Department of Mathematics and Computer Science

7th Workshop on Kinetic Theory and Applications

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Abstracts

Kazuo Aoki (National Taiwan University, Taipei and National Cheng Kung University, Tainan)

Title: Shock wave structure for polyatomic gases with large bulk viscosities

Abstract: The structure of a standing plane shock wave in a polyatomic gas is investigated on the basis of kinetic theory, with special interest in gases with large bulk viscosities, such as the CO2 gas. The polyatomic version of the ellipsoidal statistical model is employed, and the shock structure is obtained numerically for different upstream Mach numbers and for different (large) values of the ratio of the bulk viscosity to the shear viscosity. The double-layer structure consisting of a thin upstream layer with a steep change and a much thicker downstream layer with a mild change is obtained. This work is a collaboration with Shingo Kosuge (Kyoto University).

Leif Arkeryd (Chalmers University of Technology)

Title: Bose condensates in interaction with excitations; a coupled Gross-Pitaevskii and quantum-kinetic model

Abstract: The talk will discuss various aspects of a model for Bose gases with force term, in the so-called 'high-temperature range' below the temperature where Bose-Einstein condensation sets in. The model is of two-component type, consisting of a non-linear Gross-Pitaevskii equation for a condensate interacting with a gas of excitations modelled by a quantum-kinetic equation with a non-trivial intrinsic force term. In particular, new results in collaboration with A. Nouri on well-posedness and trend to equilibrium for the system in a periodic setting, will be presented.

Hans Babovsky (Technical University of Ilmenau)

Title: Design of discrete velocity models

Abstract: Discrete velocity models (DVM) can be applied for rarefied flow simulations on a range of scales. On one end, they can be designed as numerical integration schemes for the Boltzmann collision operator. It turns out that such schemes can combine reasonably high order with good numerical efficiency. On the other end, they can be applied to provide useful closure relations in the macroscopic limit. In this latter case, one has to keep an eye on the algebraic properties of the models as well as on the scaling procedure leading to the macroscopic description. The talk reports on recent developments.

Claude Bardos (University Paris Diderot, Paris 7)

Title: Onsager Conjecture in bounded domain with boundaries

Abstract: In this talk (about a recent joint work with Edriss Titi) I extend to the case of domain with boundary the result of Constantin, E, and Titi concerning the conservation of energy for weak solutions of the Euler equation as soon as they belong to the Hölder space $C^{(0,1/3)}$.

Besides being a new result, the presence of boundary requires a direct proof that may have other applications.

Alexander Bobylev (Keldysh Institute of Applied Mathematics, Moscow)

Title: On consistent BGK models for gas mixtures

Abstract: There are a lot of publications on BGK-type models for mixtures, beginning with the paper by Gross and Krook (G and K from BGK!) published in 1956. We consider in this talk only the models, consistent with classical Boltzmann equations, i.e. satisfying such properties as positivity of solutions, conservation laws, H-theorem, and uniqueness of equilibrium state. We show how to construct a class of models for N-component mixtures based on most natural assumptions and prove a consistency of that class. Then we discuss a comparison with consistent models by other authors.

Stéphane Brull (University of Bordeaux)

Title: Modelling and numerical study of the polyatomic bi-temperature Euler system

Abstract: This work is devoted to the study of the non-conservative bi-temperature Euler system in the context of plasma physics. Physically, this model describes the interaction between one species of ions and one species of electrons. Under the quasi-neutrality assumption, the electronic and ionic mass fractions are constant. The fluid velocity is the same for electrons and ions, while the energies, and therefore the pressures and temperatures, differ. Solving non-conservative hyperbolic systems is a delicate problem because the definition of weak admissible solutions is difficult.
Here, we consider the weak solutions obtained by the relaxation limit of the moments of an underlying two species polyatomic kinetic model coupled with the Poisson and Ampère equations through the electric field with appropriate scaling. This approach generalizes in particular the case of a monoatomic kinetic system introduced in a previous paper where only the case $\gamma = 5/3$ was allowed.
Moreover, the system owns a dissipative strictly convex entropy-entropy flux pair, which is compatible with the microscopic Boltzmann entropy.
Then we derive a kinetic scheme for this system based on a transport-projection approach. By taking advantage of the Chapman-Enskog expansion, we get a discretization of the non-conservative terms in function of the conservative fluxes of the Euler system. This scheme is shown to satisfy a discrete entropy dissipation property.
Finally, this scheme is compared to several schemes developed for this model (discrete BGK schemes, relaxation schemes ...).

Silvia Caprino (Tor Vergata, University of Rome)

Title: The Vlasov-Poisson plasma with infinite charge: An attempt to modeling a magnetic shield

Abstract: I will review some recent results on the Vlasov-Poisson plasma in case of infinite charge, which is in case that the distribution of charged particles is not integrable at infinity. I will present some models of magnetically confined plasmas, in a torus and in an infinite cylinder, and will discuss on the possibility of modeling a magnetic shield, that is a case of a plasma owing out of an obstacle protected by an impenetrable magnetic barrier.

Pierre Degond (Imperial College London)

Title: Coarse-graining of collective dynamics models

Abstract: In this talk, we will report on some new individual-based models of collective dynamics and their coarse-graining into continuum models. The applications span from collective cell dynamics (such as social bacteria or sperm) to flocking of birds or fish. Models of social behavior are best set up at the individual scale where behavioral rules can be easily introduced and tested. However, the complexity of individual-based models increases rapidly with the number of individuals and their calibration or control can hardly be implemented at this level. To overcome this limitation, one often uses continuum model that describe the system through average quantities such as densities or mean orientation. But the downside of most models in the literature is that the link between the rules at the individual behavior and the coefficients in the macroscopic model are not known exactly and are at best extrapolated from heuristic consideration. Here, we propose a systematic and mathematical rigorous way to derive continuum models from collective dynamics models. It relies on the introduction of a new concept, the 'generalized collision invariants', which permits to overcome the lack of physical invariance in most systems undergoing collective dynamics. In this talk, we will review some recent developments of these concepts and how they can be used to model systems of practical scientific importance.

Francis Filbet (University Paul Sabatier, Toulouse III)

Title: On a three dimensional vision based collision avoidance model

Abstract: I will present a three dimensional collision avoidance approach for aerial vehicles inspired by coordinated behaviors in biological groups. The proposed strategy aims to enable a group of vehicles to converge to a common destination point avoiding collisions with each other and with moving obstacles in their environment. The interaction rules lead the agents to adapt their velocity vectors through a modification of the relative bearing angle and the relative elevation. Moreover, the model satisfies the limited field of view constraints resulting from individual perception sensitivity. From the proposed individual based model, a mean-field kinetic model is derived. Simulations are performed to show the effectiveness of the proposed model.

Irene Gamba (University of Texas at Austin)

Title: Common features between the quantum Boltzmann equation cold regimes and the wave turbulence model for stratified flows

Abstract: Both the quantum Boltzmann equation for bosons at very low temperature and the model for wave turbulence theory for stratified flows, exhibit many similarities. Both represent statistical flow models given by integral forms in velocity or momenta space who lack some conservation properties, while keeping the gain-loss rates structure like the classical Boltzmann equation. While both of them differ from the classical formulation of the space homogeneous Boltzmann equation, they share the structure that allow us to construct strong solutions in the space on continuous functions in time (and differentiable for positive times), with k-moments (L^1_N) in wave space. This is done using techniques of control of ODE's methods in Banach spaces by characterizing an invariant bounded, convex, closed solutions subset of integrable solutions with bounded moments in velocity space.
This is work reflecting collaborations with Ricardo Alonso, Leslie Smith, and Minh Binh Tran.

Francois Golse (École Polytechnique, Paris)

Title: Quantization of probability densities: a gradient flow approach

Abstract: Quantization designates the approximation of continuous probability densities by convex combination of finitely many Dirac measures. There is a notion of quantization error, defined in terms of the Monge-Kantorovich(-Vasershtein) distances. The talk will discuss the gradient flow defined by the quantization error in the limit where the number of points in the support of the approximating, discrete probability measure tends to infinity. (Work in collaboration with E. Caglioti and M. Iacobelli).

Maria Groppi (University of Parma)

Title: Kinetic-based models for tumor-immune system competition

Abstract: A mathematical model, based on a mesoscopic approach, describing the competition between tumor cells and immune system in terms of kinetic integro-differential equations is presented. Four interacting populations are considered, representing, respectively, tumors cells, cells of the host environment, cells of the immune system, and interleukins, which are capable to modify the tumor-immune system interaction and to contribute to destroy tumor cells. A closed set of autonomous ODEs is then derived by a moment procedure; two three-dimensional reduced systems of ODEs are obtained in some partial quasi-steady state approximation and their qualitative analysis is performed.

Tai-Ping Liu (Academia Sinica, Taipei and Stanford University)

Title: Hopf-Cole transformation

Abstract: The Hopf-Cole transformation turning the strongly nonlinear Burgers equation into the linear heat equation plays an important role in the development of mathematical sciences. In this article, the transformation is viewed from historical perspective. Some open problems concerning the application of the Hopf-Cole transformation are also raised.

Claudia Negulescu (University Paul Sabatier, Toulouse III)

Title: Kinetic modelling and numerics of strongly magnetized tokamak plasmas with mass disparate particles. The electron Boltzmann relation.

Abstract: In the present talk, I will justify on a formal level the obtention of the electron Boltzmann relation in a suitable asymptotic limit, starting from a fully kinetic description of magnetically confined fusion plasmas. The obtained asymptotic limit model consists of the electron Boltzmann-equilibrium along the magnetic field lines, completed by a non-trivial dynamics perpendicular to these field lines. In the same asymptotic limit, the ions reach a gyrokinetic or hydrodynamic regime. The Boltzmann approximation for the electrons is widely used in numerical simulations in the aim to drastically reduce the computational burden. It is thus crucial to understand how to obtain this reduced model from modelling assumptions and asymptotic considerations, starting from a microscopic description. Some first numerical examples via an Asymptotic-Preserving scheme permitting to follow on the discrete level this asymptotic limit will be presented.

Anne Nouri (Aix - Marseille University)

Title: On some quantum kinetic equations related to anyons

Abstract: Anyons are quantum quasi-particles existing in one or two dimensions. The talk will consider a nonlinear kinetic Boltzmann equation describing their evolution in a special periodic one-dimensional setting with large initial data. Well-posedness of the Cauchy problem is proven. The results are extended in some cases to quantum particles under Haldane statistics with higher dimensional velocities.

Irina Potapenko (Keldysh Institute of Applied Mathematics, Moscow)

Title: Electron acceleration by plasmic waves caused by a laser pulse

Abstract: Electron acceleration caused by a laser pulse is studied numerically with help of quasilinear diffusion in the momentum space. The structure of the electron distribution function is investigated in the 1D1V case. Previous to front, the extending distribution function tails is building-up in the course of impulse propagation. The numerical solution has the coincident asymptotic form with the obtained analytical solution.

Mario Pulvirenti (University of L'Aquila)

Title: Continuum limit for metamaterials: an inverse problem

Abstract: We consider a quite general one-dimensional continuum. Our aim is to construct and analyze discrete approximations in terms of physically realizable mechanical systems. We validate our construction by proving a convergence theorem of the microscopic system to the given continuum, as the scale parameter goes to zero. In other words, we are interested on an inverse problem: given some macroscopic properties, find the microscopic mechanical system, which realizes it. This is a joint work with A. Carcaterra, F. dell'Isola and R. Esposito.

Sergej Rjasanow (Saarland University)

Title: Stochastic and deterministic solution of the Boltzmann equation

Abstract: In the present lecture, we approximate the spatially one-dimensional Boltzmann equation by the use of a stochastic particle method and, alternatively, by a deterministic spectral Galerkin-Petrov approach with different basis and test functions. This approximation of the Boltzmann equation works without a grid in the velocity space. The result of this approximation is a system of partial differential equations. We show that this system is hyperbolic and can be transformed in a system coupled via its right-hand side only. A further interesting property of this approximation is an automatic conservation of mass, momentum and energy. As a numerical example, we consider the one-dimensional heat transfer problem. In collaboration with Thorsten Kessler.

Chiara Saffirio (University of Zürich)

Title: Derivation of the linear Bolzmann-Vlasov equation from particle system

Abstract: We consider a tracer particle moving in a random distribution of hard disks in 2d of radius ε, in the low density limit. In addition to the core collision, each obstacle generates a potential $\varepsilon\varphi$ that takes into account long-range effects. We will discuss the instability arising from taking into account the long-range effects in this collisional dynamics. As $\varepsilon \to 0$, the Boltzmann-Vlasov equation can be derived.
This is a work in progress with L. Desvillettes and S. Simonella.

Giampiero Spiga (University of Parma)

Title: Macroscopic closures of kinetic equations beyond the monatomic gas

Abstract: Real world applications of gas dynamics involve situations well beyond the classical scheme of a single monatomic molecule, which is typical of kinetic approaches such as the nonlinear Boltzmann equation or its BGK relaxation models. An evident example is provided by reactive and polyatomic gases, which share the common feature that kinetic temperature is not a quantity conserved by collisions, and internal energy is not a byproduct of the pressure tensor. Fluid-dynamic equations of different types at a macroscopic scale may be derived from the kinetic level (Boltzmann or BGK), by either moment methods or Chapman-Enskog procedure. In both cases a crucial role is played by an additional (dynamical) pressure arising from the internal molecular states.

Shigeru Takata (Kyoto University)

Title: Influence of boundary geometry on the fluid-dynamic quantities near the boundary

Abstract: We show that the gradients of the fluid-dynamic (or macroscopic) quantities normal to the boundary diverge even on the smooth boundary, irrespective of the (nonzero) Knudsen number. The boundary geometry determines the diverging rate. On the planar or concave boundary, the logarithmic divergence ln s should be observed, where s is the normal distance from the boundary. In other cases, the diverging rate is enhanced to be the inverse-power $s^{1/n}$, where n ($\geqslant 2$) is the degree of polynomial which locally represents the boundary. Some numerical demonstrations are given as well.
This is a joint work with Satoshi Taguchi.

Giuseppe Toscani (University of Pavia)

Title: Fokker-Planck description of socio-economic phenomena

Abstract: In this talk, we introduce and discuss various one-dimensional linear Fokker-Planck type equations that have been recently considered in connection with the study of interacting multi-agent systems [1] [2]. In general, these Fokker-Planck equations describe the evolution in time of some probability density of the population of agents, typically the distribution of the personal wealth or of the personal opinion, and are mostly obtained by linear or bilinear kinetic models of Boltzmann type via some limit procedure. The main feature of these equations is the presence of variable diffusion and drift coefficients, which introduce new challenging mathematical problems in the study of their long-time behavior.

References

[1] L. Pareschi, G. Toscani, Interacting Multiagent Systems: Kinetic Equations and Monte Carlo Methods, Oxford University Press, Oxford (2014)

[2] G. Furioli, A. Pulvirenti, E. Terraneo, G. Toscani, Fokker-Planck equations in the modelling of socio-economic phenomena, Math. Mod. Meth. Appl. Scie. 27 (1) 115-158 (2017)

Tong Yang (City University of Hong Kong)

Title: Solutions to the spatially inhomogeneous non-cutoff Kac equation

Abstract: Considering the one-dimensional inhomogeneous non-cutoff Kac equation, based on the analysis on the linearized operator obtained by Lerner-Morimoto-Pravda-Starov-Xu, we first show the existence of global solution to the equation around a global Maxwellian by combining two sets of macro-micro decomposition. Then by using the dissipative norm of the linearized operator in the fractional Hermite-Sobolev space and by using the perturbation theory, the spectrum structure of the linearized Kac equation will be given. The optimal time decay estimate for the nonlinear Kac equation is then obtained. This is a joint work with Hongjun Yu. The research is partially supported by the Joint NSFC-RGC Research Fund, N-CityU 102/12.