Particle Systems and PDE's IV

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Abstracts

Mini-courses

Jean Christophe Mourrat (ENS Lyon)

Title: Singular stochastic PDE's as scaling limits

Singular stochastic PDEs are non-linear stochastic PDEs that need to be renormalised in order to make sense. In physicists' language, one needs to add ``counter-terms'' in order to balance the divergences caused by the roughness of the solution. The goal of the course is to explain how singular stochastic PDEs can arise as scaling limits of discrete stochastic systems. We will focus on the convergence of a long-range Ising model near criticality to the so-called \phi^4_2 model.

Eric Carlen (Rutgers University, USA)

Title: Functional inequalities and evolution equations for particle systems

We discuss recent work on the relation between certain functional inequalities and
the dissipative properties of certain evolution equations arising in the study of systems of
interacting particle. We will show how such functional inequalities can be applied to the evolutions equations, and also how evolution equations may be used to prove such inequalities.

Plenary Talks

Franz Achleitner (Vienna University of Technology)

Title: Traveling waves for a bistable reaction-diffusion equation with nonlocal-diffusion

We consider a single component reaction-diffusion equation in one dimension with bistable nonlinearity and a nonlocal space-fractional diffusion operator of Riesz-Feller type. Our main result shows the existence, uniqueness (up to translations) and stability of a traveling wave solution connecting two stable homogeneous steady states. In particular, we provide an extension to classical results on traveling wave solutions involving local diffusion. This extension to evolution equations with Riesz-Feller operators requires several technical steps. These steps are based upon an integral representation for Riesz-Feller operators, a comparison principle, regularity theory for space-fractional diffusion equations, and control of the far-field behavior.

Anton Arnold (Vienna University of Technology)

Title: Mechanical systems with boundary control: asymptotic stability and dissipative diecretizations

We consider two undamped mechanical systems: a clamped beam with payload at the free end and a gantry crane with heavy chains. In order to damp the undesired oscillations, a closed-loop control is applied to the free ends. This yields a coupled ODE-PDE system involving the beam equation and, respectively, the wave equation in the two examples. For the resulting (non) linear evolution systems we shall discuss well-posedness (based on semigroup theory), asymptotic stability (using the precompactness of the trajectories and LaSalle's Invariance Principle), and a dissipative FEM (using piecewise cubic Hermitian shape functions and a Crank-Nicolson scheme time discretization).

References:
[1] M. Miletic, A. Arnold: A piezoelectric Euler-Bernoulli beam with dynamic boundary control: Stability and dissipative FEM, Acta Applicandae Mathematicae 138, No.1 (2015), 241-277.
[2] M. Miletic, D. Stürzer and A. Arnold: An Euler-Bernoulli beam with nonlinear damping and a nonlinear spring at the tip; Discrete and Continuous Dynamical Systems-B 20, No. 9 (2015).
[3] M. Miletic, D. Stürzer, A. Arnold, A. Kugi: Stability of an Euler-Bernoulli beam with a nonlinear dynamic feedback system; to appear in IEEE Transact. Autom. Control, 2016.
[4] D. Stürzer, A. Arnold, A. Kugi: Asymptotic stability of a closed-loop control system - applied to a gantry crane with heavy chains, preprint 2015.

Christophe Bahadoran (Baise Pascal University, France)

Title: Large deviations and Lyapunov functionals for conservation laws with boundary conditions.

Motivated by the problem of stationary large deviations in nonequilibrium stationary states of driven lattice gases, and the associated macroscopic fluctuation theory of Bertini et al., we study the minimization of a path action functional subject to a given final state. This functional quantifies the deviation from entropy solutions with boundary conditions in the sense of Bardos et al. and can be expressed in terms of the kinetic entropy production measure. Its bulk component was introduced by Belletini et al. (2010), and we introduce boundary costs that generalize those introduced by Bodineau and Derrida (2006). The outcome is a generalization of the functional introduced by Derrida et al. (2003). We shall discuss microscopic models to which this approach can hopefully be applied.

Giada Basile (University Roma La Sapienza, Italy)

Title: Stationary profile of temperature for chains of oscillators

We consider a chain of harmonic oscillators whose dynamics is perturbed by a stochastic noise conserving energy and momentum. We look at the the stationary profile of energy when the chain is in contact with two Langevin heat baths at different temperatures.

Cédric Bernardin (University of Nice, France)

Title: Fractional diffusion in chains of oscillators

We consider a harmonic chain perturbed by an energy conserving noise and show that after a space-time rescaling the energy-energy correlation function is given by the solution of a skew-fractional heat equation with exponent 3/4.

Oriane Blondel (University Claude Bernard, Lyon 1, France)

Title: Random walk on environments with spectral gap

We consider random walks in random environments with positive spectral gap. Under suitable assumptions on the "asymmetry" of the jump rates w.r.t. the reference measure, we identify the invariant measure for the process seen from the walker and establish a law of large numbers and invariance principle for the walker. These findings rely on a general result concerning L^2 perturbations of Markov generators. We have in mind applications to random walks on a toy model for glassy systems. Joint work with Luca Avena and Alessandra Faggionato.

Silvia Caprino (University of Roma Tor Vergata, Italy)

Title: On the Vlasov-Poisson plasma with infinite charge and velocities

We consider an in_nitely extended plasma, that is a continuum of mono-charged particles interacting via the Coulomb potential. The existence of the time evolution of such system has been widely studied for particle distributions which are integrable in space and compactly supported in velocities. We present some results, aimed to removing both these assumptions.

Eduard Feireisl (Institute of Mathematics AS, Czech Republic)

Title: Measure-valued solutions in fluid dynamics revisited

We discuss stability of the so-called measure valued solutions to the compressible Euler as well as Navier-Stokes system. For the latter, we introduce a new concept of dissipative measure valued solution satisfying the (relative) energy inequality.The fundamental result is stability of strong (classical) solutions in the class of measurs-valued solutions - the so-called weak-strong uniqueness principle. Applications of this result to problems of stability of various procedures including certain numerical schemes will be discussed.
Based on joint work with E.Chiodaroli, P.Gwiazda, O.Kreml, A, Swierczewska-Gwiazda, and Emil Wiedemann**.**

Klemens Fellner (Institute for Mathematics and Scientific Computing, Graz, Austria)

Title: Continuum and Discrete Models of Cohesive Swarms

Mathematical models of swarms of moving agents with non-local interactions have many applications and have been the subject of considerable recent interest. For modest numbers of agents, cellular automata or related algorithms can be used to study such systems, and we illustrate how discrete models relate to a class of one-dimensional continuum models, in which the agents possess a density $\rho(x,t)$ at location x at time t.The agents are subject to a stochastic motility mechanism and to a global cohesive inter-agent force. The motility mechanisms covered include classical diffusion, nonlinear diffusion (which may be used to model, in a phenomenological way, volume exclusion or other short-range local interactions), and a family of linear redistribution operators related to fractional diffusion equations. A variety of exact analytic results are discussed, including equilibrium solutions and criteria for unimodality of equilibrium distributions, full time-dependent solutions, and transitions between asymptotic collapse and asymptotic escape. We address the behaviour of the system for diffusive motility in the low-diffusivity limit for both smooth and singular interaction potentials and show how this elucidates puzzling behaviour in fully deterministic non-local particle interaction models. We conclude with speculative remarks about extensions and applications of the models.

François Golse (École Polytechnique, France)

Title: On the Mean-Field and Classical Limits of Quantum Mechanics

Consider the N-body Schrödinger equation, with particle interaction given by a real-valued, even potential V with Lipschitz continuous gradient. We assume a mean-field scaling, i.e. that the coupling constant is of order 1/N, where N is the number of particles. We are concerned with the large N limit of this problem, assuming that the action of the typical particle is small compared to the Planck constant h. Following Dobrushin's ideas for the mean-field limit in classical mechanics, we obtain an estimate for a functional which is a

quantum analogue of the Monge-Kantorovich quadratic distance between phase-space probability densities. We prove that the mean-field limit of the N-body linear Schrödinger equation leading to Hartree's nonlinear, mean-field equation for the single-particle density is uniform as h tends to 0. An obvious consequence of this uniformity is that the Vlasov equation with Lipschitz interaction force can be derived rigorously from the N-body Schrödinger equation in the limit as 1/N and h converge to 0 jointly. (Joint work with C. Mouhot and T. Paul).

Stefan Grosskinsky (Warwick University, UK)

Title: Metastability in a condensing zero-range process in the thermodynamic limit

We consider a zero-range process with jump rates decreasing with the occupation number, which is known to exhibit a condensation phenomenon where a finite fraction of all particles concentrates on a single lattice site. We derive a scaling limit for the asymptotic metastable dynamics of the condensate location in the thermodynamic limit on a one-dimensional torus. Our proof follows previously developed methods using potential theory and a martingale approach, which have been applied to zero-range processes on finite lattices. The main challenge and novelty of this work arises from the absence of attractor states which complicates the proof of equilibration within metastable wells for a given condensate location, and requires a coupling argument to get uniform bounds on exit rates. This is joint work with Ines Armendariz and Michalis Loulakis.

Milton Jara (IMPA, Brazil)

Title: The weak KPZ universality conjecture.

We explain what the weak KPZ universality conjecture is, and we present a proof of it in the stationary case.

Jian-Guo Liu (Duke University, USA)

Title: Euler sprays and optimal transportation

In this talk, I will present a recent work jointly with Bob Pego and Dejan Slepcev that Wasserstein geodesics between two bounded open sets with equal volume is a limit of a sequence of weak solutions to the incompressible Euler equation (Euler sprays). I will also discuss a relation with Brenier’s notion of generalized Euler flows.

Mahendra Panthee (UNICAMP, Campinas, Brazil)

Title: Comparison between model equations for long waves and blow-up phenomena

The purpose of this talk is two-fold. The first one is to compare solutions of the fifth-order KDV-BBM type model to that of the fifth-order KdV model that appear to describe the propagation of long waves in shallow water. The second one is to describe the possibility of blow-up phenomenon of the fifth-order KDV-BBM type model under certain restrictions on the coeffcients. This is a joint work with X. Carvajal (UFRJ, Rio de Janeiro, Brazil) and M. Scialom (UNICAMP, Campinas, Brazil).

Nicolas Perkowski (Humboldt-University of Berlin, Germany)

Title: Energy solutions of Burgers equation

Energy solutions give a way of formulating the equilibrium stochastic Burgers equation as a martingale problem. They were introduced in 2010 by Goncalves and Jara as a tool to study the equilibrium fluctuations of weakly asymmetric particle systems, but until recently it was not known whether they are unique. In this talk I will show that the stronger formulation of Gubinelli, Jara (2013) gives rise to unique solutions and apply this to study the equilibrium fluctuations of weakly asymmetric Ginzburg-Landau dynamics. Based on joint works with Joscha Diehl and Massimiliano Gubinelli.

Mario Pulvirenti (University Roma La Sapienza, Italy)

Title: Correlations and backward clusters for a hard-sphere system in a low density regime

In this talk I illustrate some recent results concerning the nature of the dynamical correlations arising in the time evolution for a system of hard spheres, in the Boltzmann-Grad limit. The correlations, which prevent the statistical independence of any couple of particles, are related to the mean size of the so called backward cluster (group of particles which influence the behavior of a given particle).
The results presented have been obtained in collaboration with Aoki, Simonella and Tsuji.

Valeria Ricci (University of Palermo, Italy)

Title: Large number asympotics for dispersed, non regular distributions of inclusions in a fluid

We shall describe the large number asymtpotics for systems consisting in a fluid surrounding a non regular distributions of inclusions. The fluid satisfies a given boundary (or initial-boundary) value problem (involving a second order operator of divergence form) in a perforated domain and the holes in the domain are occupied by the inclusions; fluid and inclusions are coupled by the boundary conditions only. These systems are meant as models at some "microscopic" scale for describing, in a suitable asymptotics, the behaviour at a macroscopic level of composite media. We shall give a general overview of the results about the homogenized limit of such a kind of systems obtained in previous works (performed in collaboration with L. Desvillettes and F.Golse) under a different perspective. In particular we shall describe the homogenized limit in the frame of the potential theory, generalising those results with respect to the dimension of the physical space and the shape of the inclusions.

Gunter Schutz (Institute of Complex Systems II, Germany)

Title: Matrix product ansatz for quantum non-equilibrium steady states

We demonstrate that the exact nonequilibrium steady state of the one-dimensional Heisenberg XXZ spin chain driven by boundary Lindblad operators can be constructed explicitly with a matrix product ansatz where the matrices satisfy the quantum algebra U_q[sl(2)]. For the isotropic Heisenberg chain, coupled at the ends to boundary reservoirs polarized in different directions, we calculate the exact stationary magnetization profiles and magnetization currents. On hydrodynamic scale the magnetization profiles are harmonic functions with a frequency proportional to the twisting angle θ. The currents of the magnetization components lying in the twisting plane and in the orthogonal direction behave qualitatively differently: In-plane transport is subdiffusive and vanishes as the boundary coupling increases, while the transverse transport is ballistic and saturates as the coupling increases.

Marielle Simon (PUC-RIO, Brazil)

Title: Crossover to the stochastic Burgers equation for the WASEP with a slow bond

For interacting particle systems of exclusion type, the derivation of macroscopic laws is more or less well

understood as soon as the jump rates are symmetric, but for weakly asymmetric systems only partial answers have been given. Even harder is the derivation of macroscopic laws for microscopic dynamics with local defects. More precisely, when the microscopic particle system is locally perturbed, the macroscopic laws can hold different boundary conditions. In this talk we address the simple exclusion process with a weak asymmetry, and we also perturb the dynamics at one particular bond. We derive the density fluctuations of the system around equilibrium and we prove the crossover from the Edwards-Wilkinson universality class to the KPZ universality class, when the particular bond is weakly perturbed; in higher regimes, the limit density fluctuation field is an Ornstein-Uhlenbeck process associated to the heat equation with suitable boundary conditions. The main difficulty of the proof is the derivation of a second order Boltzmann-Gibbs principle, which allows to replace certain additive functional of local functions of the dynamics by additive functionals given in terms of the density of particles. Since our rates are not bounded from below and the usual spectral gap inequality is unknown, we develop a new way to estimate the error in the replacement performed in the Boltzmann-Gibbs principle and, in particular, we do not use the spectral gap inequality.
This is a joint work with P. Gonçalves (Universidade do Minho and PUC-Rio) and T. Franco (UFBA).

Alexis Vasseur (University of Texas at Austin, USA)

Title: Global Existence of Solutions to the 3D Navier-Stokes Equations with Degenerate Viscosities

We prove the existence of global weak solutions for 3D compressible Navier-Stokes equations with degenerate viscosities. The method is based on the Bresch and Desjardins entropy. The main contribution is to derive the Mellet-Vasseur type inequality for the weak solutions, even if it is not verified by the first level of approximation.
This provides existence of global solutions in time, for the compressible Navier-Stokes equations, for any gamma bigger than one, in three dimensional space, with large initial data, possibly vanishing on the vacuum.

Rui Vilela Mendes (CMAFCIO, University of Lisbon, Portugal)

Title: Superprocesses and ultradistributions

From branching particle systems one obtains, in the scaling limit, measure-value processes called superprocesses. In addition to providing models for evolving populations, superprocesses provide probabilistic representations of the solutions of nonlinear partial differential equations (PDE's). However, the class of PDE's that can be handled by measure-valued superprocesses is rather limited. This suggests an extension of the configuration space of superprocesses to ultradistribution-valued processes which have a wider range of applications in the solution of PDE's.

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