Abstracts and Author Index

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Orthodox Academy of Crete
Kolympari - Chania - Greece

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STATISTICAL PHYSICS
2008

International Conference in ΣΤΑΤΙΣΤΙΚΗ ΦΥΣΙΚΗ

Editors
G. Kaniadakis and A.M. Scarfone

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The nonequilibrium Ehrenfest gas: A chaotic model with flat obstacles?

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The tools of statistical mechanics and billiards theory are essential to study transport phenomena in models of physical systems at or away from equilibrium [1,2].
Dispersing Sinai billiards are chaotic systems with singularity [3], but is unknown whether billiards at non-equilibrium with focusing and/or flat obstacles are chaotic and the current analytical techniques seem not suitable to answer this question since they uses the fact that obstacles are dispersing [4]. The Ehrenfest gas with electric field and Gaussian isokinetic thermostat is a model where the obstacles are rhombi, hence flat, [5]. The presence of flat boundaries and the external field may suggest that nearby trajectories are always focused, so that the overall dynamics should be not chaotic. However, it is not obvious that this is the case for all values of the electric field. Numerical investigations, starting with random initial conditions and considering the electric field in different ranges, show that the asymptotic behaviour of the system is either chaotic, periodic or quasi periodic orbit. In the latter case, after a large number of collisions, we observe a striking decrease of the largest Lyapunov exponent towards negative values, as time grows. The exponent looks to have converged for a large number of collisions, but after a longer time it starts to decrease. This suggests the presence of a small stable region that is situated around the vertex of the rhombi. A periodic orbit of period four was oserved, which is embedded in the chaotic attractor and has one positive Lyapunov exponent, strongly suggesting the presence of chaos. Furthermore, we show how the attractor changes by increasing the magnitude of electric field or by changing the parameters of the geometry. The chaotic regions and the stable regions interchange each other with strong discontinuities and it is necessary to hone the range of the parameters to smaller and smaller cipher.
This unexpected behaviour has an impact on the global transport properties, whose study is of both theoretical and nanotechnological interest.

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Equilibration of relativistic matter with non-extensive composition rules.

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The non-extensive approach to thermodynamics has been debated by Nauenberg based on the treatment of the thermal equilibration process. The main objection was that while in the classical thermodynamics the equilibration of the temperature is unique, in the two (or more) parameter approach it is not straightforward how and whether both parameters would equilibrate and whether this process would be unique. If this were so, then one may not consider power-law spectra of particles as ones stemming from a statistically stationary state.
We address this controversy in the framework of a particular simulation of collisions between relativistic (in fact massless) particles: Our approach is, however, not based on using a non-extensive entropy formula. Instead we consider non-extensive energy composition rules as a basic dynamical ingredient to our model.
Since due to a mathematical theorem the function equations describing a general, associative but not necessarily additive composition rule, can always be mapped to the addition (this is the so called formal logarithm of the composition group), an additive quasi-energy, $X(E)$, arises in terms of which the stationary distribution is exponential, $f(E) \sim \exp(-X(E)/T)$. It is extremely interesting that to leading second order in the low-energy expansion of an associative composition formula the emerging rule is given by the Tsallisian one: $h(x,y) = x + y + a\,x\,y$. In this case one obtains $X(E) = 1/a\,\log(1 + aE)$ and the stationary distribution becomes a power-law $f(E) \sim (1 + a\,E)^{-v}$ with $v = 1/a\,T$.
We have studied lately the equilibration between two subsystems of massless particles prepared with stationary power-law tailed distributions of the one-particle kinetic energy in the framework of a particular parton cascade model solving numerically the Boltzmann equation with the above energy composition rules in micro-events. We have found that even subsystems with different non-extensivity parameters achieve a common equilibrium. In the particular cases of the same $a = (q-1)/T$ value, the two systems with an equal number of particles thermalize to the arithmetic mean in T and q and keep the power-law form of the distribution.

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Univariate and multivariate properties of wind velocity time series.

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It is well known that wind can help the the ecosystem to re-absorbs pollutants and can be used for energy generation also. The statistical approach to wind study has a long story [1] but its definitive modeling is still a challenge. As atmospheric wind is a highly non-stationarity process, simple models fails to catch some of its statistical properties. For instance, the

scaling of the probability density function (PDF) of wind velocity differences diverge from that of isotropic turbulence [2,3]. Moreover the wind velocity recorded in a particular station is correlated in space and time with the wind velocity recorded in neighboring stations, therefore a multivariate analysis can be used to extract relevant statistical information.
Among the different existing wind models some of them take into account different regimes of mean and/or variance to explain the presence of extreme values in wind differences PDF [2,3]. Moreover seasonality and autocorrelation of wind velocity as well as spatial correlations require appropriate statistical treatments [1].
In this work we present results concerning the study of the individual as a well as the collective dynamics in the wind velocity time series. The analysis has been carried out using wind velocity time series recorded in 29 different recording station of the SIAS [4] located in Sicily. The velocities have been recorded during the 4-year period 2003-2006.
The results concerning the individual dynamics are aimed to illustrate the statistical properties of wind velocity differences. Specifically, we compare PDF and calm time intervals with those obtained from models showing the extent to which such models are applicable.
The collective dynamics investigation has been performed by associating a metric distance $d_{ij} = \sqrt{2(1-\rho_{ij})}$, based on the cross-correlation ρ_{ij} of the wind velocity time series, to each couple of stations. Using this distance it is possible to obtain a dendrogram and a network - Minimum Spanning Tree (MST) - that are able to reveal the taxonomy of correlations in the analyzed time series reproducing the geographic distribution of the stations of observation. Moreover, the MST provides informations not available in the dendrogram such as the connections and lagged correlations.

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Navigability of complex networks.

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Networks are ubiquitous in all domains of science and technology, and permeate many aspects of daily human life, especially upon the rise of the information technology society. Our growing dependence on them has inspired a burst of activity in the new field of network science, keeping researchers motivated to solve the difficult challenges that networks offer. Among these, the relation between network structure and function is perhaps the most important and fundamental. Transport is one of the most common functions of networked systems. Examples can be found in many domains: transport of energy in metabolic networks, of mass in food webs, of people in transportation systems, of information in cell signaling processes, or of bytes across the Internet.
In many of these examples, routing or signaling of information propagation paths through a complex network maze plays a determinant role in the transport properties of the system. The observed efficiency of this routing process in real networks poses an intriguing question: how is this efficiency achieved? When each element of the system has a full view of the global network topology, finding efficient routes to target destinations is a well-understood computational process. However, in many networks observed in nature, including those in society and biology (signaling pathways, neural networks, etc.), nodes efficiently find intended communication targets even though they do not possess any global view of the system. For example, neural networks would not function so well if they could not route specific signals to appropriate organs or muscles in the body, although no neuron has a full view of global inter-neuron connectivity in the brain.
In this work, we identify a general mechanism that explains routing conductivity, or navigability of real networks based on the concept of similarity between nodes [1]. Specifically, intrinsic characteristics of nodes define a measure of similarity between them, which we abstract as a hidden distance. Taken together, hidden distances define a hidden metric space for a given network. Our recent work shows that these spaces explain the observed structural peculiarities of several real networks, in particular social and technological ones [2]. Here we show that this underlying metric structure can be used to guide the routing process, leading to efficient communication without global information in arbitrarily large networks. Our analysis reveals that, remarkably, real networks satisfy the topological conditions that maximize their navigability within this framework. Therefore, hidden metric spaces offer explanations of two open problems in complex networks science: the communication efficiency networks so often exhibit, and their unique structural characteristics. Our results have enormous consequences for network science and engineering, opening the possibility, for example, to design efficient routing and searching strategies for the Internet and other technological or social networks.

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Assessment of structural vulnerability of power grids by network performance based on complex networks.

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Complex networks (CN) have received considerable attention recently since the investigation of small-world and the characterization of scale-free have been discovered in many real networks. Power grids have been widely acknowledged as a typical type of CN. Many works have applied concepts and measurements of CN to analyze the structural vulnerabilities or the mechanism of cascading failure in power grids. However, the theory of CN has developed most from the generic physical perspective which focuses on the common features of all interested networks including internet, WWW, social network, and transportation networks etc. Therefore, the initial research works on CN developed many common concepts and measurements which are supposed to be efficient to any kind of complex networks. Whereas, the common features of CN mostly