List of Talks

Abstracts of Talks

Global Existence and Uniqueness analysis of Reaction-Cross-Diffusion Systems

Xiuqing Chen
Sun Yat-Sen University

The global-in-time existence of weak and renormalized solutions to reaction-cross-diffusion systems for an arbitrary number of variables in bounded domains with no-flux boundary conditions are proved. The cross-diffusion part describes the segregation of population species and is a generalization of the Shigesada-Kawasaki-Teramoto model. The diffusion matrix is not diagonal and generally neither symmetric nor positive semi-definite, but the system possesses a formal gradient-flow or entropy structure. The reaction part is of Lotka-Volterra type for weak solutions or includes reversible reactions of mass-action kinetics and does not obey any growth condition for renormalized solutions. Furthermore, we prove the uniqueness of bounded weak solutions to a special class of cross-diffusion systems, and the weak-strong uniqueness of renormalized solutions to the general reaction-cross-diffusion cases.

Suppression of phase separation and epitaxial thin film blow up by mixing

Yu Feng
Peking University

In this talk, we study the effect of adding an advection term, and the resulting increased dissipation rate, on the growth of solutions to two specific non-linear parabolic PDEs. One is the well-known Cahn-Hilliard equation, and the other is used to model thin-film growth. In the classical model, the Cahn-Hilliard equation's solution spontaneously forms domains with $c = \pm 1$ separated by thin transition regions. While, for the thin-film type equation, one can prove that the solutions starting from the initial data with negative energy will blow up in a finite time.
In contrast to the classical model, we imposed an incompressible velocity field $u(t, x)$ to the two equations to model the stirring of the fluids. Our main result asserts that if the imposed velocity field is sufficiently mixing, then no phase separation occurs in the Cahn-Hilliard model, and the global existence of the solutions to the thin-film type equation can be proved. Further, both solutions will converge exponentially to a homogeneous mixed state. The mixing effectiveness of the imposed drift is quantified via the associated advection-hyperdiffusion equation's dissipation time.

Potential singularity formation of the 3D axisymmetric Navier-Stokes equations with vanishing numerical diffusion

De Huang
Peking University

The 3D Navier-Stokes equations govern the motion of the viscous incompressible fluid. Whether the solution of the Navier-Stokes equations can develop a finite-time singularity from smooth initial data is one of the most challenging problems in fluid dynamics. In this work, we present strong numerical evidence that the 3D axisymmetric Navier-Stokes equations with vanishing numerical viscosity and smooth initial data of finite energy develop a potential finite-time locally self-similar singularity at the origin. An important feature of this potential singularity is that the solution develops a two-scale traveling wave that travels towards the origin. The two-scale feature is characterized by the property that the center of the traveling wave approaches to the origin at a slower rate than the rate of the collapse of the singularity. We perform careful resolution study, scaling fitting, and asymptotic scaling analysis to provide further support of the potential finite time locally self-similar blowup.

Hypocoercivity based local sensitivity analysis for multiscale kinetic equations with uncertainties

Shi Jin
Shanghai Jiao Tong University

Hypocoercivity based analysis is a powerful tool for kinetic equations which allows one to understand the regularity and long-time behavior of both linear and nonlinear kinetic equations, despite that kinetic operators are degenerately dissipative. We extend such analysis to linear and nonlinear kinetic equations with random uncertainties in initial data or collisional kernels, which allows us to establish regularity, local sensitivity with respect to uncertain random parameters, and long-time exponential decay of the solution toward the global equilibrium in the random space, as well as spectral convergence and long-time error decay of the polynomial chaos based stochastic Galerkin methods, a popular method used for uncertainty quantification.

Entropy-bounded solutions to the compressible Navier-Stokes equations with far field vacuum

Jinkai Li
South China Normal University

The entropy is one of the fundamental physical states of a fluid. For the ideal gases, it can be expressed as a certain linear combination of the logarithms of the density and temperature in the non-vacuum region, and, in the viscous case, it satisfies an equation of highly singular in the region close to the vacuum. Due to the singularity of the logarithmic function at zero and the singularity of the entropy equation near the vacuum region, the mathematical analyses on the behavior of the entropy near the vacuum region, were rarely carried out; in particular, in the presence of vacuum, it was unknown if the entropy remains its boundedness. It will be shown in this talk that the ideal gases retain their uniform boundedness of the entropy, locally or globally in time, if the vacuum occurs at the far field only and the density decays slowly enough at the far field. Precisely, we consider the Cauchy problem to the full compressible Navier-Stokes equations, with or without heat conductivity, and establish the local and global existence and uniqueness of solutions with uniformly bounded entropy in space at each time slice, in the presence of vacuum at the far field only. These are joint works with Prof . Zhouping Xin.

On principal eigenvalues for 2nd order elliptic and time-periodic parabolic operators

Yuan Lou
Ohio State University

We will discuss asymptotic behaviors of principal eigenvalues for 2nd order elliptic and time-periodic parabolic operators, with either small small diffusion or large drift. The talk is based on joint works with Shuang Liu (Renmin University of China), Rui Peng (Jiangsu Normal University) and Maolin Zhou (Chern Institute).

Global well-posedness for a generalized Keller-Segel system with full degenerate dissipation and mixing

Binbin Shi
Shanghai Jiao Tong University

In this talk, we study the mixing effect for a generalized Keller-Segel system with full degenerate dissipation and relaxation enhancing flow. We show that the global well-posedness of solution with large advection. Since dissipation term degenerate into the damping, the enhanced dissipation effect no longer occurs. We prove that the mixing effect can weak the influence of nonlinear term.

Fokker-Plank system for movement of micro-organism population in confined environment

Min Tang
Shanghai Jiao Tong University

Self-propelled micro-organisms, such as C. Crescentus and different types of Escherichia coli accumulate near boundaries. Micro-swimmers bump into various obstacles and boundaries, alter the motility and are trapped in the near surface region. Motivated by the experiment and some theoretical models, we consider here self-propelled micro-organisms confined between two parallel plates. We propose appropriate boundary conditions for the Fokker-Plank equation in confined environment, so that it can describe the correct probability density distribution of self-propelled micro-organisms. We study the time evolutionary system and establish the relative entropy estimate and give its long term convergence to steady state solution.

The linearized Vlasov and Vlasov-Fokker-Planck equations in a uniform magnetic field

Fei Wang
Shanghai Jiao Tong University

We study the linearized Vlasov equations and the linearized Vlasov-Fokker-Planck equations in the weakly collisional limit in a uniform magnetic field. In both cases, we consider periodic confinement and Maxwellian (or close to Maxwellian) backgrounds. In the collisionless case, for modes transverse to the magnetic field, we provide a precise decomposition into a countably infinite family of standing waves for each spatial mode. These are known as Bernstein modes in the physics literature, though the decomposition is not an obvious consequence of any existing arguments that we are aware of. We show that other modes undergo Landau damping. In the presence of collisions with collision frequency $\nu \ll 1$, we show that these modes undergo uniform-in-ν Landau damping and enhanced collisional relaxation at the time-scale $O(\nu^{-1/3})$. The modes transverse to the field are uniformly stable and exponentially thermalize on the time-scale $O(\nu^{-1})$.

1-D Navier-Stokes equation with BV data: well-posedness and wave propagation

Haitao Wang
Shanghai Jiao Tong University

It is established recently by Liu-Yu a constructive existence theory of weak solution to isentropic Navier-Stokes equation with initial data of small total variation. The key ingredient in their work is the pointwise structures of heat kernel with BV coefficient. In this talk, we will first review their result. Then, by refining the heat kernel estimates, we prove the regularity and uniqueness of the weak solution. Moreover, if the initial perturbation in BV class is localized in space, we can describe the wave propagation precisely. This talk is based on joint works with Shih-Hsien Yu and Xiongtao Zhang.

Gaussian fluctuations for interacting particle systems with singular kernels

Zhenfu Wang
Peking University

We consider the asymptotic behavior of the fluctuations for the empirical measures of interacting particle systems with singular kernels. We prove that the sequence of fluctuation processes converges in distribution to a generalized Ornstein-Uhlenbeck process. Our result considerably extends classical results to singular kernels, including the Biot-Savart law. The result applies to the point vortex model approximating the 2D incompressible Navier-Stokes equation and the 2D Euler equation. We also obtain Gaussianity and optimal regularity of the limiting Ornstein-Uhlenbeck process. The method relies on the martingale approach and the Donsker-Varadhan variational formula, which transfers the uniform estimate to some exponential integrals. Estimation of those exponential integrals follows by cancellations and combinatorics techniques and is of the type of large deviation principle.

The stability analysis of a 2D Keller-Segel-Navier-Stokes system in fast signal diffusion

Zhaoyin Xiang
University of Electronic Science and Technology of China

In this talk, we investigate the stability of a fully parabolic-parabolic-fluid (PP-fluid) system of the Keller-Segel-Navier-Stokes type in a bounded planar domain under the natural volume filling hypothesis. In the limit of fast signal diffusion, we first show that the global classical solutions of the PP-fluid system will converge to the solution of the corresponding parabolic-elliptic-fluid (PE-fluid) system. As a byproduct, we obtain the global well-posedness of the PE-fluid system for general large initial data. We also establish some new exponential time decay estimates for suitable small initial data, which in particular ensure an improvement of convergence rate on time. To further explore the stability property, we carry out three numerical examples of different types: the nontrivial and trivial equilibriums, and the rotating aggregation. The simulation results illustrate the possibility to achieve the optimal convergence, and show the vanishment of the deviation between the PP-fluid system and PE-fluid system for the equilibriums, and the drastic fluctuation of error for the rotating solution.

Uniform structural stability of Poiseuille flows in a pipe under Navier boundary conditions

Chunjing Xie
Shanghai Jiao Tong University

In this talk, we discuss the recent progress on the uniform structural stability of Poiseuille flows in a pipe under Navier boundary conditions. The key point is that the estimate is uniform with respect to both the fluxes of the flows and the slip coefficients in the Navier boundary conditions. One of the key ingredients of the analysis is to deal with the case with large flux and intermediate slip coefficients.

Compressible Navier-Stokes Equations, Vacuum and Entropy

Zhouping Xin
Chinese University of Hong Kong

The dynamics of the vacuum state is one of the challenging issues for the viscous compressible fluids. Due to the strong degeneracy of the compressible Navier-Stokes system in the presence of vacuum, there are many difficulties associated with global well-well-posedness of either strong or even weak solutions. This is particularly so for multi-dimensional case and with thermo-energy. Since the entropy is one of the most important physical states and it's equation is highly singular near vacuum, so solutions with bounded entropy are of great importance. In this talk, I will discuss some of key issues in studying the full Navier-Stokes system and present some recent results on entropy-bounded strong solutions.

Global hydrostatic approximation of hyperbolic Navier-Stokes system with small Gevrey class 2 data

Ping Zhang
Chinese Academy of Sciences

We study a hyperbolic version of the Navier-Stokes equations obtained by using Cattaneo heat transfer law instead of Fourier law, evolving in a thin strip $\mathbb{R} \times (0, \varepsilon)$. The formal limit of these equations is a hyperbolic Prandtl type equation. We prove the existence and uniqueness of a global solution to these equations under a uniform smallness assumption on the data in Gevrey 2 class. Then we justify the limit from the anisotropic hyperbolic Navier-Stokes system to the hydrostatic hyperbolic Navier-Stokes system with Gevrey 2 data. We also exhibit smallness assumptions on the data in Gevrey 2 class, under which the solutions are global in time.

Linear stability of the Couette flow in the 3D isentropic compressible Navier-Stokes equations

Ruizhao Zi
Central China Normal University South

Consider the linear stability of the three dimensional isentropic compressible Navier-Stokes equations on $\mathbb{T} \times \mathbb{R} \times \mathbb{T}$. We prove the enhanced dissipation phenomenon for the linearized isentropic compressible Navier-Stokes equations around the Couette flow $(y, 0, 0)^{\top}$. Moreover, the lift-up phenomenon is also shown in this paper. Compared with the 3D incompressible Navier-Stokes equations [Ann. of Math.,185(2017), 541–608], the lift-up effect here is stronger due to the loss of the incompressible condition. This is based on a jointwork with Lan Zeng and Zhifei Zhang.

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