after accelerating the electron beam to high energies inside a photo-injector. While these methods are highly accurate, they are unsuitable for rapid analysis of the emittance during the fabrication process. To overcome this limitation, together with avoiding the extreme conditions of the RF gun, we are developing TRAMM, a portable transverse-momentum measurement device easily connectable to our photocathode production system. With such a device, we plan to investigate the real-time dependence of the emittance upon the typical parameters that control the cathode growth, such as the quantum efficiency and the cathode chemical/structural composition.

Heterodyne Near Field Speckles for beam size measurements with broadband X-rays: Preliminary results and perspectives.

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Recently, the Instrumental Optics Laboratory at the Physics Department of University of Milan, in collaboration with CERN and the ALBA synchrotron light source, has developed a novel interferometric technique for two-dimensional electron beam profiling based on Heterodyne Near Field Speckles (HNFS). It relies on the statistical analysis of speckle fields generated by highly monochromatic X-rays from an undulator source. In this contribution we present recent numerical results concerning the extension of the HNFS technique to broadband X-rays from a bending magnet. Simulations based on the Mie scattering theory are performed for the specific case of beamline FE34 at ALBA, in view of experiments starting in 2022. In particular, the effects of different monochromator bandwidths are investigated to assess the minimum value for a reliable extension of the HNFS technique. We also compare different colloidal samples and novel targets for signal-to-noise ratio optimization. These studies are of importance in view of applications at the Future Circular Collider (FCC) at CERN.

Electrical performances comparison between monofacial and mifacial solar minimodules in outdoor conditions.

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The expected increase in energy demand and the urge to reduce the environmental impact urgently requires the adoption of renewable energy and carbon-neutral energy technologies. Amongst these, photovoltaics (PV) is becoming one of the most important. Bifacial photovoltaics (BPV) is the most promising and represents a compelling technology for the future development of PV. In this perspective, the Best4U project aims to find solutions to increase the efficiency of PV modules and improve bifaciality to reduce installations cost. The BPV module (BPVm) simultaneously collects incident solar radiation and the albedo radiation from the backside. Consequently, a BPVm produces more power density than a monofacial one. However, the intrinsic variability of solar power due to geographical location, weather and solar spectrum evolution play a notable role in system costs. To this purpose, inside the BEST4U project we evaluated the primary dependences of the power output of the BPVm on the operating temperature, background radiation and solar spectrum. Promising results were obtained in terms of energy yield and duration of daily energy production for the BPVm compared with the monofacial one.

Phasor analysis in polarization-resolved optical scanning microscopy for progeria organization imaging.

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Polarization-resolved optical scanning microscopy is a powerful, non-invasive and label-free technique based on light polarization effect on biomaterials. We indicated an image phasor analysis to track localized microscopic changes of the sample pixel by pixel. We presented a distinctive way to obtain additional information at the molecular level, integrating this imaging microscopy technique with a phasor data analysis approach to provide an intuitive information out of the reciprocal spatial frequency space. We integrated confocal fluorescent scanning microscopy with polarization-resolved optical scanning microscopy to take the advantage of both modalities. In a graphical manner, we showed the comparison of normal HEK cell nucleus with progeria cell nucleus in terms of chromatin compaction and nucleus deformation throughout the microscopic image. Based on discrimination of the polarimetric contrasts, the graphical representation can be applied to further applications in biological fields to recognize different molecular species in the illumination volume in an easy and fast manner without any necessity for huge computations.

Un algoritmo di Machine Learning per classificazione multi-label di spettri XRF.

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La fluorescenza a raggi X (XRF) è una tecnica analitica ampiamente consolidata che consente di determinare la composizione chimica dei materiali in modo non distruttivo. La sua applicazione allo studio delle opere d'arte e ai materiali antichi è fondamentale per ottenere informazioni circa la loro provenienza geografica, le materie prime impiegate e le tecniche e i processi di realizzazione. Gli spettri XRF risultanti da ciascuna misura possono essere trattati come array N dimensionali, ciascuno dei quali contiene le intensità in funzione dell'energia dei fotoni di fluorescenza rivelati. Nell'ambito delle attività del laboratorio XRAYLab dell'ISPC-CNR di Catania proponiamo un modello di classificazione di tipo *One vs. All* che permette l'identificazione degli elementi chimici contenuti nei singoli spettri XRF e di mostrarne la distribuzione attraverso le immagini. Il modello si basa su k reti neurali, dove k è il numero di elementi chimici da riconoscere e ogni rete è responsabile del riconoscimento di un solo elemento chimico. Combinando insieme gli output del modello è possibile ottenere la caratterizzazione degli elementi che sono presenti in ciascun spettro.

Numerical simulation of a hollow-core woodpile coupler for dielectric laser accelerators.

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Dielectric laser accelerators (DLAs) are operated at optical near-infrared (NIR) wavelengths; this permits a reduction of the accelerators typical feature from centimeter to micron. The miniaturization and the higher damage threshold of dielectrics, as compared to metal, produce higher accelerating gradients ($\sim$ GV/m). In this paper we present the design of a dielectric Electromagnetic-Band-Gap (EBG) mode converter that allows an efficient coupling of the accelerating mode and high power operation in compact DLA. The design is based on a woodpile Photonic Crystal which provides a full transverse confinement of the laser field with clear advantages with respect to other quasi-2D coupler designs. The coupler is composed by two perpendicularly coupled hollow-core waveguides: a TE-like mode waveguide and a TM-like mode accelerating waveguide. The structure has been designed to obtain a minimum Insertion Losses (IL) and a maximum mode conversion efficiency in the operating bandwidth. The properties of the confined accelerating mode have been analyzed. In order to derive the accelerating gradient and beam properties, Astra beam-dynamics simulations have been performed.

Ultrafast transient holographic microscopy.

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Imaging the transient optical response of several nano objects simultaneously is beneficial to many research fields. The ultrafast dynamics of a single nano object is typically studied using a single-pixel detector and high-frequency modulation of the pump pulse combined with synchronous lock-in detection. However, wide-field transient microscopy of multiple objects is difficult due to the low frame rate of 2D cameras. Here we present an ultrafast microscope which overcomes this limitation using a holographic design, which all-optically demodulates the photoinduced signals and allows the simultaneous observation of many single nano objects in steady state and transient scattering over an area of $100 \times 100\ \mu\text{m}^2$. Thus, the heterogeneity of the dynamics of multiple nano particles can be probed. Further it enables phase imaging and, hence retrieving out-of-focus signals. This bears potential in

biology, to probe functionalized gold nanoparticles, which replace fluorescent labelling but allow single-particle sensitivity. Applications of the latter could be gold nanoparticles with DNA strands to quantify virus loads or 3D tracking of single particles in cells.

Two-dimensional electron beam diagnostics with X-ray Heterodyne Near Field Speckles.

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Assessing the two-dimensional (2D) transverse distribution of particle beams is of utmost importance to quantify the performance of state-of-the-art synchrotron light sources. It also represents a challenge for upcoming fourth-generation large-scale facilities with unprecedented small beam emittances. Here we describe a novel interferometric technique for 2D electron beam diagnostics named Heterodyne Near Field Speckles, developed in collaboration with CERN and the ALBA synchrotron light source. The method relies on the self-referencing interference between the faint spherical waves scattered by a random diffuser and the intense trans-illuminating radiation beam. Fourier analysis of the resulting speckle patterns allows to perform 2D coherence mapping of the incoming X-rays, hence 2D beam profiling. We review the fundamentals of the method and present recent advances obtained at ALBA. We evidence how the technique complies with requirements for beam size measurements at future fourth-generation light sources near the diffraction limit. Complementary studies and applications are also discussed, with emphasis on the extension to the Future Circular Collider (FCC) at CERN.

An innovative neutron imaging technique for elemental characterization of inhomogeneous samples.

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Neutron Resonance Transmission Imaging (NRTI) is an innovative non-destructive technique based on the presence of resonance structures in the neutron-induced reaction cross-sections, which allow the identification of isotopes and elements. NRTI is performed at the INES (Italian Neutron Experimental Station) beamline of the ISIS spallation neutron source, where a time- and spatial-resolved detector is employed for Time-of-Flight (ToF) measurements of the neutron beam transmitted through the object. NRTI provides 2D map of the elemental composition of the artefact, enabling studies of inhomogeneities. Results obtained by transmission analysis of archaeological samples made of bronze and brass alloys are presented.

Formation of graphene-like nanostructure on Ni(111) using phthalocyanine as precursor.

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On many substrates, single layers of phthalocyanine show the formation of well-ordered surface over-structures, with the possibility of molecule polymerization. The morphology of the final overlayers depends on many factors, including the particular interaction between the molecules and the used substrate and the presence of thermal treatments. In this work we studied the case of metal-free hydrogen phthalocyanine (H_2-Pc) and iron phthalocyanine (Fe-Pc) deposited on Ni(111). It is found that the molecules start breaking/polymerize at around 210 °C in the case of $H_2 - Pc$ and at around 240 °C in the case of Fe-Pc. Under proper conditions, the molecules can form graphene-like overlayers, and we observed that the processes needs several hours to get equilibrium. The molecular break/polymerization and all steps of the graphene-like superstructures formation were monitored using *in situ* X-ray and ultra-violet photoemission spectroscopies.

CVD-grown graphene on Si substrate: Raman mapping, AFM and HR-SEM multi-modal analysis.

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The many application prospects for graphene include the use of carbon-based technology as possible valid alternative to the silicon-based one, especially for satisfying the request of extreme miniaturization, that requires large-area mono-layer sheets. The Chemical Vapour Deposition (CVD) is a simple and cost-effective method to grow large-area graphene films. Although the CVD-grown graphene on a metal surface is of high crystalline quality, it must be transferred to a dielectric/semiconductor substrate for applications. This process is still a bottleneck because the transfer tends to induce mechanical damage. As a consequence, it is highly desirable to produce high-quality graphene films on a wide range of substrates directly through CVD without a metallic catalyst. In this work, we report the growth of graphene directly on single-crystal silicon and nickel substrates using metal-free chemical vapor deposition and the characterization by micro-Raman spectroscopy with surface mapping, High-Resolution Scanning Electron Microscopy (HR-SEM) and Atomic Force Microscopy (AFM) to identify the changes in the CVD-grown structure with the reaction parameters.

Assessment of the electrical substitution method for photodetectors self-calibration.

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The chipS·CALe project, within the *European Metrology Programme for Innovation and Research*, is focussed on developing a more robust linkage to the revised SI candela for optical power measurements. The chipS·CALe target is to establish a self-calibrating method for photodiodes at cryogenic temperature. The method is based on combining the photoelectrical current measurement and the electrical substitution principle, where the temperature increase caused by the absorbed radiant power is matched with the one due to the Joule heating by means of electrical power, easily traceable to SI. We present the progress made in developing a measurement system for electrical substitution. The quality of our setup is assessed using only electrical power, thus comparing the estimated power to the truly measured one. While we are still improving the measurement read-out system we show that the relative deviation between estimated and measured power at liquid-nitrogen temperature is already 0.007%, in average, with a standard deviation of 0.03%.

Characterization of bioplastics for circular economy.

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Plastic made from petrochemicals and fossil fuels degrades in very long time and pollutes the environment. On the contrary bio-degradable or compostable plastics, derived from renewable materials like corn, starches, cellulose, and lactic acid, can tackle the environmental concerns of plastic packaging. Compostable plastics are non-toxic and decompose back into carbon dioxide, water, and biomass when composted. Enormous research and projects like SPATIALS3, a hub of research and innovation in the field of nutrition, have been undertaken to improve and characterize the biopolymers in order to bring their mechanical and physical properties comparable to those of fossil-based plastics. Raman Spectroscopy (RS) demonstrated to be a valid technique for polymer characterization with the advantage that portable instrumentation is already available on the market. In our work we investigated with RS and SEM the bioplastics as prepared and after treatments mimicking the interaction they have in food packaging: the results shows that the vibrations assigned to the bio-polymers are unchanged upon water treatment up to 80 °C, showing that RS is a robust technique for on-field tests.

Machine-learning methods for breathomics based on a nanostructured carbon sensors array.

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The COVID-19 pandemic has pointed out the importance of developing a rapid and reliable diagnostic test for respiratory diseases such as pneumonia and seasonal flu, along with the possibility to deploy screening test for the detection of COVID-19 infections. In this frame, e-noses might play a major role in the screening of respiratory diseases. In this study, we explore the capability of a sensor array based on nanostructured carbon layers to discriminate, through the analysis of the exhaled breath, patients affected by chronic obstructive pulmonary disease (COPD) from healthy subjects. After a careful characterization of the sensors through the exposure to selected biomarkers, the array was exposed to the exhaled breath of patients affected by COPD and healthy control volunteers. A combination of PCA, supported vector machine, and LDA shows that the sensors array can be trained to accurately discriminate healthy from COPD subjects. Further analysis has been carried out with a neural network appoach, along with hierarchical clustering, which allowed us to evaluate the most effective tools for patients classification and discrimination.

Compact optical sensor for high-concentration hydrocarbon detection employing a quartz tuning fork as infrared photodetector.

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A compact optical gas sensor for hydrocarbon detection based on tunable diode laser absorption spectroscopy with a quartz tuning fork (QTF) as photodetector was demonstrated. The light-induced thermo-elastic effects occurring in QTFs allowed infrared photodetection when the sensor operates in $2f$-wavelength modulation approach. An interband cascade laser with central emission wavelength of 3.34 μm was used as laser source to target absorption features of methane (C_1) and ethane (C_2). A custom 9.8 kHz T-shaped QTF with grooved prongs was directly enclosed in the gas cell with an optical absorption path of 2.5 cm. The detection of hydrocarbons mixtures was demonstrated in a wide concentration range, from several percent down to part-per-million and part-per-billion level for C_1 and C_2, respectively, at 300 ms of signal integration time. The compactness of the developed sensor makes it suitable for real-time, *in situ* measurements representing a powerful tool for geological and petroleum explorations.

In situ surface-enhanced attenuated total reflection spectroscopy of self-assembled monolayers.

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Probing the interface between nanometer-thick self-assembled monolayers (SAM) on Au films and electrolytes via mid-infrared spectroscopy is a challenging task. Conventional optical techniques are not suitable, as the penetration depth of radiation is much larger than the thickness under investigation. On the other hand, metal underlayer attenuated total reflection relies on the local electric field density increase in a thin layer interposed between materials with higher refractive index. Also, surface-enhanced infrared absorption spectroscopy (SEIRAS) and polarization-modulation infrared reflection absorption spectroscopy (PM-IRRAS) allow to reveal spectroscopic features related with the SAM. We will review experimental approaches suitable for *in situ* and *in operando* characterization of solid-liquid interfaces, showing examples of bio-functionalized SAMs on Au thin films used as gates in electrolyte-gated transistor sensors.

Accuratezza della resa cromatica nei beni culturali.

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Si presenta la creazione di un dataset consistente nelle acquisizioni 3D di 50 modelli di colorazione differente, acquisiti all'interno di una cabina luce in tre diverse posizioni e variando due differenti illuminanti, per un totale di 300 acquisizioni. Ciascun punto acquisito consiste in due terne: una rappresenta le coordinate spaziali e l'altra il colore (terna R, G, B). Tramite l'utilizzo di uno spettrofotometro è stata acquisita la terna $L, a*, b*$ di ciascun modello 3D per ognuno dei due illuminanti. Si vuole utilizzare il dataset così creato per allenare un modello di intelligenza artificiale che esegua la specificazione del colore.

Neutron emission rate measurements by MnSO4 bath

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The Laboratory of Neutron Metrology of ENEA-INMRI provides a calibration service at national level for neutron radiation detectors. Calibration requires neutron reference sources which strength is determined using $MnSO_4$ bath technique, which is based on a steel sphere (1 m of diameter) containing 550 L of $MnSO_4$ solution. The neutron source enters the bath by means a watertight container. The neutron activation of ^{55}Mn in the solution produces ^{56}Mn

($T_{1/2} = 2.57878(46)$ h) which decays in ^{56}Fe, by emitting gamma-rays. At the saturation level, the neutron source is extracted and a NaI(Tl) detector is inserted into the sphere to measure the activity of the bath. The neutron emission rate of the neutron source is then determined by knowing the activity of the bath for which it is necessary to know the NaI(Tl) efficiency and all the effects related to the Mn bath (geometry, neutron cross-sections, etc.). All these effects are estimated by Monte Carlo simulations performed with Fluka code. The work highlights the measurements performed at ENEA-INMRI with the $MnSO_4$ of an Am-Be neutron source NPL certified. The experiment allows to benchmark all the experimental set-up used.

The Extreme Energy Events experiment: Investigation of the sorrounding building environment on the detector response.

Campana M., the EEE Collaboration
Dipartimento di Matematica e Fisica "E. De Giorgi", Università del Salento, Italia

The Extreme Energy Events experiment (EEE) aims to study Extensive Air Showers (EAS) focusing on the secondary muon component. The experiment is made up of a network of about 60 muon tracker telescopes, each made of three Multigap Resistive Plate Chambers (MRPC), distributed across Italy and at CERN. For a deeper involvement of students and teachers in the EEE projects, several telescopes are located in partecipating high school buildings. Studying EAS requires excellent performances, thus it is worth to consider the influence of buildings on collected data. MRPC response, as well as detector geometry and details about the sorrounding materials, have been implemented in a GEANT4-based framework (GEMC) to study, by means of simulations, the telescope response of each experimental setup and produce experimental-like data. Single muon events are generated according to a model that produces a realistic muon flux. The framework has been used to compare simulations to selected EEE telescopes data affected differently by the presence of surrounding materials. We demonstrated that the simulation framework is able to reproduce the observed flux asymmetries due to different shielding.

Overview of photo-neutralization techniques for negative ion beam injectors in future fusion reactors.

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In fusion reactor technology, the Neutral Beam Injection (NBI) system is one of the principal systems for plasma heating. The main issue in current NBI devices is the adoption of a gas neutralizer, whose efficiency for negative ion beams is limited to about 30%. Conversely, the efficiency of a photo-detachment–based NBI system can be as high as 90%. In a gas or plasma neutralizer, the extra electron in the negative ion is detached by stripping, while in photo-neutralizers it detaches by absorbing a visible or near-infrared photon. The main technological challenge is the level of required optical power (several MW), which forbids direct illumination of the ion beam and implies the exploitation of light trapping techniques (*e.g.*, resonant or non-resonant cavities). Therefore, research activities focus on the development of suitable coherent sources and enhancement cavities. The present work discusses the different photo-neutralization concepts so far developed, describing their working principles, advantages and critical points as well as new possible methodologies to realize photo-neutralization for nuclear fusion reactor applications.

Nonstationary signals analysis: New approaches, applications and open problems.

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The analysis of nonstationary signals is, in general, a challenging task. One way to tackle it is to first decompose the signal into simpler components and then analyze them separately. This is the idea behind the Empirical Mode Decomposition (EMD) method, published originally in 1998. EMD had a big impact in many fields of research as testified by the more than 14000 citations (based on Scopus). However, the mathematical properties of EMD and its generalization, the Ensemble EMD, are still under investigation. For this reason, an alternative technique, called Iterative Filtering (IF), was proposed. In this talk, we briefly review these techniques and present new insights into the IF mathematical properties. In particular, we show that computational time can be drastically reduced using in a wise and unexpected way the FFT. We present applications to CSES mission datasets, introduce an extension to handle multivariate or multidimensional signals, and discuss future directions of research.

Spectrophotometric study about scattering surface effects due to nanoparticles deposition on historical paintings.

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The present contribution is aimed at presenting a study concerning the scattering effects on painting surfaces treated with different concentrations of titanium dioxide nanoparticles. The painting mock-ups have been prepared in laboratory with historical pigments and binders and different concentrations of titanium dioxide nanoparticles have been applied on the surface. The optical effects of the presence of the nanoparticles have been studied through the spectrophotometric method. The measurements have been conducted by spectrophotometer equipped with variable angle reflectance accessory and selecting angles from 15° to 60°. From the reflectance values in the visible range (400–700 nm), obtained for each angle, the Y Tristimulus Value has been calculated for the D65 illuminant and the 10° standard observer. The results showed that the preferential angles of scattering changed with the concentration of nanoparticles on the surface of the painting mock-ups.

Modellizzazione di celle solari multigiunzione.

Corso R., Lombardo S.
Consiglio Nazionale delle Ricerche

Le celle multigiunzione rappresentano una soluzione interessante per superare i limiti teorici delle celle a singola giunzione, ormai prossimi al raggiungimento. Viene presentato un modello per determinare l'efficienza di una cella solare a doppia giunzione a stacking verticale basato sul metodo della wave transfer matrix. Questo approccio consiste nell'associare a ciascun elemento del sistema un operatore matriciale che agisce sull'ampiezza del campo elettromagnetico. In questo modo è possibile simulare sistemi arbitrariamente complessi tenendo anche conto delle riflessioni interne al sistema. Partendo da una cella inferiore in silicio, sono stati simulati diversi materiali per la cella superiore e per gli strati intermedi. Per ciascuna configurazione sono state determinate le riflessioni e le trasmissioni verso l'esterno del sistema, l'assorbimento degli strati conduttivi e quello di ciascuno dei due strati semiconduttori, e da questi ultimi la corrente generata dalla cella. Di particolare interesse risulta la modellizzazione del texturing dello strato di silicio. Il supporto economico per l'attività è avvenuto nell'ambito del progetto BEST-4U (codice di contratto ARS01_00519).

Simulazione con FLUKA di un nuovo telescopio Anilina-SiC(4H) per neutroni di 15 MeV.

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Il carburo di silicio (SiC) è un semiconduttore, considerato come una possibile alternativa al silicio per il rilevamento di particelle e fotoni. Le sue caratteristiche lo rendono molto promettente per esperimenti di fisica nucleare in cui la temperatura e l'ambiente di radiazione precludono l'uso di semiconduttori microelettronici convenzionali. Alcuni studi basati sugli effetti dell'irraggiamento di neutroni, protoni e ioni pesanti sui diodi SiC hanno evidenziato l'elevata radiation hardness di questi dispositivi, che mantengono le loro prestazioni dopo irraggiamento ad alte dosi. Le simulazioni in questo studio sono state effettuate con il software Monte Carlo FLUKA. Con esso si è simulato un rivelatore telescopico parallelepipedale con una superficie di base di 25 mm^2, costituito da un primo stadio di anilina (C_6H_7N) e da un secondo stadio silicon carbide (SiC-4H). Sono state provate combinazioni di spessori differenti dei due stadi. Le caratteristiche del fascio di neutroni incidenti erano: energia dei neutroni 15 MeV e fluenza neutronica uguale a 4.45 10^{11} (n/cm^2). Viene valutata la combinazione telescopica migliore.

Catalyst for green hydrogen generation.

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Catalysis and electrolysis are crucial processes for the development of sustainable energy systems, since they enable solar fuel production, such as hydrogen or ammonia, as well as CO_2 reduction. The competitiveness and sustainability of the process are strictly related to the development of efficient and robust catalysts and the reduction of employed amount of noble metals is crucial to reduce the costs. We have adopted electroless deposition by spontaneous galvanic displacement as a simple, low-cost, highly scalable technique and we have found optimal conditions for Pt and IrO_2 deposition on nickel foam. The electrode coverage by the catalyst achieved with such an approach has also a positive impact on its stability, decreasing the degradation rate when compared to the case of bare Ni foam. The average amount of noble metal in the best-performing electrodes is well below the typical values adopted for PEM (Proton Exchange Membranes Electrolyzers). The proposed approach is highly promising for gas diffusion electrodes, and can be implemented in electrolytic cells, as well as in fuel cells. The work has been supported by the European Project PECSYS under grant agreement No. 735218.

Benchmarking of covalently modified graphene-based sensors.

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2D materials show unique physical and chemical properties which can be exploited in several applications, including chemical gas sensors. Among the 2D materials, graphene has attached particular interest and it has started to be used as a sensing element to detect and monitor concentration of different gases. Nevertheless, pristine graphene does not show remarkable performances as gas sensor, and functionalization is often required to improve its sensing capability. In the present study, graphene has been succesfully modified by using diazonium chemistry with different functional groups (NO_2, COOH and Br). After thorough characterization by AFM, Raman, and XPS measurements, one pristine and 3 functionalized graphene layers have been settled on a platform, to simultaneously monitor their response as chemiresistive sensors to selected gas molecules. This allowed us to directly compare the performances of the 4 sensors under the same working condition. Calibration curves for NH_3 and NO_2 exposures have been drawn for each sensor. Benchmarking with data reported in the literature for graphene chemiresistors show that the present layers display a superior sensitivity in the sub-ppm range.

Nuovo protocollo multidisciplinare non invasivo per lo studio di meteoriti tramite spettroscopia gamma con HPGe e tecniche di indagine neutronica su sorgenti impulsate.

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La caratterizzazione fisico-chimica di meteoriti assume una notevole importanza non soltanto dal punto di vista culturale, ma anche nello studio della cosmogenesi e della radiazione cosmica primaria. Un nuovo protocollo per la caratterizzazione delle meteoriti, interamente non invasivo, è stato testato su campioni di prova e validato per confronto con una mappatura Raman e SEM-EDS. Tramite spettroscopia gamma abbiamo stimato l'irraggiamento cosmico del campione, mentre con tecniche basate sulla cattura neutronica (NRCA, NRTI, NAA) abbiamo determinato la composizione elementale del campione. Successivamente, con l'utilizzo della diffrazione neutronica (ND) sono state caratterizzate le fasi cristalline. Queste tecniche, pur avendo peggiore risoluzione spaziale, forniscono ottime sensibilità su metalli e silicati, i principali costituenti delle meteoriti, e sono totalmente conservative, fornendo dunque una nuova possibilità metodologica non invasiva per l'analisi e la caratterizzazione di meteoriti.

Label-free microscopy enhanced by the polarization emission of a Zeeman laser.

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Polarized light scanning microscopy is an advanced imaging modality, which exploits the modification of a predefined polarization state induced by a sample to produce label-free images. This technique provides valuable morphological information about the samples, but its speed is hindered by the standard generation rate of input polarization states. In this work, we propose to overcome this limit by using a Zeeman laser to encode multiple polarization states at high frequency (700 kHz). We introduced this light source into a confocal fluorescence microscope in order to realize a multi-modal imaging setup. We present the theoretical model of our imaging system and its experimental validation using reference samples (birefringent optics and optically active molecules). Furthermore, we demonstrate that our setup can provide imaging contrast within a few μs, a timescale comparable to the pixel dwell time. The resulting polarimetric signal-to-noise ratio is improved, without increasing the complexity of the setup or the acquisition time. Finally, we present the associated Circular Intensity Differential Scattering (CIDS) images with the fluorescence modality of *in situ* chromatin.

Graphene-based tunable terahertz modulators.

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We report on terahertz amplitude modulators using electrolyte-gated graphene single layers placed at a quarter wavelength distance from a reflecting Au film (Salisbury mirror scheme). By exploiting the electric field concentration at the graphene/electrolyte interface, a modulation as high as 45% is achieved in a wide spectral range (1.5–6 THz) with applied voltages in the range [−0.6 V, +0.6 V], which is remarkable considering the small voltages and the atomically thin active region. Graphene-based THz modulators' main advantages are: facile fabrication, low cost and excellent tunability, thus promising for THz system applications.

Sezione VII
Didattica e storia della fisica

Comunicazioni

An educational discussion about the Polchinski's paradox.
Bonacci E.
ATINER, Athens
Time-travel scenarios like the "wormhole billiard ball paradox" have a strong educational impact in physics and are usually solved through causal loops along closed time-like curves (CTCs). We wish to enrich the discussion about the Polchinski's conundrum by exploring the graph isomorphism (GI) related to the low energy collision, with its past self, of an electron leaving a static wormhole at the same time of entrance (as a positron) or before (as an electron). Our GI analysis of the electron CTCs relies on three hypotheses (each raising an open question) and results in Feynman s-channel, t-channel and u-channel diagrams.

Sahara 1960: I fisici italiani tra egemonia culturale e cesura generazionale.
Rossi P.
Dipartimento di Fisica, Università di Pisa
Nel febbraio 1960 la Francia iniziò una serie di esperimenti atomici nel Sahara algerino. La preoccupazione per il possibile fallout radioattivo fu particolarmente viva in Italia, e portò a un'iniziativa del quotidiano L'Unità, organo del PCI, volta alla sottoscrizione di una mozione di denuncia da parte dei fisici italiani. Le firme furono numerose (circa 220) e testimoniano la forte capacità di egemonia del PCI sulla comunità scientifica. Un'analisi dei profili dei firmatari mostra anche l'esistenza di un gap anagrafico, oltre che di status accademico, che separava la generazione formatasi prima della guerra da quella maturata dopo Hiroshima.

STEM e Parità di Genere.
Monetti G., De Luca R.
Università di Salerno
Si relaziona sul percorso didattico interdisciplinare sperimentato nel triennio 2019/2021 volto a sviluppare il tema della Parità di Genere nelle STEM. In particolare, si presentano i tre percorsi didattici svolti, nel triennio, secondo un unico filo conduttore e una stessa logica: fare lezione coniugando un percorso laboratoriale (svolto con metodo IBSE) con un percorso di apprendimento di contenuti non solo tecnico-scientifici ma anche storico-sociologici. La parte comune ai tre percorsi è stata, infatti, la problematica della parità di genere con attenzione particolare al campo delle STEM. Si mostra come ripercorrendo sinteticamente la storia dei premi Nobel assegnati (in fisica son stati 4) e mancati, analizzando le motivazioni storico-sociologiche di tali mancanze e usando l'indagine del DASTtest, del sociologo australiano David Chambers, si può stimolare lo studente alla riflessione e alla introspezione riguardo ad alcuni stereotipi sulle donne e la scienza. Infine, si mostra in dettaglio come i tre percorsi svolti in laboratorio ispirati a Lise Meitner, Maria Telkes e alle donne NASA siano stati progettati come una escape-room a sfondo scientifico.

Il contributo dei fisici nel 1° Congresso Internazionale di Elettro-Radio-Biologia (Venezia, 10-15 settembre 1934).
Bagni E.
Dipartimento di Economia e Management - Università di Pisa
Nel 1934 Bruno Rossi è tra gli organizzatori del Congresso in esame. Una delle sessioni è presieduta dal fisico Compton, con vicepresidente Enrico Fermi. Negli Atti del Congresso

(Cappelli Editore, Bologna, 1935) sono presenti scritti di alcuni fisici, italiani e stranieri, tra i quali tre Premi Nobel per la Fisica [Compton (1927), Marconi (1909), Blackett (1948)], nonché di un Premio Nobel per la Medicina (Adrian, 1932).

Physics Debate. Una sperimentazione ben riuscita di student engagement.

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Physics Debate rappresenta una forma innovativa di coinvolgere studenti su temi di attualità scientifica. L'iniziativa nasce da una sperimentazione, in ambito PLS-Fisica, fatta presso il Liceo Fermi di Ragusa durante il lockdown 2020. Quest'anno l'iniziativa si è estesa a studenti di scuola superiore della Sicilia orientale. Al fine di rendere più efficace l'interazione tra studenti ed esperti, sono stati proposti degli incontri tematici, applicando alle conferenze il metodo della flipped classroom. Una settimana prima di ogni incontro, infatti, gli studenti si documentavano sui temi proposti, tramite video e documenti, potendo così metabolizzare l'argomento ed essere pronti a fare domande agli esperti. Durante i video-dibattiti, 4 incontri a marzo 2021, in un susseguirsi di domande e risposte, gli studenti hanno potuto approfondire i temi trattati. Le numerose domande degli studenti in ogni incontro e l'esito del questionario di valutazione, testimoniano il grande successo dell'iniziativa.

La datazione delle immagini galileiane della Luna.

TUCCI P.
Università degli Studi di Milano

Né nel Sydereus Nuncius (SR) né nei manoscritti galileiani sono indicati il giorno e i tempi delle osservazioni delle 5 immagini telescopiche della Luna pubblicate. In due lavori del 1975 e del 1978 G. Righini datò le immagini della Luna usando metodi puramente astronomici. O. Gingerich sostenne invece che le immagini galileiane erano troppo irrealistiche per poter essere usate in valutazioni quantitative. Nella comunicazione ripercorrerò le varie tappe della discussione fino al 1978 quando E.A. Whitaker pubblicò un'analisi molto dettagliata della problematica. La possibilità di datare le immagini lunari lungi dall'essere un problema puramente astronomico è rilevante dal punto di vista storiografico poiché mette in discussione non solo le abilità osservative galileiane ma anche la sua capacità di argomentare sulla base di sensate esperienze. G. Righini e, in parte, E.A. Whitaker confermarono quanto già T.B. Settle (1961) e S. Drake (1973) avevano evidenziato contrapponendosi all'interpretazione di A. Koyrè© secondo il quale Galilei non avrebbe realizzato gli esperimenti (e le osservazioni, aggiungo io) descritti nelle sue opere.

Figure di Chladni: Engage sulle onde meccaniche stazionarie.

MONETTI G., DE LUCA R.
Università degli Studi di Salerno

Durante il periodo Covid-19 dell'anno scolastico 2020/2021 è stato sviluppato, per gli studenti di Scuola Secondaria di Secondo Grado, un percorso didattico a distanza con metodologia IBSE inerente alle onde meccaniche e al comportamento delle onde stazionarie. La fase Engage è stata implementata mostrando un video sulla formazione delle figure di Chladni, ottenute facendo vibrare, con una corda di violino, una lastra metallica sulla quale è depositata della sabbiolina. Il percorso ha trattato il concetto di onde meccaniche e ristretto il campo alle onde stazionarie in una dimensione, allo scopo di spiegare la formazione delle figure sulla lastra metallica. Con un generatore di onde stazionarie unidimensionali, è stata evidenziata la presenza di nodi e ventri nelle figure ottenute su una corda vibrante a frequenze multiple della frequenza fondamentale. Questa osservazione ha fatto sì che si potesse intuire come, sulla lastra vibrante, la sabbiolina si allontani dalle zone in prossimità dei ventri bidimensionali e si addensi, invece, in prossimità delle linee nodali, dando così luogo alle figure di Chladni. Il percorso didattico è stato svolto in maniera circolare e accattivante.

Werner Heisenberg's retirement and the renewal of General relativity in Germany.

Bonolis L.
Max Planck Institute for the History of Science, Berlin

The interplay of the astrophysical discoveries of the 1960s and the advent of the golden age of General Relativity, in parallel with Joseph Weber's announcements claiming detection of gravitational waves, sparked the entry of Ludwig Biermann's group at the Max Planck Institute for Astrophysics in Munich, into the search for gravitational waves, at the beginning of the 1970s. Archival documents show how, at the same time, on the background of discussions related to Heisenberg's retirement as director of the Max Planck Institute for Physics - especially focusing on the future of the Institute itself - a decision was taken by Heisenberg and Biermann to have the prominent relativist Jürgen Ehlers appointed director of a new Department for gravitation theory and relativistic astrophysics, also aiming at relaunching research in this field in Germany. In this way, the stage was set for subsequent remarkable developments in both experimental and theoretical realms, later culminating in the building of the gravitational-wave observatory GEO600 near Hanover and in the foundation of a Max Planck Institute for Gravitational Physics in Potsdam, the Albert Einstein Institute.

Fisica e Geografia, per una didattica della Imago Mundi.

Giudici S.
Dipartimento di Fisica - Università di Pisa

L'interdisciplinarietà è una caratteristica della Geografia. Basta pensare alla varietà di strumenti che essa impiega nel costruire l'immagine del mondo: da quelli materiali come il teodolite, la bussola, il GPS, a quelli immateriali dell'antropologia e dell'ermeneutica. Esistono, pertanto, molte Geografie: astronomica, matematica, umana, economica, politica e molte altre. Per effetto della sua stessa trasversalità, la disciplina si è frammentata e non mancano allarmi di un sempre più diffuso analfabetismo geografico. Una soluzione può essere quella di sfruttare la complessità della disciplina, discutendo esplicitamente questioni geografiche nell'ambito delle materie che il sapere geografico coinvolge. Una di queste è senz'altro la Fisica, chiamata in causa a partire dalle misure storiche del raggio terrestre fino alla attuale modellizzazione geo-fisica e alle tecniche di geo-localizzazione. L'intervento discute alcuni punti di contatto tra le due discipline ed illustra esempi di percorsi didattici ispirati alla storia della Fisica, in particolare dell'ottica e della geodesia.

Un approccio misto alla didattica digitale integrata per i corsi di ripasso di Fisica al Politecnico di Milano.

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Il Politecnico di Milano organizza da anni i corsi di ripasso in fisica per le matricole dei corsi di ingegneria, con l'obiettivo di sanare eventuali lacune o misconcetti e favorire il successo formativo. Nell'ultimo anno accademico le limitazioni dovute all'emergenza sanitaria hanno spinto a riprogettare completamente i corsi in modalità a distanza adottando forme didattiche diversificate. La struttura del corso, diviso in 8 moduli per nuclei fondamentali, si è articolata in quattro tipi di attività: i) lezioni frontali in streaming non interattive di circa un'ora, fruibili in modo sincrono o asincrono per tutti i circa 1000 iscritti; ii) attività di circa 3 ore, in gruppi virtuali di circa 100 studenti, con esempi ed esercizi svolti da tutor che stimolavano l'interazione tra pari; iii) quiz proposti dai tutor nelle attività di gruppo, con raccolta delle risposte e discussione successiva; iv) forum per interazioni totalmente asincrone con i tutor o il docente referente. Al termine del corso gli studenti hanno espresso un grado di soddisfazione superiore al 75%. Il loro percorso universitario viene monitorato in forma anonima per valutare gli effetti a lungo termine del corso.

Ricerche sulla libbra metrica campione conservata presso la Collezione Instrumentaria delle Scienze Fisiche dell'Università di Ferrara.

Maragno A.
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Nella presente comunicazione saranno indagati molteplici aspetti riguardanti uno strumento di particolare interesse conservato presso la Collezione Instrumentaria delle Scienze Fisiche, compresa nel Sistema Museale d'Ateneo dell'Università di Ferrara: una libbra metrica campione in ottone, contenuta in astuccio di cuoio istoriato con interno in velluto, databile al primo decennio del XIX secolo. Sarà anzitutto fornita una dettagliata descrizione dello strumento, ora oggetto museale. Saranno poi approfondite le motivazioni della sua costruzione e le originarie modalità di utilizzo, sulla base delle numerose riforme dei pesi e delle misure avvenute nell'epoca compresa tra la discesa delle truppe napoleoniche nella Penisola e la nascita del Regno d'Italia. Saranno inoltre esposte le ragioni a sostegno dell'ipotesi che questo strumento abbia rappresentato per lungo tempo lo standard di riferimento collocato nel Municipio di Ferrara e della sua attribuzione al raffinato costruttore ferrarese Pietro Torquato Tasso (1765-1842), del quale sarà presentato un manoscritto inedito.

Teaching quantum mechanics in high schools: A proposal based on Heisenberg's *Umdeutung*.

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In the last year basic principles of quantum mechanics have been widely recognized to play a role also in scientific high school curricula, in order to engage students with modern physics and stimulate their interest towards science and technology. In this contribution we present a simple proposal, based only on 2-vectors and 2×2 matrix algebra, which allows the teacher to introduce main quantum mechanical features, such as non locality and entanglement, without resorting to advanced mathematical tools. The inspiring source of our proposal, as well as its firm theoretical foundation, can be recognized as the famous 1925 *Umdeutung* paper by W. Heisenberg, which provides a simple calculational method to deal with quantum mechanical states and observables, based on the identification of the physical quantities of interest with transition frequencies and amplitudes. Indeed such frequencies and amplitudes form matrices.

Felice Ippolito: A historical tragedy that honors the memory of Edoardo Amaldi.

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1964: led by the CERN co-founder Amaldi, the largest mobilization in the Italian physics history defends Ippolito, former leader of CNEN (now ENEA), unjustly incarcerated and risking a heavy sentence. The accusations are baseless and/or ridicule, a persecution launched by the future president of the republic Saragat and implemented by politicians and judges of questionable integrity. Ippolito is condemned, and Amaldi talks about "a defeat as severe as Caporetto". Whose consequences are catastrophic: the Italian research governance is largely destroyed, becoming vulnerable to politics and bureaucracy. The impact continues even today, including the massive emigration of young talents.

Ottic@home: Un percorso di apprendimento attivo di ottica geometrica e ottica fisica.

De Giorgi M.L., Paladini F.
Dipartimento di Matematica e Fisica "E. De Giorgi"

Nei percorsi di didattica a distanza dell'insegnamento della Fisica, la sfida principale consiste nel coinvolgimento attivo degli studenti nelle esperienze di laboratorio. Nell'ambito dei laboratori PLS di Fisica è stato proposto agli studenti delle scuole secondarie un percorso che affronta numerosi aspetti dell'ottica, geometrica e fisica. Ogni esperienza è stata inizialmente svolta nei laboratori del dipartimento con strumentazione scientifica e seguita in remoto, quindi sono state fornite indicazione per ripetere gli esperimenti a casa con apparati homemade e applicazioni disponibili per smartphone. Successivamente i ragazzi hanno approfondito le tematiche con l'ausilio di simulazioni interattive fruibili on line. La raccolta dei dati sperimentali ha consentito un'analisi rigorosa dei risultati ed una discussione collettiva finale estremante partecipata.

Presentation of the book "Dai quark ai cristalli", Bibliopolis, Napoli.

Srivastava Y.
Northeastern University, Boston MASS USA e Presidente, Associazione Preparata, Roma

A new edition of Giuliano Preparata's book "Dai quark ai cristalli", published by Bibliopolis, Napoli shall be presented, along with the website with activities of the association. An inventory of GP's lectures, notes and papers shall be available soon.

Valutazione dell'efficacia di un corso introduttivo di laboratorio di meccanica con Arduino e smartphone.

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La tematica dell'efficacia dei corsi di laboratorio è di crescente importanza. In questa comunicazione viene descritta la progettazione e la realizzazione di un laboratorio di Meccanica alla Sapienza Università di Roma (primavera 2021). A causa della pandemia, la maggior parte degli incontri è stata in remoto. Le lezioni del corso sono state tenute da un unico docente, mentre per la parte laboratoriale gli studenti sono stati suddivisi in due gruppi, in uno dei quali si sono introdotte tecniche digitali per l'acquisizione e l'analisi dei dati consentendo di svolgere, con un approccio attivo e collaborativo con le Breakout rooms, gli esperimenti da casa. L'utilizzo di tali strumenti è stato facilitato dal docente tramite brevi video e note scritte. Per valutare l'impatto del laboratorio rispetto alle modalità più tradizionali, si è proposto a tutti i turni (prima e dopo il corso) il questionario validato E-CLASS (Colorado Learning Attitudes about Science Survey for Experimental Physics), i cui risultati vengono qui presentati.

Esiste una Early Physics? Frammentazione concettuale e rappresentazioni multiple per l'insegnamento della Fisica nei suoi primi anni curricolari.

BOLOGNA V., PERESSI M.
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Il primo approccio alla Fisica suscita spesso un'esperienza di disorientamento che a volte evolve in disaffezione e opposizione. Un'analisi del PCK degli insegnanti di Fisica in diverse scuole secondarie ha fatto emergere una caratteristica fortemente applicativa degli schemi di interazione tra Matematica e Fisica proposti agli studenti, che non facilita in loro un atteggiamento positivo. Abbiamo quindi accompagnato alcuni insegnanti coinvolti nella ricerca didattica nella revisione dei loro PCK, con particolare attenzione alle difficoltà degli studenti e alla strategia didattica da adottare. L'approccio in fase di sperimentazione è basato sostanzialmente su due assi: la frammentazione concettuale e l'adozione delle rappresentazioni multiple, per promuovere competenze quali la traduzione tra i diversi linguaggi disciplinari e la capacità di argomentazione. Parallelamente il docente sviluppa uno strumento per ampliare gli schemi di interazione interdisciplinare. Le peculiarità di questo approccio e delle sue future implicazioni suggeriscono di chiamare tutte le attività ad esso riferibili come Early Physics, in analogia al ben più noto analogo approccio per la matematica.

A new interpretation of the Antikythera Mechanism.

AMABILE A.
Università degli Studi di Napoli Federico II

In this talk I'll propose an original theoretical framework for the decipherment of the Antikythera Mechanism (AM), independent from Ptolemy's unreliable testimony about his predecessors' astronomical results. Many elements suggest that the astronomical theory mechanized by the AM was a relativistic one, with the sidereal motion of the Sun-Earth system working as a master clock for the description of all the other relevant heavenly motions. Although the phenomenological scope of this theory was probably partially overlapping with Newton's theory of gravity, it is also likely that the notions of absolute space, time and motion had no place in Greek astronomy. This observation suggests that important theoretical clues could be found in the works of Christiaan Huygens, who overcame the inconsistencies of Newtonian mechanics by putting it on a purely relativistic kinematical ground. Moreover, since any plausible Greek astronomical theory has to be cast in geometrical terms, the method of the hodograph, devised by Sir William Hamilton for expressing the Newtonian law of attraction in geometrical language, seems to be a promising candidate for our purposes.

Tracker e Smartphone, due risorse strategiche per una didattica innovativa della Fisica, non solo in tempo di pandemia.

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Lo stato pandemico di questi ultimi anni ha compromesso molte attività di laboratorio, depauperando la didattica della fisica di una sua parte fondamentale. Questa carenza ci ha indotti a istituire, nell'ambito del Piano Lauree Scientifiche-Fisica, un corso di formazione sull'uso di Tracker e lo smartphone per realizzare esperienze di laboratorio anche a distanza. Il corso si è svolto a distanza nei mesi di dicembre/20 e gennaio/21, con la partecipazione di più di 60 docenti delle scuole superiori della Sicilia orientale. L'approccio è stato mirato al "fare" con un metodo peer to peer, con il coinvolgimento attivo dei corsisti. Alla fine del corso è stato somministrato un questionario anonimo di valutazione e autovalutazione, da cui emerge il pieno successo dell'iniziativa. Dopo 3 mesi ne è stato proposto un altro per monitorare l'impatto concreto sulla didattica e sono emersi dati interessanti che confermano l'esisto positivo e incoraggiante del primo test. Molti corsisti infatti hanno già impiegato nella loro didattica quotidiana questi strumenti, mettendoli in pratica anche in modo originale.

"Sperimentare giocando, conoscere sperimentando" mostra interattiva in edizione speciale online LabTop.

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La mostra interattiva di Scienze "Sperimentare giocando, conoscere sperimentando", giunta alla sua ottava edizione, si è svolta quest'anno online nell'edizione speciale LabTop - Laboratori domestici in rete. La mostra, a cadenza biennale, è promossa dall'AIF-Sezione di Giarre-Riposto in collaborazione con la Sezione di Catania e con il Piano Lauree Scientifiche-Fisica. Come nelle precedenti edizioni, gli exhibit della mostra sono esperimenti scientifici ideati e condotti dagli stessi studenti della scuola secondaria (inferiore e superiore), che quest'anno li hanno preparati in casa realizzando pure i video da "esporre" in rete. Alla mostra è stato abbinato un concorso in cui sono stati premiati i video giudicati migliori secondo criteri di originalità, correttezza delle procedure eseguite e della descrizione dell'esperimento, efficacia comunicativa e qualità artistica delle riprese video. È stato previsto anche un premio social ai video più votati dal pubblico. A testimonianza di quanto i giovani si lascino coinvolgere con entusiasmo se opportunamente stimolati, più di un centinaio i video pervenuti, anche da fuori Sicilia, esposti nelle sale virtuali della mostra online.

E pluribus unum: La storia della prima colossale collaborazione scientifica internazionale.

Lovisetti L.
Liceo Scientifico Statale "Nicolò Copernico", Brescia, Italia.

Nel giugno 1761 e 1769, mentre gli stati europei si dilaniavano nelle lotte per l'egemonia coloniale, più di 250 astronomi e studiosi di nazioni diverse diedero vita alla prima impresa scientifica internazionale: l'osservazione del transito di Venere, un evento estremamente raro che, osservato contemporaneamente da località assai distanti, avrebbe permesso di calcolare la distanza Terra-Sole. Un magistrale esempio di come la collaborazione e la condivisione costituiscano due elementi essenziali per il progredire della scienza, ma anche di come la conoscenza e lo studio della storia di un concetto scientifico ci permettano di coglierne appieno il significato attuale.

Principi ed equazioni della fisica.

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Si discuterà il progetto PCTO Principi ed equazioni della fisica del PLS-Fisica della Statale di Milano (8 incontri in remoto più lavoro autonomo per la produzione di video - totale: 23 ore). Scopo del progetto è stato quello di fornire agli studenti occasioni di orientamento e aiutarli a cogliere il fascino e gli aspetti creativi ed emozionanti della fisica in un sorprendente territorio culturale umanistico che identifichi il tema scientifico come un percorso complesso di tipo logico, storico, filosofico, musicale, letterario che descrive il processo di sviluppo dell'intera umanità. "L'amore per le cose nasce dalla conoscenza che hai di esse", Leonardo.

Tecnologie quantistiche e la rivoluzione culturale: Un modulo di formazione insegnanti.

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Una grande sfida che l'Europa sta chiedendo alle università di affrontare riguarda la necessità di coinvolgere le scuole sui temi della seconda rivoluzione quantistica (`https://digital-strategy.ec.europa.eu/en/news/new-strategic-research-agenda-quantum-technologies`). Nel febbraio 2021, l'università di Bologna ha organizzato un corso di formazione insegnanti sulle tecnologie quantistiche. Il corso, realizzato all'interno del progetto IDENTITIES e in collaborazione col progetto PLS, ha coinvolto, per 6 incontri di 3 ore ciascuno, circa 30 persone tra docenti in formazione e in servizio di matematica e fisica. Il corso è stato costruito in coerenza con un approccio interdisciplinare, sviluppato al fine di valorizzare le nuove tecnologie come contesto per: introdurre concetti base di fisica quantistica; formare competenze interdisciplinari e riflettere sul tema scienza e società.

Lab2Go: A project for supporting laboratory practice in teaching STEM disciplines in high school.

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(6) *Istituto Nazionale di Fisica Nucleare, Sezione Torino*
(7) *Sapienza Università di Roma, Dipartimento di Scienze della Terra*
(8) *Istituto Nazionale di Fisica Nucleare, Sezione Roma Tor Vergata*
(9) *Sapienza Università di Roma, Dipartimento di Storia Antropologia Religioni Arte e Spettacolo*
(10) *Sapienza Università di Roma, Dipartimento di Ingegneria Informatica Automatica e Gestionale*
(11) *Istituto Nazionale di Fisica Nucleare, Sezione Cagliari*
(12) *Scuola di Ingegneria, Università della Basilicata*
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The laboratory practice is essential for learning physics and scientific subjects; unfortunately it is often overlooked in teaching. In order to establish a contact between schools and experimental science, Sapienza Università di Roma and INFN launched Lab2Go, an initiative in the framework of Percorsi per le Competenze Trasversali e per l'Orientamento (PCTO) and supported by Piano Lauree Scientifiche (PLS), with the goal of spreading laboratory practice among students and teachers in high schools. Lab2Go was born in Rome and focused on physics, however in just a few years it expanded across Italy thanks to an increasing involvement of INFN and university departments and enlarged its scope to other disciplines (animal biology, botany, chemistry, geology, robotics, scientific museology). Moreover, for preserving the mission of promoting hands-on learning despite the restrictions introduced by COVID-19 pandemic, Lab2Go@Home has been introduced: on-line seminars aimed at showing experiments that can be reproduced at home using easily accessible materials, using resources such as smartphones apps, web tools and devices as the Arduino board.

Measurement of the Planck's constant in the framework of the Lab2Go project.

Casaburo F. [1][2], Marcelli N. [3][4], Sorbara M. [3][4], Agostinelli M. [5], Astone P. [2], Baldassarre F. [5], Brunori F. [5], Crisci S. [5], De Bonis G. [2], De Lucia X. [5], De Pedis D. [2], De Valeri G. [5], Di Sciascio G. [4], Faccini R. [1][2], Falato J. [5], Fraietta V. [5], Fratticci S. [5], Gatto C. [5], Guadagnini S. [5], Oliviero V. [5], Organtini G. [1][2], Passamonti V. [5], Piacentini F. [1][2], Ruggiero N. [5], Salerno M. [5], Tedesco L. [5]
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Aiming at exposing high school students to experimental Physics, Sapienza Universitaà di Roma and INFN participate to the Lab2Go project in the context of PCTO and supported by PLS. In a webinar offered in the framework of the Lab2Go@home initiative (on- line version of Lab2Go), tutors from INFN Roma 2 proposed a method for measuring the Planck's constant by reconstructing the characteristic curve of a LED, acquiring voltage and intensity of current by using a voltmeter and an ammeter, respectively. A similar experiment, but replacing the voltmeter and the ammeter with an Arduino board, was proposed by tutors from Università Sapienza and INFN Roma to students of Liceo Scientifico "L. Trafelli" in Nettuno. The employ of LEDs allows for a simple, but functional, approach to measure the Planck's constant making it accessible to the high school level; moreover, using Arduino for the acquisition of voltage and current enables a fast execution of the experiment and allows students to acquire additional competences, as for example coding and programming. In this report, we will show the two measurement methods and the obtained results.

Il PLS-Fisica-G6 sulla formazione degli insegnanti in fisica: una rete di collaborazioni.

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[12] *Unità PLS Fisica, L'Aquila*
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Il PLS ha fondato una nuova cultura del rapporto scuola-università, ha prodotto innovazione e crescita di competenze. Nell'ultimo anno il Gruppo PLS-Fisica-G6, organizzandosi anche

in sottogruppi, ha svolto 10 diverse attività sulle azioni formative per gli insegnanti,: 1) uno scambio delle esperienze con riunioni frequenti, 2) una indagine sulle caratteristiche delle azioni formative in fisica per insegnanti in tutte le sedi PLS, 3) un convegno di confronto e discussione delle caratteristiche del contributo dato allo sviluppo professionale degli insegnanti di scuola secondaria, 4) una indagine su approcci e modalità formative sulla fisica quantistica, 5) una indagine ed un convegno sull'insegnamento universitario della fisica ai futuri insegnanti di scuola primaria, 6) un corso co-organizzato tra 4 sedi (BS-MI-PR-UD) a Brescia per insegnanti di biennio, 7) uno studio sulla multimedialità nell'insegnamento della fisica, 8) un confronto tra gli insegnamenti di didattica della fisica nei corsi universitari, 9) un repository di materiali per la formazione degli insegnanti, 10) pubblicazioni sul Giornale di Fisica ed a livello internazionale del lavoro svolto. Un programma di condivisione di strumenti, metodi e azioni è pronto per il prossimo PLS.

● Laboratorio di storia della scienza: Un'esperienza in DAD.

Torre M.
Liceo Scientifico "L. B. Alberti", Valenza, AL

Uno dei rischi nella didattica della fisica è il dogmatismo: lo studente accetta passivamente la regola fissa e immutabile che l'insegnante gli trasmette. Questo pericolo si corre quando si fa percepire agli studenti un impianto teorico astratto, privo di legami storico-sociali, dove il ruolo dello scienziato è secondario. Per superare questo problema, è possibile sfruttare le potenzialità degli esperimenti storici. Il contributo descrive una sperimentazione realizzata nell'a.s. 2020-21 (in DAD e in presenza) in una classe 1° Liceo Scientifico Quadriennale, in cui sono stati ricostruiti alcuni esperimenti storici di Galilei e altri esperimenti più "tradizionali". Gli esperimenti "tradizionali" riguardavano la conservazione dell'energia, mentre quelli storici di Galilei il moto dei proiettili e il piano inclinato. La ricostruzione di quest'ultimi si è basata sul famoso manoscritto "Folio 116v" del 1608. L'intento didattico mirava a valorizzare il "fare per capire" attraverso l'uso dei materiali poveri, i quali hanno il grande merito di migliorare l'attivazione di tutti quegli aspetti emotivi e motivazionali suggeriti dalla letteratura pedagogica per il laboratorio scientifico.

● "Sarà giusto?". Sviluppo di competenze di autovalutazione Bayesiana nell'apprendimento della fisica.

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Il senso di smarrimento che gli studenti esprimono quando devono affrontare un problema di fisica di cui il libro di testo non fornisca già un risultato numerico, oppure quando il frutto del loro procedimento non coincide con quanto indicato come soluzione, è spesso causa di frustrazione e di disincentivo allo studio della Fisica, come se essa consistesse appunto solo nella soluzione esatta di problemi matematici invece che nell'acquisizione di uno stile di ragionamento volto alla comprensione della realtà. A questo scopo si sono progettate e costruite alcune attività volte all'introduzione nella didattica di uno strumento noto come Aggiornamento Bayesiano. Tali attività sono state sperimentate durante il percorso di introduzione ai fenomeni ondulatori per alcune classi quarte di un Liceo Scientifico di Trieste. Vengono qui descritte le caratteristiche salienti di questo strumento, sia in termini di efficacia ai fini dei processi di autovalutazione nell'apprendimento e nella costruzione della consapevolezza disciplinare da parte dello studente sia nella possibilità di sviluppi di percorsi interdisciplinari da parte del docente.

Esperimenti con lo smartphone per lo studio della radiazione di un corpo nero in un laboratorio a distanza.

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Presentiamo un'attività sperimentale, proposta durante un corso di laboratorio in remoto e realizzabile con materiale a basso costo, per studiare la radiazione termica. Lo spettro di una lampadina a filamento viene acquisito a diverse temperature utilizzando uno spettroscopio costruito a casa dagli studenti, mentre la misura della temperatura del filamento si ottiene indirettamente dalla variazione della resistenza del filamento. Si sono confrontati due metodi per misurare l'intensità della luce: il primo con il sensore di luce ambientale di uno smartphone, il secondo con lo spettroscopio e la fotocamera dello smartphone. Osserviamo un buon accordo dei dati sperimentali con le previsioni teoriche della distribuzione di Planck nel limite dell'approssimazione di Wien nell'intervallo di lunghezze d'onda che caratterizza la risposta del sensore di luce e della fotocamera dello smartphone.

Highlighting interdisciplinarity between physics and mathematics in historical papers on special relativity: Design of blended activities for pre-service teachers.

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This paper is framed within the Erasmus+ project titled IDENTITIES, whose aim is to develop interdisciplinary teaching materials for preservice teacher education. In collaboration with the research group in STEM education of Crete, a blended module on Special Relativity has been developed. The module is based on an analysis of the original texts by Lorentz, Poincaré, Einstein and Minkowski (written between 1904 and 1908), aimed to recognise the interplay between mathematics and physics implemented in the four papers. The analysis has been carried out by applying the "Boundary Crossing and Boundary Object" research framework developed in 2011 by Akkermann and Bakker. The results of the analysis show that Lorentz Transformation can be read as a Boundary Object and this lens allows for different nuances of the interplay between mathematics and physics to be recognised in the four papers. A series of activities to be conducted in blended mode in a preservice teacher education course have been designed with the goal of exploiting Special Relativity as a context to develop interdisciplinary skills.

Rivelatore portatile di raggi cosmici.

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Lo studio della radiazione cosmica può rappresentare un primo interessante approccio al mondo della fisica delle particelle. Cosmic IT è un rivelatore portatile di raggi cosmici costituito da una valigetta compatta che contiene tre piani di barre scintillanti operanti in coincidenza, l'elettronica e una power bank. Il sistema registra l'istante di arrivo di ogni particella e l'energia depositata nelle barre, quantità acquisite ed elaborate da un Raspberry PI collegato ad un display touch screen. Il sistema, testato in montagna e in volo, è pensato per essere facilmente utilizzabile in ambienti esterni al laboratorio e per stimolanti esperienze didattiche.

Rivelatori di luce Čerenkov per raggi cosmici.

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I raggi cosmici rappresentano il prodotto del più potente acceleratore di particelle che esista: l'Universo. Sfruttando l'effetto Čerenkov è possibile individuare la componente muonica secondaria che giunge fino a terra. Questo intervento descrive lo sviluppo di due rivelatori trasportabili e utilizzabili in ambito didattico, basati su un thermos da cucina e un acquario riempiti d'acqua, accoppiati a fotomoltiplicatori e a un'elettronica che fornisce ampiezza e tempo dell'impulso. Tali rivelatori permettono misure di flusso e, nel caso del thermos, la ricostruzione della direzione di arrivo dei muoni.

Indagare il principio di relatività e il principio di equivalenza nella meccanica classica: Una sequenza didattica basata su esperimenti e simulazioni.

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La relatività classica è un argomento tanto rilevante quanto critico nell'insegnamento della fisica. Sarà illustrata una sequenza di insegnamento-apprendimento sui moti relativi che affronta alcuni aspetti fondamentali come il principio di relatività e quello di equivalenza nella meccanica classica. Per evidenziare concetti chiave selezionati e motivare gli studenti nella loro esplorazione dell'argomento sono state utilizzate attività sperimentali basate sulla videoanalisi e alcune simulazioni interattive, che possono essere modificate al volo dagli studenti. Questi strumenti sono utili per stimolare l'indagine autonoma e a supportare la modellizzazione di diverse situazioni fisiche. La sequenza, strutturata secondo la strategia Predict-Observe-Explain, è stata sperimentata con due gruppi di studenti universitari.

Experimental determination of the educational impact of physics laboratory activities in university courses.

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From the point of view of educational impact, four different ways of carrying out physics experiments have been compared on university students of the Physics course of the first year of Chemistry and Pharmaceutical Technologies of the University of Camerino (Italy). For building the statistical samples and determining the learning achievement in proficiency, agency, and self-awareness, the evaluation tools have been constructed and validated by means of Item Response Theory and Factor Analysis. The statistical experiment analyzed in this work demonstrated that: - the inquiry-based didactic paths, especially if realized in the e-learning modality, reach the maximum efficiency in the knowledge of the topics and student agency; - the didactic paths carried out in the laboratory, especially for the inquiry-based experiments, reach the maximum value in the self-awareness of the acquired knowledge. We have observed the student agency in the construction of original knowledge on the considered topics, as a form of adaptation to the relevant environment, when the didactic path was carried out in an inquiry mode, strengthening similar results reported in the literature on the subject.

Vedere la realtà con gli occhi di Einstein: Uno strumento per l'insegnamento della relatività ristretta.

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La relatività ristretta è ancora un nodo critico nell'insegnamento della fisica nella scuola media superiore italiana. L'impossibilità della teoria di mostrare semplici riscontri quotidiani impedisce di strutturare esperienze didattiche laboratoriali, limitando così l'insegnamento alle sole lezioni frontali. In questo intervento verranno presentati i risultati di una sperimentazione di insegnamento della relatività ristretta con quattro classi di quinto liceo scientifico. In questo progetto è stato utilizzato uno strumento meccanico che consente di spiegare e illustrare in modo visuale le trasformazioni di Lorentz e le loro conseguenze principali. Docenti e studenti hanno potuto affrontare "hands-on" fenomeni come la perdita di simultaneità o la dilatazione dei tempi.

What next? Giovani che raccontano il futuro.

BALOSSINO I.
INFN Ferrara

Aprire le porte dei nostri laboratori, farne uscire la fisica agli acceleratori e spiegarne scopi, tecniche e impatto sulla società; oggi e, soprattutto, nel futuro. Invitiamo i giovani, cittadini del futuro, a scoprire la fisica delle alte energie nelle nostre sedi e vivremo con loro una giornata di curiosità e ricerca. Sfrutteremo il punto di vista dei giovani per spiegare il futuro della fisica con un approccio diretto di condivisione che verrà sintetizzato in un cortometraggio. Questa comunicazione presenterà il progetto dell'INFN "What Next! Giovani che raccontano il futuro" a cui partecipano 17 sedi e laboratori in tutto il territorio nazionale.

Epidemics Spreading: An Educational Proposal for High School Students.

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Over the centuries, the investigation of epidemic spreading has become increasingly scientific and interdisciplinary, resulting in the last years in computational epidemiology. Here an educational proposal to high school students is promoted. It comprises a seminar, where theoretical modelling of epidemic spreading and its solution using differential equations is shown, and the explanation of a Python simulation of a N-particle Random Walk in a 2D box, with a disease spread dynamics. This independent simulation highlights how behaviours of different classes of the population are compatible with the theoretical models. This allows to show how, though with two quite different approaches, typical tools and methods of physics and in general of science, make us understand the peculiar features of epidemic phenomena. Moreover, they show how these models can provide predictive indications.

PLS-Fisica: Stage e laboratori per la didattica e l'orientamento formativo.

TOSI S.
Dipartimento di Fisica, Università di Genova

Un sicuro successo perseguito dal Piano nazionale Lauree Scientifiche (PLS) è stato l'aver introdotto modalità innovative nel raccordo Scuola-Università. Gli stage e i laboratori rappresentano da sempre un'ossatura fondamentale del PLS-Fisica. Allo scopo di fare il punto della situazione e di condividere linee di indirizzo per la progettazione delle future edizioni, il PLS-Fisica ha organizzato per luglio 2021 il workshop "Stage e laboratori per la didattica e l'orientamento formativo in fisica". La comunicazione riassumerà i risultati e le discussioni scaturite durante il workshop, raccogliendo spunti e suggerimenti, per identificare le buone pratiche da mantenere e per individuare i punti critici su cui è opportuno intervenire e apportare miglioramenti.

Equilibrio di genere nei corsi di laurea in Fisica: Risultati di un'indagine PLS.

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Nell'ambito del PLS i gruppi di ricerca delle Università di Bologna, Messina, Pavia, Torino e Trento hanno attivato una riflessione sul tema del genere. In questo gruppo di lavoro ci proponiamo di analizzare due aspetti: la bassa numerosità di studentesse in ingresso alla laurea in Fisica e il loro perseguimento di una carriera post-laurea. Per indagare questi aspetti sono stati costruiti alcuni strumenti di indagine: due questionari, uno rivolto a studentesse e studenti di scuola secondaria l'altro alle matricole dei corsi di Fisica, e sono stati raccolti alcuni dati sulla distribuzione di genere relativamente alle iscrizioni ai corsi di laurea e ai dottorati. Nella comunicazione si presenteranno i risultati del lavoro.

Un corso di tutorato sviluppato nell'ambito PLS fisica per supportare la didattica in remoto.

Testa I.
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La pandemia da Covid-19 ha profondamente colpito l'università, costringendo ad una rapida transisizione alla modalità didattica remota. Molta attenzione è stata posta all'organizzazione dei corsi in remoto e all'utilizzo di approcci metodologici che potessero massimizzarne l'efficacia. Molta meno attenzione è stata posta ai corsi di tutorato, con la conseguenza che spesso tali corsi sono stati soppressi o ridotti a mere ripetizioni delle lezioni di teoria. In questa comunicazione presenteremo un corso di tutorato sviluppato nell'ambito PLS-FISICA Napoli per il corso di laurea di ingegneria in cui si è sperimentato l'utilizzo delle break-out rooms di Microsoft Teams per riprodurre in ambiente virtuale il lavoro di gruppo. Guidati da un tutor, gli studenti venivano suddivisi in rooms composte da 5-6 studenti ciascuna e ad ogni stanza veniva dato un trittico di problemi diversi. Gli studenti dovevano discutere i problemi nelle room e riportarne la soluzione in plenaria. La sperimentazione è stata efficace in quanto circa il 70% degli studenti che seguivano il corso di tutorato ha poi superato l'esame al primo tentativo.

The contribution of a game in learning quantum mechanics concepts: A pilot study with secondary school students.

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Quantum physics in secondary school is a challenge involving the need that teachers may gain competences overcoming the traditional narrative approach to quantum theory, that the young generations gain conceptual understanding of the main concepts of the theory, and that citizens be aware about quantum technologies involved in everyday-life devices and in those, like quantum computers, which are going to invade the market. On the other hand, games designed with educational purpose can be powerful tools to boost cognitive experiences and creative thinking, implying the voluntary attempt to overcome obstacles and push one's limits without fearing failures. Here, we report a pilot study including a very short intervention module on the concepts of quantum state, properties, measurement, superposition, and entanglement, combined with playing the quantum version of the game TiqTaqToe available at `www.qplaylearn.com`. The context is a voluntary group of 24 students of different age levels of a Scientific Lyceum in Treviso. We discuss the outcomes of such a learning environment, based on the qualitative analysis of students' answers to two open questions questionnaires.

● Formazione degli insegnanti di scuola primaria sulle basi dei circuiti elettrici in continua.

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La formazione su temi di fisica dei futuri insegnanti di scuola primaria è una sfida da affrontare sulla base della ricerca didattica sui concetti stessi. In epoca di Didattica a Distanza l'attivazione degli studenti è stata stimolata mediante questionari concettuali in-out, basati su una proposta didattica sui circuiti elettrici messa a punto nell'ambito dei Laboratori CLOE dell'Unità di Ricerca in Didattica della Fisica dell'Università di Udine ed integrata da documentazione di sperimentazioni sulla conduzione elettrica con ragazzi di 7-12 anni. Si presentano i risultati delle risposte ai questionari, che offrono il quadro delle esigenze formative dei futuri insegnanti di scuola primaria.

● Dalla chimica quantistica alla fisica classica: Martin Karplus e l'approccio computazionale al sistema a tre corpi nella reazione (H, H_2).

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Il 1964-1965 fu un periodo cruciale nell'attività di ricerca di Martin Karplus quando, piuttosto inaspettatamente, lo scienziato si avvicinò alla dinamica delle reazioni di scattering

usando un'approssimazione quasiclassica con l'aiuto delle tecnologie informatiche. Questo evento segnò un allontanamento dagli studi di risonanza magnetica nucleare che, fino ad allora, avevano caratterizzato il suo lavoro. Ciò portò Karplus, in modo innovativo e in forte controtendenza rispetto al resto della comunità scientifica di allora, a studiare la dinamica della reazione di diffusione (H, H_2) partendo da un background quanto-meccanico e utilizzando, nell'approssimazione adiabatica, la meccanica newtoniana. In questa comunicazione s'intende discutere il modo in cui Karplus operò, commentando la rilevanza dei suoi studi quantistici e quasiclassici e il ruolo che essi hanno avuto, con un'impronta marcatamente interdisciplinare all'interno delle scienze fisiche, nello sviluppo delle simulazioni fondamentali al computer.

Una sfida in Percorsi per le Competenze Trasversali e l'Orientamento che continua verso traguardi sempre più alti.

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Liceo Scientifico Leonardo da Vinci di Treviso e Università degli Studi di Udine

La collaborazione tra Università di Udine ed liceo scientifico da Vinci di Treviso nella progettazione e implementazione di PCTO, iniziata nell'a.s. 2016/2017, è continuata fino ad oggi, sebbene in una più complessa situazione di didattica a distanza, riuscendo a garantire altissima qualità anche con modalità a distanza. L'Università si è posta come datore di lavoro per gli studenti chiamati ad effettuare una consulenza su ricerca e sviluppo per l'individuazione di soluzioni a problemi didattici, come la ricerca di APP per cellulare efficaci per l'apprendimento della fisica e come mondo con cui fare ricerca sui processi di apprendimento. Sono state fatte proposte basate su responsabilità degli studenti singoli e in gruppi. L'adesione è stata crescente; nel corrente a.s. hanno partecipato 6 classi terze e 5 classi quarte impegnate in attività di laboratorio su temi curricolari con interessanti e nuove occasioni di approfondimento e effettiva possibilità di personalizzazione. Gli studenti hanno mostrato grande spirito di iniziativa e intraprendenza, riuscendo a realizzare esperimenti originali, efficaci anche su tematiche ambientali. Nessuno si è astenuto e il livello medio è alto.

(Ri)scoprire la bellezza di insegnare fisica. Un corso di formazione per insegnanti in servizio.

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"(Ri)scoprire la bellezza di insegnare fisica" è la prima proposta condivisa del gruppo G6 "Formazione Insegnanti" del PLS-Area Fisica. Dopo aver organizzato diversi corsi presso la propria sede, i responsabili locali del PLS-Fisica dell'Università Cattolica, di Udine, di Milano e di Parma hanno voluto condividere l'esperienza maturata negli anni di PLS e confrontarsi su contenuti, approcci e metodi, progettando e organizzando un corso di formazione a più voci. Il corso, suddiviso in cinque incontri ed erogato da remoto, ha fornito conoscenze e competenze per l'insegnamento di alcuni argomenti di Fisica. Due le tematiche scelte: i moti e i fluidi in equilibrio. Oltre agli aspetti teorici, è stata dedicata particolare attenzione alla parte di preparazione di percorsi didattici, che partendo dai nodi concettuali aiutassero i docenti nella pratica didattica. Divisi in piccoli gruppi, i docenti hanno discusso, eseguito misure e raccolto dati su alcuni esperimenti chiave per la co-progettazione di un percorso didattico sui temi scelti. Il questionario PCK, somministrato e discusso poi con i partecipanti, contribuirà ad arricchire la ricerca in didattica su queste tematiche.

Dalla termodinamica ai sistemi complessi: Analisi di una proposta didattica sui cambiamenti climatici per sviluppare abilità di pensiero sistemico.

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Lo studio del sistema climatico sta acquisendo sempre maggiore rilevanza tra i giovani, anche grazie alla risonanza mediatica che ha avuto negli ultimi anni. In questo contributo verrà presentato un percorso didattico sperimentato in una classe quarta liceo in cui si è scelto di analizzare il sistema climatico attraverso il passaggio dalla termodinamica ai sistemi complessi. Saranno mostrati i passaggi chiave della ricostruzione disciplinare in prospettiva didattica del nesso tra termodinamica e complessità. Tra gli strumenti didattici, verrà analizzato il ruolo del videogioco ChangeGame, prodotto dal Centro euro-Mediterraneo sui Cambiamenti Climatici, per sviluppare competenze di pensiero sistemico.

Sulle spalle dei giganti: Un'esperienza di PCTO su Guido da Vigevano.

Ferraris C., Torre M.
Università di Pavia

Si presentano i risultati di un'esperienza di PCTO, svolta nell'a.s. 2020-21 interamente in DAD, con 100 alunni di un Liceo Scientifico e Artistico. L'esperienza didattica mirava a far conoscere e diffondere l'importante figura di Guido da Vigevano, scienziato, medico e ingegnere del XIII secolo le cui opere hanno ispirato e preceduto (da un punto di vista artistico e raffigurativo) quelle di Leonardo da Vinci. L'intero percorso verteva, in particolare, sull'opera "Le macchine del re" che è stata analizzata dai ragazzi dal punto di vista storico, architettonico, ingegneristico, fisico e artistico, spingendoli a riflettere sul superamento dicotomico tra discipline umanistiche e scientifiche.

I Principi della Dinamica: Presentazione di un progetto didattico per la scuola superiore.

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Università degli Studi di Milano

Presentiamo un percorso didattico sui tre Principi della Dinamica per studenti delle scuole superiori di indirizzo non scientifico. Esso è stato progettato nel corso "Preparazioni di Esperienze Didattiche 1" per il corso di laurea magistrale in Fisica della Statale di Milano e sperimentato in una classe terza Liceo delle Scienze Umane. Discuteremo punti di forza e criticità del percorso nel quale l'insegnamento è stato prevalentemente Inquiry e supportato da esperienze di laboratorio; i Principi della Dinamica sono stati illustrati in ordine inverso rispetto alla trattazione tradizionale e le lezioni pensate e svolte sia in presenza sia a distanza.

Introducing Probabilistic Analysis to Physics and Mathematics Students Through Contagion Models.

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Building off of the pandemic, students' awareness of the basics of epidemic dynamics can be tapped to extend the discussion to physical problems and settings, e.g., reaction-diffusion systems such as pollution models, chemical reactions, evolutionary processes, that are often taught as stochastic processes, but without including numerical experiments and model building. We discuss an epidemiological model for measles diffusion that can be used to introduce students to how to model linear processes and the qualitative features induced by nonlinearity. We recommend ways to compare deterministic and stochastic approximations, especially the Gillespie algorithm, that develop probability (and noise) concepts through very

simple numerical implementations that show the limits of both. We show a demonstration case of a variation that includes the efficiency of a vaccine, and a dynamical population, but the same approach can be used, for example, to present what a variant of a disease means according to the epidemiological model, leaving opened the possibility to build a multidisciplinary project. This is just an inspiration for the teachers to introduce personalized modifications.

Sperimentazione di ricerca sulla meccanica quantistica: Un impegno concettuale conclusosi con un gioco.

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Due classi del Liceo Scientifico Leonardo da Vinci di Treviso sono state impegnate per 8 ore sui fondamenti della meccanica quantistica con un approccio a due stati basato sulla polarizzazione ottica. Al termine hanno giocato un torneo con Tic Tac Toe di QPlay Learn sul principio di sovrapposizione e l'entanglement, cercando di creare strategie di gioco dalla conoscenza dei concetti. Il percorso ha preso avvio da esplorazioni sperimentali sulla polarizzazione ottica e la legge di Malus. L'ipotesi della luce come fotoni ha portato a riconoscere la polarizzazione come proprietà del singolo fotone e a introdurre le proprietà mutuamente esclusive e incompatibili. Lo stato come vettore ha acquisito ruolo nella identificazione del formalismo adatto a descrivere un sistema a due stati ed è stato identificato nel suo ruolo assieme a quello di misura, distinguendolo da quello di proprietà considerando interazioni di fotoni con polaroid e cristalli birifrangenti. Il principio di sovrapposizione e le sue conseguenze sono state esaminate concettualmente e formalmente. Tre test hanno sondato gli esiti di apprendimento. Un questionario finale ha esaminato il percepito e il gradimento.

PLS-Fisica-G6: Indagine sulle iniziative di formazione degli insegnanti in fisica quantistica.

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(2) *Unità PLS Fisica dell'Università degli Studi Roma Tre*
(3) *Unità PLS Fisica dell'Università degli Studi di Pavia*
(4) *Unità PLS Fisica dell'Università degli Studi di Udine*

Nell'ambito del Piano Lauree Scientifiche (PLS), area Fisica, si sono costituiti dei Gruppi di Lavoro: uno di essi (G6) si è focalizzato sulla formazione degli insegnanti ed un suo sottogruppo ha posto attenzione ai corsi svolti dalle sedi PLS per insegnanti di scuola secondaria sulla fisica quantistica. Riassumiamo e discutiamo i risultati di un'indagine svolta, tramite questionario, che ha indagato la metodologia utilizzata nella progettazione e nello sviluppo dei corsi per insegnanti su tale tema, sulle conoscenze e sulle competenze acquisite dai docenti, e sull'impatto che tali corsi possano aver avuto o potranno avere sull'insegnamento della meccanica quantistica a scuola.

Progettazione e validazione psicometrica di un questionario per misurare la partecipazione degli studenti alle attività del PLS.

Testa I., Tricò F., Costanzo G., Parlati A.
Dipartimento di Fisica - "E. Pancini" - Università Federico II, Napoli

Si descrive la progettazione e la validazione di uno strumento multidimensionale di valutazione delle attività del Piano Nazionale Lauree Scientifiche (PNLS). Lo strumento è stato validato con un campione di circa 900 studenti partecipanti alle attività condotte nei PLS di Biologia, Chimica e Fisica dell'Università Federico II di Napoli. Le analisi fattoriali esplorative e confermative suggeriscono una struttura a 5 fattori che caratterizzano la partecipazione al PLS: 1) soddisfazione per le attività seguite, 2) utilità futura delle attività seguite; 3) difficoltà incontrate durante le attività seguite; 4) coinvolgimento familiare e degli amici nelle attività seguite; 5) ansia provata durante le attività. I cinque fattori correlano significativamente con la scala di motivazione nella partecipazione alle attività. Sono inoltre significative le correlazioni tra i punteggi nelle varie dimensioni dello strumento e l'intenzione di iscriversi a corsi di laurea coerenti con il PLS seguito. Lo strumento può essere facilmente sottomesso al termine delle attività PLS e fornire risultati affidabili sulla qualità delle stesse attività.

Online learning of physics during a pandemic: A report from an academic experience in Italy.

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(2) *Dipartimento di Fisica, Università degli Studi di Cagliari, Italy*
(3) *Laboratorio Scienza, Dipartimento di Fisica, Università di Cagliari, Italy*
(4) *Dipartimento di Pedagogia, Psicologia e Filosofia, Università degli Studi di Cagliari, Italy*

The arrival of the Sars-Cov II has opened a new window on teaching physics in academia. Frontal lectures have left space for online teaching, teachers have been faced with a new way of spreading knowledge, adapting contents and modalities of their courses. Students have faced up with a new way of learning physics, which relies on free access to materials and their informatics knowledge. We decided to investigate how online didactics has influenced students' assessments, motivation, and satisfaction in learning physics during the pandemic in 2020. The research has involved bachelor ($n = 53$) and master ($n = 27$) students of the Physics Department at the University of Cagliari ($N = 80$, 47 male; 33 female). The MANOVA supported significant mean differences about gender and university level with higher values for girls and master students in almost all variables investigated. The path analysis showed that student-student, student-teacher interaction, and the organization of the courses significantly influenced satisfaction and motivation in learning physics. The results of this study can be used to improve the standards of teaching in physics at the University of Cagliari.

Riscoprire semplicemente sperimentando.

Dodero G. (1), Bregante M. (1), Grosso D. (2), Cotrufo A. (1), Cavicchi V. (3)
(1) *IISS Liceti - Rapallo*
(2) *Dipartimento di Fisica - Genova*
(3) *Liceo Calini - Brescia*

Semplici e veloci esperimenti o misure fatte con materiali di uso comune svelano la realtà di numeri e costanti apprese, ma mai verificati. Tali esperimenti svolti dai singoli studenti del biennio delle superiori, meravigliosamente svelano dall'analisi statistica dell'insieme di dati di classe la loro significatività.

SVolgere Esperimenti nei LAboratori di MIlano-Bicocca (SVELAMI-B): Laboratori fisici a distanza.

Di Martino D. (1)(2), D'Alfonso L. (1)(2), Penati S. (1)(2)
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SVELAMI-B ha offerto attività di approfondimento in ambito STEM a bambini/e di scuola primaria e a ragazzi/e di scuola secondaria di secondo grado, interamente in didattica a distanza, a partire da famose scoperte di donne scienziate. L'obiettivo era di valorizzare le potenzialità di apprendimento delle materie scientifiche, con attenzione al divario di genere, partendo da una progettazione multidisciplinare condivisa (dalla fisica, alla matematica, all'informatica, alla geologia, alla scienza della formazione). Verranno analizzati alcuni interventi condotti (principalmente sui temi "luce", "forze" e "misteri dell'Universo") e gli sviluppi possibili per la progettazione di nuovi interventi scolastici a partire da una comunità di pratica.

Le visite all'AstroGarden di Roma Tre dalla presenza all'online.

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Negli ultimi mesi molte attività didattiche svolte tradizionalmente in presenza sono state proposte in modalità online, fornendo spesso occasione di creare strumenti utili e innovativi. In questo talk descriveremo una visita a distanza al giardino astronomico di Roma Tre, l'AstroGarden, che negli anni ha ospitato studenti di diverse età. Il video, creato per la Notte Europea dei Ricercatori, si è poi trasformato in un strumento utile anche per svolgere sia attività strutturate in percorsi con gli studenti delle scuole superiori sia modalità di formazione nell'ambito dei corsi di scienze della formazione primaria.

Esplorare la Fisica Moderna: Videolezioni per la scuola superiore.

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In questo intervento descriverò alcune videolezioni realizzate dal Dipartimento di Matematica e Fisica di Roma Tre per introdurre alcuni aspetti di Fisica Moderna agli studenti di scuola secondaria superiore. I video, usati nel corso delle attività PLS svolte in questo periodo di attività a distanza, trattano diversi argomenti, dal concetto del tempo alla Relatività Ristretta e Generale, ai fenomeni più affascinanti previsti dalla Meccanica Quantistica.

Scelte universitarie degli studenti partecipanti al PLS-Fisica di UniSalento.

Maruccia Y., De Giorgi M.L., Ventura A.
Università del Salento
Il Piano Lauree Scientifiche (PLS) di Fisica dell'Università del Salento promuove percorsi formativi di orientamento per studenti delle scuole superiori delle province di Lecce, Brindisi e Taranto, finalizzati a favorire le immatricolazioni nei corsi della classe di laurea in Scienze e Tecnologie Fisiche. In questo lavoro si presenta uno studio statistico, basato su informazioni ottenute tramite sondaggi dedicati, mirato a conoscere le carriere universitarie intraprese dagli studenti che, negli ultimi dieci anni, hanno frequentato i Laboratori PLS di Fisica di UniSalento. Gli esiti delle scelte sono discussi sia rispetto alla tipologia di corso universitario, sia rispetto all'area geografica dell'ateneo di immatricolazione, studiandone l'evoluzione temporale anche rispetto al genere. L'efficacia dell'azione di orientamento è stimata attorno al 10% rispetto al totale degli studenti salentini coinvolti. Si tratta di un dato significativo se si considera che a livello nazionale gli immatricolati ai corsi di area fisica sono mediamente inferiori al 4% rispetto agli immatricolati nei corsi di laurea STEM, e dell'ordine dell'1% rispetto a tutte le aree disciplinari (fonte Anagrafe MUR).

Un percorso introduttivo di meccanica quantistica realizzato in didattica a distanza nell'ambito del PLS.

Giuliana G. (1), Marzoli I. (2), Scotti di Uccio U. (3), Testa I. (3)
(1) *School of Advanced Studies, University of Camerino*
(2) *Scuola di Scienze e Tecnologie, Università degli Studi di Camerino*
(3) *Dipartimento di Fisica "E. Pancini", Università Federico II*

Nell'ambito del P.L.S. Fisica dell'Università Federico II, è stato sperimentato un percorso didattico introduttivo di M.Q. di circa 9 h, per studenti volontari dell'ultimo anno di licei di Napoli e provincia. La metodologia è di tipo inquiry-based in DAD, implementata utilizzando le breakout Rooms di Teams. Il percorso ha trattato: quantizzazione dell'energia; concetto di azione; gli orbitali: rappresentazione, stabilità. Le breakout rooms hanno permesso di implementare efficacemente il lavoro in gruppi di 4-5 studenti. Essi dovevano rispondere, dopo ampia discussione, e limitati interventi del tutor, a domande aperte e a risposta multipla in stile tutorial, utilizzando anche rappresentazioni grafiche, fornite in schede di lavoro, su aspetti concettuali e quantitativi. Seguiva il dibattito tra gruppi per correggere le risposte e sistematizzare i concetti. I risultati del test per valutare l'apprendimento, composto da domande a risposta multipla con richiesta di giustificazione, in parte adattate dalla letteratura al percorso, in parte create ex novo, hanno mostrato un miglioramento rispetto a quelli ottenuti in ingresso. Nella comunicazione saranno presentati dettagli e risultati.

I raggi cosmici visti sott'acqua: Un'attività didattica di OCRA INFN.

Liguori D., Schioppa M., Reino W.
Liceo Scientifico "Patrizi" di Cariati e Gruppo collegato INFN di Cosenza

Studiare i raggi cosmici equivale a rivolgere l'attenzione verso una moltitudine di fenomeni naturali, alcuni ancora sconosciuti, che avvengono nell'Universo. Prima di raggiungere i nostri strumenti posti sulla superficie terrestre i raggi cosmici primari interagiscono con l'atmosfera formando gli sciami atmosferici estesi, e le particelle secondarie che giungono nei rivelatori sono il risultato di queste collisioni. Con strumenti semplici ed economici è possibile misurare il loro rate e gli effetti che produce uno strato d'acqua posto sopra al rivelatore, come fece Pacini quasi un secolo fa. In questa attività gli studenti affrontano un processo complesso in cui rivelando le particelle dello sciame sott'acqua indagano sulla loro natura.

Dal fulmine al laboratorio: L'insegnamento della fisica alla fine del XIX secolo attraverso lo studio delle lezioni di Augusto Righi.

Zavarise M., Bertozzi E.
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Augusto Righi fu senza dubbio uno dei migliori fisici italiani della sua epoca, soprattutto per la sua capacità di sperimentatore in diversi ambiti della fisica. Oltre a questo, Righi fu un abile divulgatore e docente come mostrato dai diversi strumenti inventati appositamente per le sue lezioni. Tra i documenti conservati presso l'Archivio del Dipartimento di Fisica e Astronomia di Bologna sono presenti parte degli appunti originali del primo corso libero tenuto da Augusto Righi a Bologna: "Fenomeni fisici dell'atmosfera e fenomeni fisici del corpo umano". In questa presentazione vengono illustrati i contenuti di tale corso, mostrando come essi permettano di discutere l'uso della fotografia scientifica per scopi didattici e la creatività del Righi nell'utilizzare in modo non convenzionale apparati inizialmente pensati per altri scopi. Questi manoscritti dell'ultimo decennio del XIX secolo non solo offrono un punto di vista privilegiato sulle modalità di insegnamento di Righi, ma anche un punto di partenza per l'analisi dell'insegnamento della fisica in Italia di fine '800 e del ruolo dell'Università di Bologna nel panorama scientifico italiano ed europeo.

PLS-POT-Progetto ORIENTAZIONE: Realizzazione di un MOOC di Fisica.

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(2) *Dipartimento di Fisica e Astronomia "Ettore Majorana" - Università di Catania*
(3) *Consorzio Interuniversitario Sistemi Integrati per l'Accesso, Pisa*
(4) *Dipartimento di Biologia, Ecologia e Scienze della Terra - Università della Calabria*

I Piani Nazionali PLS e POT, con il supporto del CISIA, collaborano per l'attuazione del progetto denominato ORIENTAZIONE, finalizzato a sviluppare un ambiente web per la realizzazione e fruizione di strumenti e azioni in tema di orientamento e tutorato, con particolare riferimento all'autovalutazione e all'apprendimento in autonomia degli studenti delle scuole secondarie. Tra gli strumenti dei quali è prevista la realizzazione, un ruolo centrale è rivestito da alcuni MOOC disciplinari, la cui struttura è basata sui rispettivi "Quadri di Riferimento", già elaborati dalle competenti Commissioni. Il MOOC di fisica, il primo in ordine di tempo tra quelli di nuova realizzazione, presenta marcati caratteri di originalità che lo distingueranno nel panorama degli "strumenti di istruzione di massa" in lingua italiana dedicati alle scienze empiriche. Nella presente comunicazione viene illustrato il progetto del MOOC, e lo stato dei lavori della Commissione Disciplinare incaricata di realizzarlo in collaborazione con Federica Web Learning.

Il Nuovo Cimento in the changing landscape of physics: A network-historical analysis.

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Max Planck Institute for the History of Science, Berlin, Germany

In the last years, historians have increasingly turned to network concepts and methods for analyzing historical sources and assessing past dynamics. Our group has further extended these approaches by applying multi-layer network techniques to the study of recent science combining social network analysis, citation network analysis and the analysis of the knowledge space generated by scientific publications. This approach, called socio-epistemic networks, is particularly useful to evaluate the role of specific journals in the general system of knowledge production. In this talk, we use this approach to analyze the changing position of Il Nuovo Cimento in the global field of physics through the 20th century. We investigate how the role of the journal of the Italian Physical Society developed both in the publications' co-citation network and in the knowledge space of topics created by all physics journals indexed by on-line repositories. By comparing these results with those retrieved from the analysis of Physical Review journals, this approach allows to highlight the specificities of Il Nuovo Cimento and to identify crucial moments of transformation.

Premio Asimov.

Puggioni C. (1), Mura D. (1), Tuveri M. (1), Lissia M. (1), Masoni A. (1), Bellagamba L. (7), Cecchi C. (3), Galati G. (5), Leone S. (10), Papa A. (4), Radici M. (6), Silvestris L. (11), Ventura A. (8), Vigezzi E. (9), Vissani F. (2)
(1) *INFN Cagliari*
(2) *INFN Laboratori Nazionali del Gran Sasso e GSSI L'Aquila*
(3) *Universit à degli Studi di Perugia e INFN Perugia*
(4) *Universit à della Calabria e INFN Cosenza*
(5) *Universit à di Bari Aldo Moro*
(6) *INFN Pavia*
(7) *INFN Bologna*
(8) *Università del Salento e INFN Lecce*

([9]) *INFN Milano*
([10]) *INFN Pisa*
([11]) *INFN Bari*

Il Premio ASIMOV, giunto alla sesta edizione, è un progetto rivolto alle scuole superiori per avvicinare i ragazzi ai libri di argomento scientifico, tramite un approccio attivo alla lettura. La commissione scientifica è formata da docenti di istituti superiori ed universitari, ricercatori di enti di ricerca, scrittori, giornalisti, studenti di dottorato e amici della cultura scientifica e seleziona una cinquina di libri. Gli studenti discutono le proposte con gli insegnanti, scelgono uno dei libri, lo votano e producono una recensione, che viene a sua volta valutata dal comitato scientifico. Il libro vincitore viene scelto dai voti degli studenti. Ma anche gli studenti, autori delle migliori recensioni, sono premiati e presentano i libri in pubblico. Opportuni strumenti informativi permettono il coordinamento dei numerosissimi partecipanti e una efficiente gestione dei contributi. Grazie alla collaborazione di 650 professori da quasi 200 scuole di tutta Italia e centinaia di ricercatori, la partecipazione al Premio ASIMOV è cresciuta negli anni, arrivando a contare diecimila studenti nell'ultima edizione, ben tre volte di più della precedente edizione.

Kahoot nelle attività di orientamento per la fisica.

Di Blasi M.
Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Italia

In questo intervento illustrerò un percorso realizzato dal Dipartimento di Matematica e Fisica dell'Università Roma Tre per trattare temi di fisica, astronomia e matematica con studenti della scuola secondaria di secondo grado. Il percorso, che ha coinvolto classi di 7 diversi licei romani, svolto interamente online, è stato molto apprezzato dagli studenti. Infine, porterò le mie considerazioni sull'efficacia del percorso grazie ai dati raccolti con Kahoot, che, oltre a potente strumento di intrattenimento, si è rivelato anche un buon mezzo di analisi.

MAL di scienza.

Venturini S. ([1])([2]), Aimè C. ([1])([2]), Aurelio D. ([3])([4])([5]), Budassi E. ([1])([2]), Maragnano D. ([1]), Montagna P. ([1])([2]), Pirola M. ([1])([2]), Restelli S. ([1]), Santostasi D. ([6]), Zatti L. ([1])
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([2]) *INFN Sezione di Pavia*
([3]) *Liceo "Copernico" Pavia*
([4]) *Liceo "Taramelli" Pavia*
([5]) *Liceo "Galilei" Voghera* ([PV])
([6]) *Liceo "Cairoli" Vigevano* ([PV])

Si presenta un breve corso di aggiornamento per insegnanti proposto dal gruppo "Physics4Teenagers" in ambito PLS-Fisica a Pavia, denominato "MAL di scienza" (MAL = musica, arte, letteratura) e volto a favorire l'interdisciplinarietà del sapere e a superare il dualismo tra cultura umanistica e scientifica. Esso illustra sotto molteplici punti di vista l'apporto di fisica e matematica in ambiti normalmente ritenuti "umanistici": tecniche di indagine spettroscopiche e nucleari utilizzate per lo studio dei beni culturali, basi fisiche del suono e degli strumenti a risonanza (corde e fiati), curiosità matematiche in letteratura e vincoli matematici rigorosi nella tecnica poetica. I tre seminari, pur proposti online, insistono il più possibile su aspetti laboratoriali (spesso penalizzati in didattica soprattutto a causa di percorsi di formazione degli insegnanti troppo teorici), fondamentali per favorire la partecipazione attiva e la curiosità degli studenti e per creare collegamenti tra la realtà circostante e materie come matematica e fisica. La risposta dei docenti è stata molto positiva in termini sia di partecipazione (>100 presenti a ogni incontro), sia di gradimento.

Valutare in fisica con i test?

MAROCCHI D. (1), GROSSO P. (2), PORCU F. (1), SERIO M. (1)
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(2) *I.T.I.S. Pininfarina, Moncalieri (^{TO})*

La valutazione formativa richiede l'utilizzo di strumenti valutativi differenziati che monitorino i diversi aspetti dell'acquisizione di conoscenze e competenze degli studenti. Classi numerose e limitate ore a disposizione del docente richiedono strumenti rapidi, efficaci e in larga parte condivisibili. I test a risposta multipla, arricchiti con alcune domande aperte, possono rispondere a queste esigenze? Li abbiamo sperimentati per valutare l'assimilazione di concetti di fisica di base, come l'interpretazione di grafici in cinematica. La ricerca si è svolta con studenti di età e percorso formativo diversi, in stretta collaborazione con i docenti, primi "esperti" nell'arte della valutazione.

OCRA INFN: Il percorso online per scoprire i raggi cosmici.

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(3) *Laboratorio Nazionale del Gran Sasso LNGS, Italia*
(4) *Laboratorio Nazionale del Sud LNS, Italia*
(5) *Dipartimento di Fisica, Università La Sapienza di Roma, Italia*
(6) *Dipartimento di Matematica, Università di Salerno, Italia*
(7) *Università di Sassari, Italia*

OCRA (Outreach Cosmic Ray Activities) è un progetto INFN per la realizzazione e la condivisione a livello nazionale di attività di public engagement nel campo della fisica dei raggi cosmici dedicato a docenti e studenti. Sul sito di OCRA è possibile familiarizzare con i raggi cosmici e cimentarsi nell'analisi dei dati raccolti con esperimenti divulgativi o da veri e propri esperimenti. Si possono studiare i muoni rivelati dal telescopio-Totem nella metropolitana di Napoli o dal Cosmic Ray Cube, sempre a portata di cellulare grazie all'apposita app. Si può studiare il flusso di raggi cosmici al variare dell'altitudine o sotto il livello del mare. Si possono, infine, ripetere le misure dell'Osservatorio Pierre Auger, il sito più grande al mondo per lo studio dei raggi cosmici di altissima energia, utilizzando i dati pubblici. Sul sito è anche possibile consultare lo spazio dedicato ai docenti dove si trovano indicazioni metodologiche per sviluppare i percorsi in classe ed integrarli nell'attività curricolare. Inoltre, durante questa primavera, è stato attivato un corso di aggiornamento che ha fornito ai docenti ulteriori informazioni tecniche e strumenti didattici.

PLS-Fisica-G6: La formazione in fisica per i futuri insegnanti di scuola primaria in Italia.

DE ANGELIS I. (1), CLAUDIO C. (2), IMMÉ J. (3), MICHELINI M. (4), PAGLIARA S. (5), SABBARESE C. (6), STRAULINO S. (7)
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(2) *Unità PLS Fisica dell'Universitdì Palermo*
(3) *Unità PLS Fisica dell'Universitdì Catania*
(4) *Unità PLS Fisica dell'Universitdì Udine*
(5) *Unità PLS Fisica dell'UniversitCàttolica di Brescia*

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A 20 anni dall'istituzione del corso di laurea in Scienze della Formazione Primaria abbiamo deciso di avviare un'analisi degli insegnamenti di didattica della fisica, comunque denominati. Allo scopo è stato predisposto un questionario a cui hanno risposto 30 colleghi di 22 sedi. La necessità di approfondire le impostazioni date a questa nuova sfida per la formazione in fisica ci ha portato a proporre un convegno in cui le 8 esperienze più mature e differenziate venissero illustrate in dettaglio in seduta plenaria e il confronto mirato all'intesa sui nodi culturali e professionalizzanti portasse ad individuare principi condivisi e criteri di progettazione e conduzione di quella formazione dei futuri insegnanti nella nostra materia, che li rende capaci di rispondere ai quesiti curiosi dei bambini e organizzare ambienti di apprendimento attivo con un'impostazione che costruisce conoscenza scientifica. Uno specifico comitato scientifico ha elaborato le questioni da approfondire, che sono state discusse in 4 gruppi di lavori paralleli. I lavori del convegno si sono arricchiti di ulteriori 16 contributi. Gli esiti del convegno saranno oggetto di un numero speciale del Giornale di Fisica.

Effetti dell'istruzione a distanza dovuta all'emergenza pandemica causata dal COVID-19 sugli studenti universitari di fisica in Italia.

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Si presentano i risultati di uno studio che ha coinvolto un campione di 362 studenti universitari italiani di fisica, a cui abbiamo chiesto di valutare retrospettivamente la loro esperienza di didattica a distanza attivata in conseguenza dell'emergenza dovuta al COVID-19. Lo studio ha riguardato il benessere psicologico, la motivazione, la percezione sulla propria vita accademica, l'attitudine nei confronti della fisica e dei fisici, oltre che la percezione complessiva dell'esperienza della didattica a distanza. I risultati mostrano un apprezzamento generale per l'organizzazione e dell'efficacia dei corsi online. Tuttavia, l'insegnamento online ha avuto un impatto negativo sull'engagement e sull'interazione tra studenti e con i docenti. In particolare, il 22% degli studenti ha lamentato un disagio psicologico dovuto alla didattica a distanza. Inoltre, si è riscontrata una significativa diminuzione da parte degli studenti dell'interesse verso la fisica come disciplina e della confidenza nelle proprie capacità. Infine, sembra emergere negli studenti un atteggiamento più pessimista nei confronti delle prospettive di lavoro legate alla fisica.

Relativity from Galilei to Einstein: A reflection.

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A century after its postulation, Einstein's theory of (special) relativity appears to be consolidated and supported by several experiments. Therefore, it ought to become a fundamental pillar of a physics course addressed to high school or undergraduate students, instead of a being a mere exotic item that is only accessible to brilliant and gifted minds. The study of special relativity and, more generally, the study of modern physics becomes a paramount issue since it revisits and gives an insight of many features on classical physics. Moreover, modern physics plays an important role in shaping a student's general knowledge. The aim of the presentation is to offer an non-traditional discussion of the key ideas of the theory of (special) relativity. By using an axiomatic-deductive approach, the evolution of the basic concepts, such as synchronisation, simultaneity and causality, will be revisited, starting from Galilei and Newton's theorisations to Einstein's.

Meteo Open Data @ School.

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Nell'ambito dell'educazione alle tematiche ambientali si propone la realizzazione di una rete di scuole per la misura di grandezze meteorologiche e del livello di inquinamento con strumentazione a basso costo. Il progetto prevede una prima fase per la costruzione delle centraline di rilevamento nelle scuole del secondo ciclo che prevedano attività curricolari o di PCTO, attraverso schede tipo Arduino associate a sensori per la rilevazione di parametri ambientali unitamente alle concentrazioni delle polveri sottili e altri inquinanti. I dati raccolti saranno condivisi in modo da realizzare un archivio regionale di Open Data disponibili per unità didattiche su analisi e rappresentazione dei dati. La seconda fase prevede attività in verticale su scuole di diversi ordini: gli alunni più grandi realizzeranno centraline di rilevazione con schede micro:bit e l'uso della programmazione a blocchi, i più piccoli saranno coinvolti nella progettazione degli alloggiamenti delle centraline, da realizzare poi con stampa 3D. Si è realizzata una parte della prima fase con un nucleo di scuole e saranno presentati gli elementi significativi del percorso e dei risultati ottenuti.

Il laboratorio di Fisica nel recupero del Learning Loss.

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Si presentano i risultati relativi all'insegnamento della Fisica post DAD finalizzata al recupero del Learning Loss e della socialità di classe. L'attività è stata proposta, nella fase di rientro post DAD, prevalentemente mediante esperienze di laboratorio strutturate con l'utilizzo di materiale povero e integrato con strumenti in dotazione della scuola con metodologia Cooperative Learning. L'intervento del docente in modalità di lezione frontale èstata limitata a interventi di 10-15 minuti, tempistiche dei video-tutorial, nei quali sono stati trasmessi i nodi concettuali dell'argomento e/o sono proposti esercizi per astrarre e modellizzare. Le sperimentazioni sono precedute da materiali di preparazione caricati sulla piattaforma digitale per offrire continuità al percorso formativo in DDI. La restituzione delle esperienze di laboratorio avviene attraverso presentazioni digitali di gruppo, invece che con relazioni scritte, come occasione di esercizio di public speaking per costruire un ambiente di apprendimento nel quale gli studenti sono chiamati a esporre oralmente. L'attività svolta ha permesso di recuperare fragilità e criticità e sperimentare nuove pratiche di insegnamento.

A proposal for teaching quantum and statistical physics on Einstein's footsteps.

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We outline a proposal for introducing advanced high school students to some fundamental concepts of quantum physics, by taking inspiration from the seminal papers by Einstein

where they were introduced. The Ariadne thread is the quantum theory of thermal radiation, described by Planck's law, and the concepts at issue are light quanta, wave-particle duality, and probabilistic, causality violating processes. A possible way of introducing the needed statistical tools, again inspired by some of Einstein's papers, is proposed as well. The latter proposal, suitably complemented, can be independently adopted to teach the rudiments of statistical physics, building upon elementary kinetic theory.

Particle Therapy International Masterclass: La prima esperienza italiana.

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Per la prima volta l'Italia ha partecipato all'International Particle Therapy Masterclass, evento formativo promosso dall'International Particle Physics Outreach Group. Scopo dell'iniziativa è di avvicinare gli studenti alla fisica applicata alla medicina per la terapia del cancro mediante radioterapia convenzionale e non, mostrando loro l'importanza della ricerca di base nel suo impatto sulla società ed in particolare sulla salute dell'uomo. La mattina è stata dedicata all'introduzione delle applicazioni della fisica alla salute e ad una visita virtuale del Centro Nazionale di Adroterapia Oncologica di Pavia (CNAO); nel pomeriggio, dopo l'introduzione del s/w matRad per la preparazione di un piano di trattamento -TP-, i ragazzi hanno realizzato in prima persona un TP su uno specifico organo. Infine, hanno presentato i loro risultati in un incontro virtuale internazionale organizzato al CERN con altri istituti del mondo e in presenza di esperti. In questo contributo, verrà presentata questa ricca e stimolante esperienza che ha reso "ricercatori e ricercatrici" per un giorno ventidue studenti selezionati da diverse scuole della Lombardia e della Calabria.

Educazione Civica Scientifica: Un percorso didattico sulle basi fisiche del cambiamento climatico.

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La mancanza di un'adeguata conoscenza scientifica può incidere notevolmente sulle scelte dei cittadini, con conseguenze gravi sulla nostra capacità di affrontare le grandi sfide globali come il Cambiamento climatico. L'educazione Civica Scientifica (ECS), la parte basata sull'alfabetizzazione scientifica della recentemente reintrodotta educazione civica, deve avere un ruolo centrale nella scuola del futuro. Discuteremo la rielaborazione di una TLS sulle basi fisiche dell'effetto serra in cui il lavoro di riprogettazione è stato volto ad affiancare agli aspetti disciplinari temi più tipici della ECS e del rapporto con la scienza. Verranno presentati i risultati di alcune sperimentazioni con studenti a diversi livelli di istruzione e messe a fuoco le relazioni tra conoscenza scientifica e consapevolezza civica.

Italo Federico Quercia, dalle misure di raggi cosmici nel dopoguerra con lo Stormo Baltimore all'ordinariato a Catania.

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Quercia, figura di rilievo nel panorama scientifico italiano dal dopoguerra alla fine degli anni ottanta, si occupò di ricerche sui raggi cosmici e di elettronica, partecipò attivamente alla realizzazione dell'Elettrosincrotrone di Frascati, in funzione nel '59. Ordinario di Fisica sperimentale a Catania, divenne in seguito direttore dell'Istituto e ne ricoprì anche la cattedra di Fisica molecolare. Rivestì ruoli dirigenziali per il CNEN, l'INFN ed ebbe incarichi scientifici dal CNR. Questo contributo, nell'anno del centenario della sua nascita, il 25 gennaio 1921, descriverò i primi lavori dedicati alla misura dei raggi cosmici e alcuni passaggi della sua carriera scientifica e accademica.

Misurare l'accelerazione di gravità a casa con lo smartphone: È veramente così facile?

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Negli ultimi anni diverse fonti hanno proposto gli smartphone come potenti laboratori portatili ed accessibili a tutti per svolgere numerosi esperimenti di Fisica. Tuttavia i risultati di tali esperimenti sono molto difficili da trovare, lasciandone incognito il livello di accuratezza. In questo lavoro sono stati confrontati quantitativamente i valori del modulo dell'accelerazione di gravità determinati da esperimenti basati su smartphone, di complessità progressivamente crescente. Si è partiti dalla semplice determinazione del tempo di caduta di un grave da una singola quota, per poi analizzare la dipendenza del tempo di caduta dalla quota iniziale e, infine, la legge oraria del moto ricavata dal suo filmato. Il tempo di caduta è stato misurato utilizzando l'accelerometro interno dello smartphone, il cronometro acustico della app PhyPhox, il video della caduta e un kit didattico professionale, per confronto. Verranno discussi i punti di forza e i punti critici dei vari metodi, basandosi sia sull'accuratezza dei valori di g che sulla semplicità dell'esperimento, al fine di valutare i metodi più adatti all'esecuzione in autonomia da parte di sperimentatori dilettanti.

I laboratori PLS ai tempi della pandemia.

Montalbano V.

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La pandemia ha avuto conseguenze importanti nelle attività del Piano Nazionale Lauree Scientifiche (PLS). Dalla chiusura repentina delle scuole al divieto di gite di istruzione, dall'impossibilità di accesso in alcune scuole alla riconversione dei laboratori in aule per garantire il distanziamento sociale, e soprattutto la didattica a distanza alternata a didattica in presenza nei modi più vari, hanno richiesto sforzi organizzativi di docenti e referenti per mantenere metodologie ed obbiettivi del PLS. La stessa struttura organizzativa del PLS ha subito un cambiamento in emergenza eliminando il coordinamento tra le sedi universitarie. La riorganizzazione conseguente ha privilegiato azioni diverse da una sede all'altra ma le difficoltà a realizzare attività laboratoriali hanno interessato tutti. Alcune soluzioni individuate nella coprogettazione con gli insegnanti verranno descritte, sottolineando gli aspetti che possono arricchire i laboratori PLS anche in un futuro non pandemico.

Orazio Specchia: Fisica e cultura a cavallo di due guerre.

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In questo contributo verrà discussa l'opera scientifica del fisico Orazio Specchia, a sessanta anni dalla sua morte. In particolare, verrà posto l'accento sulle prime ricerche compiute all'istituto fisico di Bologna e sull'opera di riorganizzazione delle attività di didattica e di ricerca durante il suo lungo periodo di ordinariato catanese (1933-1941). Verranno infine discussi i contributi dati da Specchia allo sviluppo ed alla diffusione dell'importante rivista culturale "L' Arduo", di cui egli fu condirettore con Bruno Biancoli e Sebastiano Timpanaro.

Progetto raggi cosmici.

Rozza D. per la Collaborazione OCRA
INFN - Laboratori Nazionali del Sud e Università degli Studi di Sassari

I raggi cosmici sono un ottimo argomento di fisica moderna per la formazione degli studenti, in particolare quelli delle scuole secondarie superiori. Infatti, la loro trattazione coinvolge differenti aspetti della fisica, ma anche diverse discipline. In questo progetto, seme della collaborazione INFN-OCRA, gli studenti degli ultimi due anni delle superiori affrontano i grandi temi della ricerca in fisica dei raggi cosmici, analizzano dati sperimentali e si accenna a temi trasversali come: l'analisi degli errori, le distribuzioni di probabilità, i viaggi spaziali, il danno biologico, le applicazioni geologiche.

Coordination and support action for Quantum Technology Education in Europe - QTEdu CSA.

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We are currently living through the Second Quantum Revolution, where the scientific knowledge based on Quantum Theory is used to develop new technologies. In 2018 European Commission launched the Quantum Flagship initiative to support the technology transfer from the research laboratories to industry. This challenging transition requires bringing together research institutes, universities, companies, and policy makers in a collaborative ecosystem. Its fundamental ingredient is education that starts from promoting the citizen awareness and engagement and continues with training programs for pupils, students and professionals. The European quantum technology community proposed a well defined education agenda and the Coordination and Support Action for Quantum Technology Education (QTEdu CSA) was born within the Quantum Flagship to respond to its needs. We present the work done by the QTEdu CSA team in the first year of the project. It covers the building up the education community network, online repositories creation, construction of a competence framework for quantum technologies, and the development of pilot programs to support pan-European synergies.

Simulazioni tra fisica, sistemi complessi e società: Un laboratorio PLS per studenti di scuola secondaria.

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Le simulazioni computazionali sono strumenti sempre più fondamentali non solo nel campo scientifico ma anche in ambito sociale, come base per decisioni politiche. Per questo a gennaio-febbraio 2021 è stata progettata e realizzata a Bologna la prima edizione di un laboratorio PLS online rivolto a studenti di scuola secondaria sulle simulazioni di sistemi complessi. Particolare rilevanza è stata data al molteplice utilizzo delle simulazioni in fisica, per poi riflettere sugli aspetti interdisciplinari e il valore delle simulazioni basate su agenti per costruire scenari futuri di problemi reali. Nella comunicazione, si illustrerà la struttura del percorso e i principali risultati raggiunti.

Progetto LabEx Bicocca: Tra i Buchi Neri e le Onde Gravitazionali.

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LabEx è un laboratorio interattivo di Fisica Sperimentale, situato presso il Dipartimento di Fisica dell'Università degli Studi di Milano - Bicocca, il cui scopo è avvicinare gli studenti della scuola secondaria di secondo grado al metodo scientifico, promuovendo la conoscenza della Fisica. Le esperienze proposte vengono selezionate sulla base della loro importanza nella storia della Fisica Moderna e/o per l'alto apporto didattico che possono offrire attraverso il loro significativo contenuto fisico e scientifico. Un esempio, tra i tanti, è l'esperienza sulla Relatività Generale, in cui, utilizzando un telo e delle biglie, è possibile accompagnare lo studente attraverso la scoperta della gravitazione, fino ad arrivare alla fisica dei buchi neri e delle onde gravitazionali. Immediatezza e interattività sono essenziali nella fruizione dell'esperienza, garantendo allo studente non solo le nozioni basilari per la comprensione del fenomeno, ma anche stimolandolo all'analisi critica di quanto osservato.

Stelle di neutroni: Star del XXI secolo.

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Presentiamo qui un percorso/laboratorio didattico, strutturato in 5 moduli Google sviluppato nell'ambito del PLS Fisica della Statale di Milano come un percorso di Active Learning a distanza con attività di autoapprendimento e successiva discussione con esperti. Esso si compone di 5 attività, con domande, lavoro su dati originali presi dalla ricerca da parte dei partecipanti, brevi spiegazioni teoriche, immagini e video. Lo scopo è stato predisporre una attività di formazione insegnanti che allo stesso tempo offra un tema di ricerca contemporanea all'avanguardia e una metodologia di apprendimento attivo. Discuteremo brevemente i risultati ottenuti nella sperimentazione pilota della primavera del 2021.

Sulle potenzialità dell'utilizzo del notebook jupyter nella didattica della fisica.

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La diffusione del Covid-19 ha attirato l'attenzione anche della popolazione studentesca verso la possibilità di descrivere il diffondersi dell'epidemia mediante modelli matematici adeguati. Grazie ai dati messi a disposizione dalla Protezione civile è nato un percorso interdisciplinare che è stato concretamente proposto a studenti degli ultimi due anni di studi presso il Liceo "B. Russell" di Roma, il Liceo Scientifico "T. Taramelli" e il Liceo Classico "U. Foscolo" di Pavia nel mese di maggio dell'A.S. 2019-2020. Presentiamo il percorso svolto in relazione anche alla possibilità di introdurre Python più in generale nella didattica della fisica.

Docenti come mediatori tra scienza e società: Il curriculum in Didattica e Storia della fisica dell'Università di Bologna.

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In una società accelerata e complessa, sempre più intrisa di scienza e tecnologia, la ricerca educativa si sta interrogando su come trasformare temi STEM in strumenti di lettura della realtà per giovani e cittadini di oggi. In questa prospettiva, la figura del docente acquisisce un ruolo chiave di mediazione tra scienza e società che necessita di competenze specifiche per essere formato. Nella comunicazione, si introdurrà il modello di formazione di futuri docenti costruito sui progetti I SEE, IDENTITIES e SEAS e messo in atto nel curriculum di Didattica e Storia della fisica, del corso di Laurea Magistrale in Physics di UNIBO.

Applications of "reconceptualised family resemblance approach to nature of science" to high school physics teaching.

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Into the Nature of Science (NOS) research field, I carried out two studies, by using a well-known framework in science education: Reconceptualized Family resemblance approach to Nature of science (RFN) by Erduran and Dagher (2014). The framework has been used to investigate the presence of NOS elements in physics guidelines adopted by the "Liceo Scientifico" high school in Italy. The study highlighted a significant presence of epistemic and cognitive aspects of science, in contrast to a scarce presence of social and institutional aspects of science. Through an Epistemic Network Analysis on the connections between the NOS categories in the guidelines, an impoverishment of categories, in the transition from general to specific section has emerged. The second analysis used RFN to investigate how a sample of five physics teachers implemented, in their teaching, NOS elements related to epistemic and cognitive practices. The results highlighted the great relevance that these elements can have to boost understanding in the discipline, to authentically engage students with physics, and to develop cultural and emotional skills crucial for becoming a responsible citizens.

Models based on interacting particles.

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Particle systems are a physics model at the basis of the representation of many natural phenomena. We will see how to realize and how to use particle systems with different SW technologies and we will discuss the results of some simulations.

A fascinating illusion: Francesco Puccinotti and electrovital currents.

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In 1839, the physician and medical historian Francesco Puccinotti (1794-1872), with the help of the physicist Luigi Pacinotti (1807-1889), attempted to measure the existence of

electrovital currents in live warm-blooded and cold-blooded animals using a Nobili's astatic galvanometer. The experimental demonstrations took place in Pisa in the morning of October 13, 1839, as part of the 1st Congress of Italian Scientists. Two committees elected by Congress discussed the experimental results of the experiments. This significant episode generated a broad scientific debate, even after the Congress, and contributed to developing in Italy the birth of electrophysiological studies.

Transients in electric circuits with Raspberry Pi and Python.

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Raspberry Pi (Rpi) can be used as a powerful lab tool for educational experiments on transient phenomena in electric circuits: we propose an approach in which almost all the needed hardware, even the power supply, for running the experiments and for data acquisition is included in the compact RPi device. Furthermore, all the codes to carry out the experiments and to analyze the data, can be realized step by step during the practical sessions using simple Python scripts and open source libraries. Successful tests can be carried out on RC and RL circuits with inexpensive components. The data acquisition rate is suitable to observe also eye-catching profiles such as the damped oscillations in RLC circuits, and high quality plots of the results can be produced with the Matplotlib module of the Python language. On the other hand, Python can be used to choose optimized values of the parameters R, L, or C, with respect to the features of the experimental setup.

From wave-particle duality to quantum state description: An online activity for high school students.

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The main purpose of our research is to design, in collaboration with physics teachers, learning activities about the nature of quantum objects. In the context of electron diffraction experiment, the concept of quantum state and the Born's interpretation of the wave function support students in the transition from classical to quantum description of electrons. We present the results of the teaching-learning activities held online in April 2021 with two Liceo Scientifico classes (44 students). We collected the students' analysis of experimental data and their answers to a pre-post questionnaire based on the Quantum Physics Conceptual Survey.

Il laboratorio ai tempi del covid: Progettazione e sperimentazione di un home kit.

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Gli esperimenti reali hanno un ruolo imprescindibile nella formazione degli studenti. Nella gestione dei laboratori in remoto, il principale obiettivo è proporre agli studenti esperimenti significativi che consentano un'analisi rigorosa. Per raggiungere questo obiettivo è stato progettato, realizzato e distribuito un kit personalizzato di esperimenti "casalinghi", adatti ai contenuti di un corso di Laboratorio e progettati per soddisfare gli obiettivi di apprendimento sia specifici del corso che quelli generali di un corso sperimentale. Il kit è stato sperimentato e, nella prospettiva che questo tipo di Kit possa essere utilizzato a scuola, è stato realizzato del materiale didattico che possa accompagnare i docenti nello svolgimento di alcune attività legate al kit elaborato.

Un'ottica differente - vedere l'infinitamente piccolo.

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In questo contributo descriviamo una proposta di Teaching Learning Sequence (TLS) che affronta alcuni aspetti fondamentali dell'ottica geometrica ed ondulatoria con un approccio IBS. La sequenza didattica si ispira ad una delle idee chiave delle nanoscienze - *Tools and Instrumentation*: parte dalle peculiari proprietà di un materiale funzionale commerciale e a basso costo, il Geckotape, per introdurre il concetto di *Struttura è Funzione*, e la conseguente importanza di indagare le proprietà strutturali microscopiche dei materiali. La TLS segue due percorsi didattici paralleli per l'ottica geometrica ed ondulatoria, prevedendo sia la costruzione e la taratura di un microscopio, sia l'utilizzo della diffrazione come mezzo per determinare le proprietà strutturali del Geckotape. Si impiegano inoltre app di simulazione, reperibili on line, per favorire l'apprendimento attivo, sia in presenza sia a distanza, e sopperire ad eventuali carenze nella dotazione dei laboratori didattici. La sequenza è stata testata in alcuni PTCO e ben si presta allo sviluppo delle competenze trasversali.

Franco Selleri revealed: What the archives told us.

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I have re-built the role of the Italian physicist Franco Selleri (1936-2013) in the Italian and international scientific and epistemological debate on elementary particle physics, foundations of quantum mechanics and foundations of the theory of relativity. By previewing his complete archives, full of extensive correspondence with world-famous scientists and a series of oral history interviews, I have investigated his scientific and popular activities, closely linked to and influenced by the historical, social and political context in which he worked, from the 60's to the beginning of the second decade of the 21st century.

Principi di Fisica per Filosofi, un corso particolare.

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Negli ultimi anni ho tenuto un Corso di Fisica agli studenti del corso di Laurea in Filosofia della Sapienza. L'esigenza di questo corso è nata da una serie di caffè scientifici tenuti alla Sapienza nel 2007. Da questi incontri appariva che gli studenti di Filosofia, bravi e preparati nel loro campo, non conoscevano spesso quale fosse il percorso storico-concettuale della fisica da Galilei ai giorni nostri. Non conoscevano in particolare gli sviluppi avvenuti nell'ultimo secolo in Relatività Speciale e Generale e in Meccanica Quantistica, o, se li conoscevano, ne avevano spesso un'idea parziale o distorta. L'idea è stata quindi di creare un corso rivolto a studenti dei corsi di laurea non scientifici che presentasse, in forma semplificata ma matematicamente corretta, i Principi della Fisica. Parlare dei Principi ci permette di evitare le trattazioni formali necessarie per discutere tutti i temi e le leggi che compongono il corpus della fisica. Da questo corso è nato poi un libro (Fisica per Filosofi, ed. Carocci 2021) che ai temi trattati unisce delle schede storico-filosofiche scritte da un filosofo, Paolo Pecere di Roma Tre, che per ogni capitolo discutessero di "cosa intanto ne pensavano i filosofi".

Indice per autori

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Indice dei Presidenti di Seduta

Sezione II
Fisica della materia

Addendum Comunicazioni

Interplay of orbital ordering and charge density wave in kagome superconductor RbV_3Sb_5.

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Recently discovered vanadium-based kagome metals AV_3Sb_5. (A = K, Rb, Cs) host competing electronic orders, charge density order, superconductivity, orbital ordering and offer the chance to explore their interplay. We performed extensive nuclear magnetic resonance (NMR) measurements in a RbV_3Sb_5 single crystal. We used DFT calculations to determine ab-initio quadrupolar interactions. The phase transition associated with orbital ordering is shown in the NMR spectra below the temperature T* ≅ 103 K. It is related to the formation of a 2x2 superstructure, which breaks the translational symmetry with a $2a_0$ period, propagating along 3 lattice directions. This symmetry breaking promotes a charge-density wave (CDW) phase. NMR provides a wealth of additional information. We shall describe these results in the framework of a complex interplay between orbital and CDW physics in the kagome superconductors.

Generalized continuous-time quantum walks and how to exploit them.

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Continuous-time quantum walks (CTQWs) on graphs are now a paradigmatic model in quantum technologies, for their ability to simulate several stochastic natural processes that seem to exploit quantum coherence, such as excitonic transport in photosynthetic bio-complexes, but also because they provide a universal model for quantum computation. Recently, a generalization of the Hamiltonian generator of CTQWs has been proposed under the name of chiral CTQWs. We fully characterize this generalization by a comparison with their classical counterparts, and we quantify the difference between the quantum and the classical evolution by a quantum-classical distance. Through this figure of merit, we devise a method to systematically build optimal chiral continuous-time quantum walks on graphs for topology-dependent tasks, e.g. quantum transport and quantum uniform mixing. We successfully apply it to cycle graphs, quantum switches, hypercubes and complete graphs. On the latter, we uncover a chiral evolution that achieves quantum search to the speed limit, improving the constant factor of Grover's algorithm, and fast uniform mixing.

Sezione III
Astrofisica

Errata Corrige

Original abstract published in this volume at page 249.

The atmospheric emission for CMB ground-based experiments.

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The CMB radiation is one of the most important observables to probe the very early stages of the Universe.This radiation represents the Universe only 380000 years after the Big Bang. The model of the Universe accepted by the whole scientific community relies on the Inflation Theory. This model predicts an expanding Universe as the result of a superluminal expansion that had happened during the very early stages of its life. The inflation theory also predicts the formation of Primordial Gravitational Waves that modified the metric imprinting a particular pattern on the polarization directions of the CMB's photons that were linearly polarized by the continuous Thomson scattering with the primordial plasma. The polarization signal is very faint, and the cosmological information coded into the large angular correlations suffers from significant spurious contribution of the systematic effects that are difficult to take under control. In this presentation, I am going to present the systematics spurious contribute introduced by the atmosphere for CMB ground-based observations and possible mitigation techniques to reduce this effect.