List of Talks

Abstracts of Talks

Dissipation anomaly for long time averages

Alexey Cheskidov
Westlake University

In turbulent flows, the energy injected at forced low modes (large scales) cascades to small scales through the inertial range where viscous effects are negligible, and only dissipates above Kolmogorov's dissipation wavenumber. The persistence of the energy flux through the inertial range is what constitutes dissipation anomaly for viscous fluid flows as well as anomalous dissipation for the limiting inviscid flows. We first analyze these intrinsically linked phenomena on a finite time interval and prove the existence of various scenarios in the limit of vanishing viscosity, ranging from the total dissipation anomaly to a pathological one where anomalous dissipation occurs without dissipation anomaly, as well as the existence of infinitely many limiting solutions of the Euler equations in the limit of vanishing viscosity. Finally, expanding on the obtained total dissipation anomaly construction, we show the existence of dissipation anomaly for long time averages, relevant for turbulent flows, proving that the Doering-Foias upper bound is sharp.

Stability of Hill's vortex and its filamentation

Kyudong Choi
Ulsan National Institute of Science and Technology

We study stability of a spherical vortex introduced by M. Hill in 1894, which is an explicit solution of the three-dimensional incompressible Euler equations. The flow is axi-symmetric with no swirl, the vortex core is simply a ball sliding on the axis of symmetry with a constant speed, and the vorticity in the core is proportional to the distance from the symmetry axis. By using the variational setting introduced by A. Friedman and B. Turkington (Trans. Amer. Math. Soc., 1981), the stability for axisymmetric perturbations up to a translation (so-called an orbital stability) is obtained by using a concentrated compactness method. With a dynamical bootstrapping scheme for particle trajectories, we prove linear in time filamentation near the vortex: there exists an arbitrary small outward perturbation growing linearly for all times. These results rigorously confirm numerical simulations by Pozrikidis in 1986. The second part is joint work with In-Jee Jeong (SNU).

Pathological solutions for active scaler equations

Mimi Dai
University of Illinois at Chicago

We will discuss recent development in construction of weak solutions for active scaler equations, for which the uniqueness and certain conservation law are violated. The purpose is to verify the sharp regularity threshold that separates the rigidity and flexibility regimes.

Entropy maximization in the two-dimensional Euler equations

Matias Delgadino
University of Texas at Austin

The underlying variational geometric structure for nematic liquid crystals will be presented. Both models due to Ericksen-Leslie and Eringen will be discussed and the relationship between them will be analyzed. The extension of the Euler-Poincaré approach, underlying the geometric structure for both models, will be presented.

Global-in-time dynamics for one-phase Muskat and two-phase Stokes gravity waves

Francisco Gancedo
University of Seville

In this talk we consider the evolution of interfaces evolving by incompressible flows. On the one hand, we study the one-phase Muskat problem, where the fluid is filtered in a porous medium. In the gravity-stable case, we show that initial Lipschitz graphs of arbitrary size provide global-in-time well-posedness. On the other hand, we study the interface dynamics given by two fluids of different densities evolving by the linear Stokes law. We show stability to the flat stable case and exponential growth in the unstable regime.

Speed-up of invasion by chemotaxis

Christopher Henderson
University of Arizona

Some species, such as certain bacteria and slime molds, "communicate" via chemical signals that either aggregate or repel individuals. This manifests in PDE models as a drift term made up of the convolution of the population density with a particular kernel. In this talk, I will give an overview of how such nonlocal terms may influence the invasion of a new environment by such a population. The focus will be on developing analytic tools to understand these models. I will also discuss connections to fluid dynamics-based models where convection plays a similar role.

Leapfrogging in fluid dynamics

Taoufik Hmidi
NYU Abu Dhabi

In this talk I will discuss some aspects on the leapfrogging phenomenon in the vortex dynamics for Euler equations in the plane. We show that under suitable constraints, four concentrated vortex patches leapfrog for any time. When observed from a translating frame of reference, the evolution of these vortex patches can be described as a non-rigid time periodic motion. Our proof hinges upon two key components. First, we desingularize the symmetric four point vortex configuration, which leapfrogs in accordance with Love's result, by concentrated vortex patches. Second, we use some tools from KAM theory to effectively tackle the small divisors problem and deal with the degeneracy in the time direction. This is a joint work with Zineb Hassainia and Nader Masmoudi.

Vanishing viscosity in the presence of boundaries

Milton Lopes Filho
Universidade Federal do Rio de Janeiro

We present a broad overview of past and current work on the vanishing viscosity limit in the presence of boundaries, focusing on 2D domains and irregular flows.

Recent advances in the controllability of fluid dynamics

Franck Sueur
University of Bordeaux

In this talk I will present some results which were obtained these last years regarding the possibility to trigger the incompressible Euler and Navier-Stokes equations by a localized action. Two types of control results will be addressed: some aims at controlling the fluid velocity everywhere while the others targets the displacement of a specific zone of fluid.

Stability threshold of nearly-Couette shear flows with Navier boundary conditions in 2D

Fei Wang
Shanghai Jiao Tong University

In this work, we prove a threshold theorem for the 2D Navier-Stokes equations posed on the periodic channel, $\mathbb{T} \times [-1, 1]$, supplemented with Navier boundary conditions $\omega|_{y=\pm 1} = 0$. Initial datum is taken to be a perturbation of Couette in the following sense: the shear component of the perturbation is assumed small (in an appropriate Sobolev space) but importantly is independent of ν. On the other hand, the nonzero modes are assumed size $O(\nu^{\frac{1}{2}})$ in an anisotropic Sobolev space. For such datum, we prove nonlinear enhanced dissipation and inviscid damping for the resulting solution. The principal innovation is to capture quantitatively the *inviscid damping*, for which we introduce a new Singular Integral Operator which is a physical space analogue of the usual Fourier multipliers which are used to prove damping. We then include this SIO in the context of a nonlinear hypocoercivity framework.

The rigidity of steady solutions of high dimensional Navier-Stokes system and its applications

Chunjing Xie
Shanghai Jiao Tong University

The Liouville type theorem for stationary Navier-Stokes system in the whole space is longstanding open problem. In this talk, we first discuss the rigidity of steady Navier-Stokes system with dimension bigger than three in a class more general than self-similar solutions, where we do not need any type of self-similarity or smallness of solutions. Furthermore, this rigidity result is used to study the regularity and far field behavior of steady solutions of high dimensional Navier-Stokes system.

Recent developments on singular stochastic PDEs in fluid mechanics and convex integration

Kazuo Yamazaki
University of Nebraska Lincoln

Stochastic PDEs forced by random noise have been studied for many decades. When the random noise is too irregular and consequently the product nonlinear term becomes ill-defined, they are called singular stochastic PDEs. Examples include the Navier-Stokes equations, the Boussinesq system, and the magnetohydrodynamics system forced by space-time white noise. On one hand, via the theory of regularity structures and the theory of paracontrolled distributions, solution theories have become possible for some of such singular stochastic PDEs in fluid. On the other hand, the convex integration technique has been able to show that some stochastic PDEs in fluid (even the singular ones) admit non-uniqueness. We review recent developments in these research directions.

On the regularity of weak solutions for ultra-parabolic equations in divergent form

Liqun Zhang
Chinese Academy of Sciences

We survey some of the recent progress on the regularity of weak solutions for ultraparabolic equations in divergent form with rough coefficients and related studies. We first introduce and explain the background of those equations and applications in related different area. Then we mainly talk about the new development in the study of De Giorgi-Nash-Moser regularity theory for weak solution of ultra-parabolic equations and some of the application of the these results in related problems.

A Novel Stochastic Interacting Particle-Field Algorithm for 3D Parabolic-Parabolic Keller-Segel Chemotaxis System

Zhiwen Zhang
The University of Hong Kong

We propose an efficient stochastic interacting particle-field (SIPF) algorithm for computing aggregation patterns and near singular solutions of the parabolic-parabolic Keller-Segel (KS) chemotaxis system in 3D. Our approach approximates KS solutions using empirical measures of particles coupled with a smoother field variable computed through the spectral method. To overcome the history dependence and high memory cost, we employ an implicit Euler discretization technique to derive a one-step recursion in time for stochastic particle positions and the field variable. This recursion is based on the explicit Green's function of an elliptic operator. Numerical experiments confirm the convergence and self-adaptive nature of the SIPF algorithm to high gradient regions, which provides a low-cost approach to studying the emergence of finite time blowup in 3D using a small number of Fourier modes and varying initial mass.

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