Equations of Fluid Mechanics: Analysis
Équations de la mécanique des fluides : analyse

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HAKIMA BESSAIH, University of Wyoming
Mean field limit of interacting filaments and vector valued non linear PDEs

Families of N interacting curves are considered, with long range, mean field type, interaction. They generalize models based on classical interacting point particles to models based on curves. In this new set-up, a mean field result is proven, as $N \to \infty$. The limit PDE is vector valued and, in the limit, each curve interacts with a mean field solution of the PDE. Our main motivation is the approximation of 3D-inviscid flow dynamics by the interacting dynamics of a large number of vortex filaments, as observed in certain turbulent fluids; in this respect, the present result is restricted to smoothed interaction kernels, instead of the true Biot-Savart kernel.

ELAINE COZZI, Oregon State University
The aggregation equation with Newtonian potential

The aggregation equation with Newtonian potential models several different physical problems, including chemotaxis (when diffusion is present) and type-II superconductivity (without diffusion). In this talk, we apply techniques from two-dimensional fluid mechanics to investigate well-posedness theory and the inviscid limit for a generalization of this equation. This is joint work with Gung-Min Gie and James P. Kelliher.

MICHAEL DABKOWSKI, Lawrence Technological University
On the Global Stability of a Nonlinear PDE with a Nonlocal Term

In joint work with Joseph Conlon, we investigate the global stability of the Lifschitz-Slyozov-Wagner model of Ostwald Ripening by introducing a perturbation of a quadratic model studied by Niethammer and Conlon. This model coupled with the mass conservation law generate a nonlinear nonlocal PDE whose asymptotic stability can be proved by examining the stability of a certain nonlinear differential delay equation. We prove an exponential rate of convergence of the solutions of our model to the equilibrium solution for a wide class of initial data.

MIMI DAI, University of Illinois at Chicago
Kolmogorov's dissipation number and the number of degrees of freedom for the 3D Navier-Stokes equations

Kolmogorov's theory of turbulence predicts that only wavenumbers below some critical value, called Kolmogorov's dissipation number, are essential to describe the evolution of a three-dimensional fluid flow. A determining wavenumber, first introduced by Foias and Prodi for the 2D Navier-Stokes equations, is a mathematical analog of Kolmogorov's number. The purpose of this paper is to prove the existence of a time-dependent determining wavenumber for the 3D Navier-Stokes equations whose time average is bounded by Kolmogorov's dissipation wavenumber for all solutions on the global attractor whose intermittency is not extreme.

THEODORE DRIVAS, The Johns Hopkins University
An Onsager Singularity Theorem for Solutions of the Compressible Euler Equations

We prove that any bounded weak solutions of the compressible Euler system satisfy kinetic energy, internal energy and entropy balance equations with possible 'inertial range' defect terms. These defects are non-vanishing only if the weak solutions have sufficiently low Besov regularity of the type observed empirically in compressible turbulence. Under some assumptions, we prove that these defects match on to the dissipative anomaly terms appearing in the inviscid limit for compressible Navier-Stokes solutions, thereby deriving Kolmogorov 4/5th–type laws. Stationary, planar shocks with an ideal-gas equation of state provide simple examples of dissipation solutions appearing in the inviscid limit and demonstrate the sharpness of our L^3 - based regularity conditions. This talk is based on joint work with Gregory Eyink.

ASEEL FARHAT, University of Virginia
Geometry of 3D turbulent flows and the scaling gap in the 3D Navier-Stokes regularity problem

We show that the scaling gap in the 3D Navier-Stokes equation regularity problem can be reduced by an $algebraic\ factor$. All preexisting improvements have been logarithmic in nature, regardless of the functional set up utilized. This result is inspired by the geometry of the regions of intense vorticity observed in computational simulations of 3D turbulent flows.

MILTON LOPES FILHO, Universidade Federal do Rio de Janeiro
Incompressible, ideal flows around many small obstacles

We study the limiting behavior of solutions of the incompressible Euler equations in the exterior of a family of disjoint small disks, with the number of disks increasing as the size of the disks vanishes.

SUSAN FRIEDLANDER, University of Southern California
Small parameter limits for magnetogeostrophic turbulence.

We discuss a three dimensional system of Boussinseq MHD equations in the context of dynamo action in the Earth's fluid core. This system is very rich in small parameters which leads to challenging and interesting singular limits.

This is joint work with Anthony Suen.

SLIM IBRAHIM, University of Victoria
Analysis of a Magneto-Hydro-Dynamic (MHD) system

I will introduce a full MHD model for plasma, and survey the recent mathematical progress made. The survey includes local and global well-posdeness of the Cauchy problem, existence and asymptotic stability of periodic solutions, and non-relativistic limits of the system allowing to recover the classical magneto-hydrodynamic model.

MICHAEL JOLLY, Indiana University
A determining form for the surface quasi-geostrophic equation

We show that the global attractor of the subcritical quasi-geostrophic equation (SQG) can be embedded in the long-time dynamics of an ordinary differential equation called a determining form. There is a one-to-one correspondence between the trajectories in the global attractor of the SQG and the steady state solutions of the determining form. The analysis combines De Giorgi techniques and elementary harmonic analysis.

ADAM LARIOS, University of Nebraska-Lincoln
Continuous Data Assimilation: Multiphysics and Nonlinear Feedback

We will discuss new nonlinear continuous data assimilation algorithms. These models will be compared with the linear continuous data assimilation algorithm introduced by Azouani, Olson, and Titi (AOT). As a proof-of-concept for these models, we computationally investigate these algorithms in the context of the 1D Kuramoto-Sivashinsky equation. We observe that the nonlinear models experience super-exponential convergence in time. We will also discuss new analytical results on linear anisotropic data assimilation for the 2D MHD equations.

ANNA MAZZUCATO, Penn State University
On the two-dimensional Kuramoto-Sivashinsky equation

I will discuss recent results concerning the Kuramoto-Sivashinky equation in two space dimensions with periodic boundary conditions. In particular, I will present a global existence result in the Wiener algebra, when growing modes are absent. This is joint work with David Ambrose (Drexel University, USA).

CECILIA MONDAINI, ICERM/Brown University
Analysis of a feedback-control data assimilation algorithm

The purpose of this talk is to present some analysis results concerning a feedback-control (nudging) approach for data assimilation that works for a general class of dissipative dynamical systems and observables. In particular, we first show how to treat the case of discrete in time measurements with systematic errors. Later, we show how to obtain an analytical estimate of the error committed when using a numerical approximation of the feedback-control equation given by the Postprocessing Galerking method. Most importantly, the error estimate obtained in this latter result is uniform in time, which reflects the global stability of the system. This talk is based on joint works with C. Foias and E. S. Titi.

EDRISS TITI, Texas A&M University and The Weizmann Institute of Science
Recent advances concerning the Primitive Equations of oceanic and atmospheric dynamics

In this talk I will show the global (in time) well-posedness for the 3D viscous primitive equations of atmospheric and oceanic dynamics for all initial data. Motivated by strong ani-sotropic turbulence mixing I will also show the global well-posedness of this model with only horizontal viscosity and either horizontal of vertical diffusion. On the other hand, I will show that in the inviscid case there is a class of initial data for which the corresponding smooth solutions of the inviscid primitive equations develop singularity (blow-up) in finite-time.

XINWEI YU, University of Alberta
Some new Prodi-Serrin type conditions for the 3D Navier-Stokes equations

In this talk I will present several new families of Prodi-Serrin type conditions which guarantee the smoothness of weak solutions for the 3D Navier-Stokes equations. These conditions involve either one of the quantities pressure, velocity, gradient of velocity, or their mixtures, and are in the form of space-time bounds on the Lebesgue, Lorentz, or Orlicz norms. This is joint work with Prof. Chuong V. Tran and Mr. Benjamin Pineau.

KAREN ZAYA, University of Michigan
On Regularity Properties for Fluid Equations

We discuss a newly developed regularity criterion for the three-dimensional Boussinesq equations, which only imposes a condition on the low modes of the velocity u. The key tool in the development of this weaker regularity criterion is linked to the dissipation wave number.