Department of Mathematics and Computer Science

6th Workshop on Kinetic Theory and Applications

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Abstracts

Kazuo Aoki

Title: Decay of a linear pendulum in a collisional gas: Spatially one-dimensional case

Abstract: An infinitely wide plate, subject to an external force in its normal direction obeying Hooke's law, is placed in an infinite expanse of a rarefied gas. When the plate is displaced from its equilibrium position and released, it starts in general an oscillatory motion in its normal direction. This is the one-dimensional setting of a linear pendulum considered previously for a collisionless gas and a special Lorentz gas in our paper [T. Tsuji and K. Aoki, J. Stat. Phys. 146, 620 (2012)]. The motion decays as time proceeds because of the drag force on the plate exerted by the surrounding gas. The long-time behavior of the unsteady motion of the gas caused by the motion of the plate is investigated numerically on the basis of the BGK model of the Boltzmann equation with special interest in the rate of the decay of the oscillatory motion of the plate. The result provides numerical evidence that the displacement of the plate decays in proportion to an inverse power of time for large time. This work is a collaboration with Tetsuro Tsuji (Osaka University, Japan).

Leif Arkeryd

Title: On the anyon Boltzmann equation

Abstract: The talk will discuss the Boltzmann equation for a gas of anyons. The main result is on large data space-dependent existence in a slab, joint work with A. Nouri.

Mohammad Asadzadeh

Title: On geometric calculus and finite elements for Vlasov-Maxwell system

Abstract: This work is a swift introduction to a few concepts in geometric calculus leading to a simple representation of Maxwell equations. We then approximate a “one and one-half” dimensional relativistic Vlasov-Maxwell system using streamline diffusion and discontinuous Galerkin finite element methods. In this part we derive optimal convergence rates due to the maximal available regularity of the exact solution.

Alexander Bobylev

Title: The spatially homogeneous Boltzmann equation in various functional spaces

Yann Brenier

Title: Hydrodynamic limit of some P and NP combinatorial optimization problems

Abstract: Optimal transport theory is a good example of a link between kinetic theory, hydrodynamics and combinatorial optimization, through the "linear assignment problem", one of the simplest P combinatorial problems. It turns out that the much more challenging "quadratic assignment problem" (which is NP and includes the famous traveling salesman problem) has a rather direct connection with hydrodynamics, as I will explain. A gradient flow approach will be introduced to deal with some suitable "hydrodynamic limits". Existence and uniqueness issues for the corresponding evolution PDEs will be discussed.

Silvia Caprino

Title: On a Vlasov-Poisson plasma with infinite charge

Abstract: A Vlasov-Poisson plasma with infinite charge is given by an infinitely extended distribution of charged particles, whose spatial density is not assumed to decrease at infinity, as it is usually done. In this situation a first difficulty concerns the good position of the problem, since in general neither the autoinduced electric field, nor the energy are bounded at time $t = 0$: This leads to consider possible physical situations in which this problem can be bypassed. I will present some of them, as a survey on some recent results.

Boris Chetverushkin

Title: Kinetic consistent equations of magnetogasodynamics and their implementation for supercomputers

Laurent Desvillettes

Title: Some new estimates for the Vlasov-Poisson equation

Abstract: In a work in collaboration with Evelyne Miot and Chiara Saffirio, we revisit the estimates proven by Pierre-Louis Lions and Benoit Perthame in the nineties on the (non-compactly supported w.r.t. velocity) solutions of the Vlasov-Poisson equation. Improvements include the possibility to take into account one Dirac mass in the distribution function, as well as a better control on the large time behavior of moments w.r.t. v.

Francis Filbet

Title: A hierarchy of hybrid numerical methods for multi-scale kinetic equations

Abstract: A Vlasov-Poisson plasma with infinite charge is given by an infinitely extended distribution of charged particles, whose spatial density is not assumed to decrease at infinity, as it is usually done. In this situation a first difficulty concerns the good position of the problem, since in general neither the autoinduced electric field, nor the energy are bounded at time t = 0: This leads to consider possible physical situations in which this problem can be bypassed. I will present some of them, as a survey on some recent results.

Irene Gamba

Title: On summability of moments and their applications

Abstract: We will discuss recent results of summability of moments to solution of the Boltzmann equation. A new concept, Mittag-Leffler moments, are introduced as a generalization of exponential moments. This is due to the fact that Mittag-Leffler functions are in fact generalized fractional power series.
This approach allows us to solve some issues under non cut-off angular cross-section and exhibits the interplay of angular singularities with tail decay in propagation and generations of tails.
These estimates are in direct connection to the legacy of A. V. Bobylev in the deep understanding of high energy tails and decay rates to equilibrium.

Francois Golse

Title: A derivation of models for aerosols

Abstract: Aerosols or spray flows can be described by coupled systems of PDEs, involving usually a hydrodynamic equation (or system of equations) for the continuous phase (e.g. the propellant) and a mean field, Vlasov type kinetic equation for the distribution function of the dispersed phase. These equations are coupled by the drag force exerted on the particles in the dispersed phase by the surrounding fluid. I will present formal derivations of such models from Boltzmann equations for gas mixtures.

(Work in collaboration with E. Bernard, L. Desvillettes and V. Ricci)

Stéphane Mischler

Title: On spectral analysis of semigroups in a Banach space and applications.

Abstract: We construct a hierarchy of hybrid numerical methods for multi-scale kinetic equations based on moment realizability matrices, a concept introduced by Levermore, Morokoff and Nadiga. Following such a criterion, one can consider hybrid scheme where the hydrodynamic part is given either by the compressible Euler or Navier-Stokes equations, or even with more general models, such as the Burnett or super-Burnett systems.

Anne Nouri

Title: Bose condensates in interaction with excitations - a two-component space-dependent model close to equilibrium.

Abstract: A model for Bose gases in the so-called 'high temperature range' below the temperature where Bose-Einstein condensates sets in, is considered. It is of non-linear two-component type, consisting of a kinetic equation with periodic boundary conditions for the distribution function of a gas of excitations interacting with a Bose condensate, which is described by a Gross-Pitaevskii equation. Results on well-posedness and longtime behaviour are proven in an H^1 setting close to equilibrium.

Irina Potapenko

Title: Numerical modeling of the electron heating for the nonlinear collision kinetic equation with a quasilinear diffusion operator

Abstract: Solutions of the time dependent spatially uniform nonlinear collision kinetic equation in the course of heating are studied numerically. Coulomb collisions are treated with the Landau-Fokker-Planck collision integral. The considered heating source is a quasilinear diffusion operator acting in a full velocity space with variable diffusion coefficient. DSMC and the finite difference methods are used. The time dependent self-similar solutions with the accelerated tails are examined.

Mario Pulvirenti

Title: Rigorous derivation of the Fick's law in a low density regime

Abstract: We consider the Lorentz model in a slab with two mass reservoirs at the boundaries. We show that, in a low density regime, there exists a unique stationary solution for the microscopic dynamics which converges to the stationary solution of the heat equation, namely to the linear profile of the density. In the same regime the macroscopic current in the stationary state is given by the Fick's law, with the diffusion coefficient determined by the Green-Kubo formula.
This results from a collaboration with G. Basile, A. Nota and F. Pezzot.

Sergej Rjasanow

Title: Galerkin-Petrov approach for the Boltzmann equation

Abstract: In the present lecture, we approximate the spatially homogeneous Boltzmann equation by the use of possibly different basis and test functions. Such numerical methods belong to the family of Galerkin-Petrov variational approximations. The result of the approximation is a system of ordinary differential equations. The Fourier spectral method [3] can be considered as a special Galerkin method. In addition, we discuss the case of globally defined basis and test functions [1],[2] which allow to construct an approximation of the Boltzmann equation without a grid in the velocity space. Interesting property of this approximation is an automatic conservation of mass, momentum and energy.

References

[1] E. Fonn. *Approximation in Space and Velocity for Kinetic Transport Equations*. PhD thesis, ETH, Zürich, 2013.
[2] G. Kitzler and J. J. Schöberl. Efficient spectral methods for the spatially homogeneous Boltzmann equation. Report 13/2013, Institute for Analysis and Scientific Computing, Vienna University of Technology, Austria, 2013.
[3] L. Pareschi and B. Perthame. A Fourier spectral method for homogeneous Boltzmann equations. *Transport Theory Statist. Phys.*, 25 : 369-382, 1996.

Giovanni Russo

Title: High order semi-implicit schemes for evolutionary nonlinear partial differential equations with applications to nonlinear diffusion relaxation problems and to kinetic equations.

Abstract: Several systems of evolutionary partial differential equations may contain stiff terms, which require an implicit treatment. Typical examples are hyperbolic systems with stiff hyperbolic or parabolic relaxation and kinetic equations in regimes close to fluid dynamic limit.

In many cases, the stiff terms are clearly identified. For example, in hyperbolic systems with hyperbolic relaxation, the hyperbolic term is usually non stiff, while the relaxation term is stiff. A natural way to treat such systems is to adopt implicit-explicit schemes, in which the relaxation is treated by an implicit scheme, while the hyperbolic part is treated explicitly.

In several cases, however, such a distinction is not so clear. For example, in the case of hyperbolic systems with diffusive relaxation, a standard approach would lead to schemes, which in the stiff limit suffer from classical parabolic CFL restriction. Such systems can be treated by a penalization method, consisting in adding and subtracting the same term, so that the system appears as the limit relaxed system plus a small perturbation.

There are cases, however, in which stiff terms are not just additive, and the penalization method is not particularly effective, since the limit system itself is not easily solvable by standard techniques.

For many such systems, we present a new approach, which consists in identifying the stiff (linearly) dependence of the system on the unknown variable. Only this linear dependence will be treated implicitly, while the rest of the system is treated implicitly. This approach generalizes classical IMEX schemes based on additive or partitioned Runge-Kutta methods, and allows the construction of high order linearly implicit schemes, which are much simpler to use than fully implicit ones.

Several examples, including nonlinear diffusion and Fokker-Planck equation will be presented.