动理学及相关领域前沿研讨会
Workshop on the recent progress of kin etic theory and related topics

Date

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Location

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Organizer

Alexandru Ionescu, Princeton University
Yu Deng(邓煜), University of Southern California
Li Xu(徐丽) , Beihang University
Xuecheng Wang(王学成) , Tsinghua University

Titles and Abstracts

Instability of Prandtl's boundary layers

Emmanuel Grenier
Ecole Normale Superieure de Lyon

The aim of this talk is to review various recent results on the linear and nonlinear instability of Prandtl's layer in the C^∞ framework.

Sharp regularization effect for the Landau and Boltzmann equation

Weixi Li
Wuhan University

We verify the smoothing effect for the spatially inhomogeneous Landau and Boltzmann equation without angular cutoff. Given initial data with low regularity, we prove its solutions at any positive time are analytic or Gevrey class with optimal index To overcome the degeneracy in the spatial variable, a family of well-chosen vector fields auxiliary operators will play a crucial role.

TBA

Nader Masmoudi
New York University Abu Dhabi

TBA

Global well-posedness of the quantum Boltzmann equation for bosons interacting via inverse power law potentials

Yulong Zhou
Sun Yat-sen University

We consider the spatially inhomogeneous quantum Boltzmann equation for bosons with a singular collision kernel, the weak-coupling limit of a large system of Bose-Einstein particles interacting through inverse power law. Global well-posedness of the corresponding Cauchy problem is proved in a periodic box near equilibrium for initial data satisfying high temperature condition.

Modified scattering for small data solutions to the Vlasov-Maxwell system

Léo Bigorgne
Universite Rennes I

We will be interested in the solutions to the Vlasov-Maxwell system arising from sufficiently small and regular data. In particular, we will compare their asymptotic behavior with the ones of the solutions to the corresponding linear equations. Even if the electromagnetic has a nontrivial memory effect, it enjoys linear scattering since it approaches, for large time, a solution to the vacuum Maxwell equations. In contrast, the distribution function merely satisfies a modified scattering statement. Due to the long-range effects of the Lorentz force, it converges along logarithmic corrections of the linear characteristics. In order to define these modified characteristics, a key step consists in identifying an effective Lorentz force governing the asymptotic behavior of the force field.

Landau damping and fat-tail equilibrium: Poisson and beyond.

Benoit Pausader
Brown University

This talk will discuss the recent proof of Landau damping on R^3 in the case of the Poisson homogeneous equilibrium, here considered as a model of fat-tail homogeneous equilibrium. We will also discuss extensions to more general fat-tail equilibriums. This is based on joint work with A. ionescu, X. Wang and K. Widmayer.

Boundary singularity of a mono-speed Lorentz model for molecules with the infiniterange potential

Shigeru TAKATA
Kyoto University

Possibility of the diverging gradient of the macroscopic quantity near the boundary is investigated by a mono-speed Lorentz-gas model, with a special attention to the regularizing effect of the grazing collision for the infinite-range potential on the velocity distribution function (VDF) and its influence on the macroscopic quantity. By careful numerical analyses of the steady one-dimensional boundary-value problem, it is confirmed that the grazing collision suppresses the occurrence of a jump discontinuity of the VDF on the boundary. However, as the price for that regularization, the collision integral becomes no longer finite in the direction of the molecular velocity parallel to the boundary. Consequently, the gradient of the macroscopic quantity diverges, even stronger than the case of the finite-range potential. A conjecture about the diverging rate in approaching the boundary is made as well for a wide range of the infinite-range potentials, accompanied by the numerical evidence.

Time asymptotic stability of generic Riemann solutions to compressible NavierStokes equations

Yi Wang
Chinese Academy of Sciences

Since 1980s, the time-asymptotic stability of single wave patterns (including viscous shock wave, rarefaction wave or viscous contact wave) to one-dimensional compressible Navier- Stokes equations are well-established and each individual wave pattern has quite different stability frameworks. Due to the incompatibilities of those different stability frameworks, it is pretty hard to prove the time-asymptotic stability of generic Riemann solutions, in particular, consisting of multiple and different wave patterns to compressible NavierStokes equations. The talk is concerned with our recent progress on the resolution of the time-asymptotic stability of generic Riemann solutions to the one-dimensional compressible Navier-Stokes equations (including both isentropic and full cases) and our developments on the stability of planar wave patterns to three dimensional compressible Navier-Stokes equations. The talk is based on the joint works with my collaborators.

On the Relativistic Boltzmann Equation with Long Range Interactions

Jin Woo Jang
Pohang University of Science and Technology

In this talk, I will discuss three recent, interrelated results concerning the special relativistic Boltzmann equation without angular cutoff. In the non-relativistic situation without angular cutoff, the change of variables from $v \to v'$ is a crux of the widely used "cancellation lemma". Firstly, in collaboration with James Chapman and Robert M. Strain, we calculate this very complex ten variable Jacobian determinant in the special relativistic situation and illustrate some numerical results which show that it has a large number of distinct points where it is machine zero. Secondly, with Strain, we prove the sharp pointwise asymptotics for the frequency multiplier of the linearized relativistic Boltzmann collision operator that has not been previously established. As a consequence of these calculations, we further explain why the well known change of variables $p \to p'$ is not well defined in the special relativistic context. Finally, also with Strain, we will present our recent proof of global-in-time existence and uniqueness of the solutions nearby the relativistic Maxwellian to the special relativistic Boltzmann equation without any angular cutoff and its asymptotic stability. We work in the case of a spatially periodic box. We assume the generic hardinteraction and mildly-soft-interaction conditions on the collision kernel that were derived by Dudyński and Ekiel-Jeżewska (in 1985). In this physical situation, the angular function in the collision kernel is not locally integrable, and the collision operator behaves like a fractional diffusion operator.

Optimal boundary regularity for the cut-off Boltzmann equation on general bounded domain

Quoc hung Nguyen
Chinese Academy of Sciences

In this talk, I will discuss some optimal boundary regularity results for the cut-off Boltzmann and Landau equations on general bounded domains.

Boltzmann equation, hard sphere systems and their small and large deviations

Sergio Simonella
Sapienza University of Rome

We review the state of the art in Grad's validity problem for a mathematical justification of fluid equations based on fundamental laws of classical mechanics. With the techniques currently available, such a problem can be faced in some simple case for perfect gases, using the kinetic theory of Boltzmann as an intermediate step. We will discuss recent results establishing the connection between microscopic and hydrodynamic scales, for perturbations of a global equilibrium, as well as macroscopic fluctuations far from equilibrium.

Sharp regularity estimates for the collisional kinetic equations

Lingbing He
Tsinghua University

We investigate the smoothing estimates for the non-cutoff Boltzmann equation with soft potentials as well as Landau-Coulomb equation in L^2 framework. We address the problem in two different settings: (i). When the initial data only possesses finite polynomial moment, the solutions to the Boltzmann equation have only finite Sobolev regularity while the solutions to the Landau-Coulomb have the infinite Sobolev regularity but with negative weight. (ii). When the initial data have exponential moments, the solutions belong to the Gevrey class with an optimal index that depends on the exponential moment for any positive time.

Knudsen zone problem for a rarefied gas: a flow induced by a discontinuous wall temperature

Satoshi Taguchi
Kyoto University

Recently, fluid phenomena in microscale systems have attracted much attention because of their connection to optofluidics and their potential application to extracting kinetic energy from heat. In microscale systems, gas flows that are not predicted by conventional fluid dynamics are known to occur. Thermally-driven flows are among them. The Boltzmann equation describes these flows, but the complex collision term makes numerical solutions challenging. Luckily, for systems with relatively large system sizes (i.e., small Knudsen numbers), fluid- dynamic-type equations and slip boundary conditions derived from the Boltzmann system can be used to describe the flow and are considered to be suitable alternatives to the direct numerical solution. However, slip boundary conditions are derived under the assumption of smooth boundary conditions, and they may not be applicable in cases where the boundary shape has a sharp edge and/or the boundary data changes abruptly along a body. Removing this restriction by constructing slip boundary conditions even in such cases is an issue that will help understand various micro-nano scale phenomena, in particular, selfpropelled active particles. This study considers the steady flow of rarefied gas in contact with a flat plate with a discontinuous wall temperature (i.e., jump). We discuss the source-sinktype condition that leads to a nontrivial solution of the incompressible Stokes equation. We then discuss the numerical analysis of the Knudsen zone problem (a spatially two-dimensional boundary-layer problem for the Boltzmann equation), which is needed to determine the coefficient involved in the source-sink-type condition, making the condition available for practical use. This

talk is based on a joint work with Tetsuro Tsuji.

Hydrodynamic limit and Newtonian limit from the relativistic Boltzmann equation to the classical Euler equations

Yong Wang
Chinese Academy of Sciences

The hydrodynamic limit and Newtonian limit are important in the relativistic kinetic theory. We justify rigorously the validity of the two independent limits from the special relativistic Boltzmann equation to the classical Euler equations without assuming any dependence between the Knudsen number ε and the light speed $\mathfrak{c}$. The convergence rates are also obtained. This is achieved by Hilbert expansion of relativistic Boltzmann equation. New difficulties arise when tacking the uniform in $\mathfrak{c}$ and ε estimates for the Hilbert expansion, which have been overcome by establishing some uniform-in-c estimates for relativistic Boltzmann operators.

Some coupled system of fluid and geometric dispersive equations

Ning Jiang
Wuhan University

We report some recent progress on the coupled system of fluid equations and geometric dispersive maps with target manifold as sphere. One of the most famous example is the Ericksen-Leslie system of nematic liquid crystal, which is a coupling of incompressible Navier- Stokes and heat flow. The following three models will be discussed: 1. inertial Ericksen-Leslie system of liquid crystal, which is a coupling of Navier-Stokes and wave map. 2. liquid crystal elastomers with inertial effect, which is a coupling of elastodynamics and wave map. 3. evolutionary model for magnetoelasticity, which is a coupling of elastodynamics and Schrodinger flow. We discuss some global well-posedness and scattering results.

Boltzmann equation with mixed boundary condition

Renjun Duan
The Chinese University of Hong Kong

We study the Boltzmann equation in a smooth bounded domain featuring a mixed boundary condition. Specifically, gas particles experience specular reflection in two parallel plates, while diffusive reflection occurs in the remaining portion between these two specular regions. The boundary is assumed to be motionless and isothermal. Our main focus is on constructing global-in-time small-amplitude solutions around global Maxwellians for the corre- sponding initial-boundary value problem. The proof relies on the L^2 hypocoercivity at the linear level, utilizing the weak formulation and various functional inequalities on the test functions, such as Poincare and Korn inequalities. It also extends to the linear problem involving Maxwell boundary conditions, where the accommodation coefficient can be a piecewise constant function on the boundary, allowing for more general bounded domains. Moreover, we develop a delicate application of the $L^2 - L^\infty$ bootstrap argument, which relies on the specific geometry of our domains, to effectively handle this mixed-type boundary condition. Joint with Hongxu Chen (CUHK).

Chemotaxis kinetic model with internal state

Min Tang
Shanghai Jiao Tong University

Various macroscopic chemotaxis models that can be derived from kinetic models with internal states in different asymptotic regimes. In this talk, we will discuss two nonclassical limits: the first one is the pathway-based diffusion model (PBDM), which is a diffusion equation with one additional variable that characterizes the internal dynamics. It characterizes the dynamics of the engineered Escherichia coli populations and can form a stripe pattern, we provide some analytical results including the linear stability analysis and positivity. The second one is to study the transitional behavior from fractional diffusion to normal diffusion. We prove by asymptotics that the drift in the internal state leads to possible transition from fractional diffusion to normal diffusion at the population level.

Landau damping, collisionless limit, and stability threshold for the Vlasov-PoissonFokker-Planck equation

Weiren Zhao
New York University Abu Dhabi

In this talk, I will present a recent work about the asymptotic stability of the global Maxwellian for the Vlasov-Poisson-Fokker-Planck (VPFP) equation with a small collision frequency. Our main result establishes the Landau damping and enhanced dissipation phenomena under the condition that the perturbation of the global Maxwellian falls within the Gevrey-1/s class and obtains that the stability threshold for the Gevrey-1/s class with $s > s_k$ can not be larger than $\gamma = \frac{1-3s_k}{3-3s_k}$ for $s_k \in [0, 1/3]$. This result is based on the joint work with Bedrossian and Zi.

Invariant Gibbs measures for 2D NLS and 3D cubic NLW

Haitian Yue
Shanghai University of Science and Technology

In this talk, we'll present our results about invariant Gibbs measures for the periodic nonlinear Schrödinger equation (NLS) in 2D, for any (defocusing and renormalized) odd power nonlinearity, and for cubic NLW in 3D. This is joint work with Bjoern Bringmann (IAS), Yu Deng (USC) and Andrea Nahmod (UMass Amherst).

Diffusion Limit and the optimal convergence rate of the Vlasov-Poisson-Boltzmann System

Mingying Zhong
Guangxi University

In the this talk, we study the diffusion limit of the classical solution to the unipolar Vlasov-Poisson-Boltzmann (VPB) system with initial data near a global Maxwellian. We prove the convergence and establish the convergence rate of the global strong solution to the unipolar VPB system towards the solution to an incompressible NavierStokes-Poisson-Fourier system based on

the spectral analysis with precise estimation on the initial layer.

Phase mixing in astrophysical plasmas with an external Kepler potential.

Sanchit Chaturvedi
New York University

In Newtonian gravity, a self-gravitating gas around a massive object such as a star or a planet is modeled via the Vlasov-Poisson equation with an external Kepler potential. The presence of this attractive potential allows for bounded trajectories along which the gas neither falls in towards the object nor escapes to infinity. We focus on this regime and prove first a linear phase mixing result in 3D outside symmetry with exact Kepler potential. Then we also prove a long-time nonlinear phase mixing result in spherical symmetry. The mechanism is phenomenologically similar to Landau damping on a torus but mathematically the situation is quite a lot more complex.
This is based on an upcoming joint work with Jonathan Luk at Stanford.

Time-periodic solutions of the Boltzmann system in $\mathbb{R}^3_x$

Yuanjie Lei
Huazhong University of Science and Technology

In this talk, we will present a comprehensive approach for addressing timeperiodic solutions in kinetic equations. We establish the global existence of time-periodic solutions to the Boltzmann equation in three-dimensional space, when subjected to general non-homogeneous external force terms. Moreover, we have formulated global solutions in the proximity of the time- periodic solutions and acquired the corresponding time decay rates. This is a joint work with Prof.H.J.Zhao.

Some progresses on Hilbert expansion of kinetic equations with collision

Qinghua Xiao
Wuhan Institute of Chinese Academy of Sciences

Our talk is concerned with the hydrodynamic limits of both the Vlasov-MaxwellLandau (VML) and the non-cutoff Vlasov-Maxwell-Boltzmann (VMB) systems in the entire space. We prove that, within the framework of Hilbert expansion, the unique classical solution of the VML or non- cutoff VMB system converges globally over time to the smooth global solution of the Euler-Maxwell system as the Knudsen number approaches zero. The core of our analysis hinges on deriving novel interplay energy estimates for the solutions of these two systems, concerning both a local Maxwellian and a global Maxwellian, respectively. Our findings address a problem in the hydrodynamic limit for Landau-type equations and noncutoff Boltzmann-type equations with a magnetic field.