BOOK OF ABSTRATCS

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V Workshop on Fluids and PDE

Online - September 20th to October 1st, 2021

Speakers

David Ambrose *(Drexel U., USA)*
Anne Bronzi *(Unicamp, Brazil)*
Ciro Campolina *(IMPA, Brazil)*
Nikolai Chemetov *(USP, Brazil)*
Alexey Cheskidov *(UIC, USA)*
Peter Constantin *(Princeton U., USA)*
Gianluca Crippa *(Univ. Basel, Switzerland)*
Mimi Dai *(UIC, USA)*
Sara Daneri *(GSSI, Italy)*
Martin Donati *(Univ. de Lyon 1, France)*
Yuanyuan Feng *(PSU, USA)*
Milton C. Lopes Filho *(UFRJ, Brazil)*
Lucas C. F. Ferreira *(Unicamp, Brazil)*
Francisco Gancedo *(Univ. de Sevilla, Spain)*
Jiao He *(Univ. d'Évry, France)*
Taoufik Hmidi *(Univ. of Rennes 1, France)*
Dragos Iftimie *(Univ. de Lyon 1, France)*
Gautam Iyer *(CMU, USA)*
Trevor Leslie *(USC, USA)*
Helena J. Nussenzveig Lopes *(UFRJ, Brazil)*
Juliana Lopes *(Unicamp, Brazil)*
Alexei Mailybaev *(IMPA, Brazil)*
Anna Mazzucato *(PSU, USA)*
Cecilia Mondaini *(Drexel U., USA)*
Andre Nachbin *(IMPA, Brazil)*
Toan Nguyen *(PSU, USA)*
César Niche *(UFRJ, Brazil)*
Gabriela Planas *(Unicamp, Brazil)*
Fábio Ramos *(UFRJ, Brazil)*
Ricardo M. S. Rosa *(UFRJ, Brazil)*
Marco Sammartino *(UNIPA, Italy)*
Roman Shvydkoy *(UIC, USA)*
Stefano Spirito *(Univ. of L'Aquila, Italy)*
Simon Thalabard *(IMPA, Brazil)*

Scientific Committee

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Organizing Committee

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Gabriela Planas *(Unicamp, Brazil)*
Marcelo Santos *(Unicamp, Brazil)*

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Welcome

It is a pleasure to welcome you to the V Workshop on Fluids and PDE - Online. The main theme of the workshop is mathematical modeling and rigorous analysis of fluid dynamics problems, particularly incompressible flows with little regularity (non-smooth) and turbulent flows.

This is the fifth edition in a series of workshops aimed at fostering collaboration among the growing community of researchers working in Brazil on mathematical fluid dynamics, in particular on the incompressible Navier-Stokes and Euler equations, as well as stimulating further collaboration with the international community. The first and third editions took place at Universidade Estadual de Campinas (Unicamp), on August 16-17, 2007 and June 27 -July 1, 2011, respectively; the second and fourth editions were held at Rio de Janeiro, at the Universidade Federal do Rio de Janeiro (UFRJ), on August 13-15, 2008 and at Instituto de Matemtica Pura e Aplicada (IMPA) on May 26 30, 2014.

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Marcelo Santos (Universidade Estadual de Campinas, Brazil)

Collaborators

Juliana Honda Lopes (Universidade Estadual de Campinas, Brazil)
Ricardo Martins Mendes Guimarães (Universidade Estadual de Campinas, Brazil)

Contents

General Information

Location

The lectures will take place at Zoom. The poster session and the coffee-breaks will be held on the virtual platform Gather Town.

Certificates

The Certificates will be send by email to all speakers and Posters presenters. The Certificates for the participants will be provided upon request.

Program

	Monday (09/20)	Tuesday (09/21)	Wednesday (09/22)	Thursday (09/23)	Friday (09/24)
10:00-10:50	Helena Lopes	Peter Constantin	Anna Mazzucato	Stefano Spirito	Dragos Iftimie
10:50-11:20	**Coffee-break GatherTown**				
11:20 - 12:10 / **11:20-11:50**	David Ambrose	Jiao He	Francisco Gancedo	Simon Thalabard	Toan Nguyen
Lunch break					
13:10-14:00	Andre Nachbin	Gautam Iyer	Ricardo Rosa	Nikolai Chemetov	Gabriela Planas
14:00 - 14:30		**Poster session GatherTown**		**Poster session GatherTown**	
14:30 - 15:00		Ciro Sobrinho		Juliana Lopes	

	Monday (09/27)	Tuesday (09/28)	Wednesday (09/29)	Thursday (09/30)	Friday (10/01)
10:00-10:50	César Niche	Lucas C. F. Ferreira	Gianluca Crippa	Marco Sammartino	Sara Daneri
10:50-11:20	**Coffee-break GatherTown**				
11:20 - 12:10 / **11:20-11:50**	Alexey Cheskidov	Martin Donati	Fábio Ramos	Anne Bronzi	Taoufik Hmidi
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14:30 - 15:00		Trevor Leslie		Yuanyuan Feng	

Lectures

Global existence for the 2D Kuramoto-Sivashinsky equation with a linearly growing mode in each direction

David Ambrose

Drexel University, USA

The Kuramoto-Sivashinsky equation is a weakly nonlinear model of the motion of the front separating two compressible fluids, which are a burnt and an unburnt phase of a gas undergoing combustion. In the case that the front is one-dimensional, much is understood about Kuramoto-Sivashinsky dynamics, largely owing to a simple form of the nonlinearity in the equation. In the two-dimensional case, the nonlinearity does not have this favorable structure, and there are many fewer results. Previously the only global existence results were strongly anisotropic, i.e. results of thin domain type. In joint work with Anna Mazzucato, we have developed the first global existence results for the two-dimensional Kuramoto-Sivashinsky equation without an anisotropic assumption. Our results depend on the size of the spatially periodic domain, as the size of the domain determines how many Fourier modes are linearly growing. We are able to admit a linearly growing mode in each spatial direction.

On the Euler equations with helical symmetry

Anne Bronzi

Universidade Estadual de Campinas, Brazil

In this talk we will survey some results regarding the global existence of weak solutions of the Euler equations in $\mathbb{R}^3$ with helical symmetry and without swirl for initial vorticity with low regularity.

Incompressible fluid flows on logarithmic lattices

Ciro Campolina

Instituto de Matemática Pura e Aplicada, Brazil

Several open problems in fluid dynamics are related to the spontaneous development of small-scale structures. A traditional investigation procedure consists in simplifying the equations of motion preserving just a part of the system believed to be important. Here we present a different approach, in which, instead of simplifying equations, one introduces a simplified configuration space: velocity fields are defined on logarithmic lattices in Fourier space with proper algebraic operations and calculus. In this framework, equations of motion retain their exact original form and maintain most scaling properties, symmetries, and invariants. Classification of such models reveals a fascinating relation with renowned mathematical constants such as the golden mean and the plastic number. Using both rigorous and numerical analysis, we describe various properties of solutions for incompressible fluid flow on logarithmic lattices, from the basic concepts of existence and uniqueness to the blowup development and turbulent dynamics. In particular, we observe strong robustness of the chaotic blowup scenario in the three-dimensional incompressible Euler equations, as well as the Fourier mode statistics of developed turbulence resembling the full three-dimensional Navier-Stokes system.

Strong convergence in the inviscid limit for 2D-Navier-Stokes equations

Nikolai V. Chemetov

University of São Paulo, Brazil

In the talk we give a review of the results related with incompressible fluids in a 2D domain with a permeable wall. The permeability is described by non-homogeneous Navier slip boundary conditions.

We consider the NavierStokes equations in a 2D-bounded domain with the non-homogeneous Navier slip boundary conditions prescribed on permeable boundaries, and study the vanishing viscosity limit. We show that the inviscid limit is a solution of the Euler equations, satisfying the Navier condition on the inflow zone of the boundary.

The convergence result is established with respect to the strong topology of the Sobolev spaces W_p^1, $p > 2$.

Joint work with F. Cipriano (Universidade Nova de Lisboa, Portugal).

Critical solutions of the Navier-Stokes equations

Alexey Cheskidov

University of Illinois at Chicago, USA

We will discuss the notion of criticality for the Navier-Stokes equations and describe a few examples of critical solutions exhibiting an optimal energy flux that results in non-uniqueness, discontinuity, or loss of the energy balance, showing the sharpness of some classical results.

Hydrodynamic Pressure

Peter Constantin

Princeton University, USA

An elementary proof of existence and uniqueness for the Euler flow in uniformly localized Yudovich spaces

Gianluca Crippa

Universität Basel, Switzerland

I will revisit Yudovich's well-posedness result for the 2-dimensional Euler equations. I will derive an explicit modulus of continuity for the velocity, depending on the growth in p of the (uniformly localized) L^p norms of the vorticity. If the growth is moderate at infinity, the modulus of continuity is Osgood and this allows to show uniqueness. I will also show how existence can be proved in (uniformly localized) L^p spaces for the vorticity. All the arguments are fully elementary, make no use of Sobolev spaces, Calderon-Zygmund theory, or Paley-Littlewood decompositions, and provide explicit expressions for all the objects involved. This is a joint work with Giorgio Stefani (Basel).

Dyadic models for magnetohydrodynamics

Mimi Dai

University of Illinois at Chicago, USA

We propose some dyadic models for magnetohydrodynamics (MHD). The dyadic models include the intermittency dimension in the nonlinear scales. For small value of the intermittency dimension, finite time blow-up solutions and non-unique Leray-Hopf solutions are constructed.

On the sticky particle solutions to the pressureless Euler system in general dimension

Sara Daneri

Gran Sasso Science Institute, L'Aquila, Italy

In this talk we consider the pressureless Euler system in dimension greater than or equal to two. Several works have been devoted to the search of solutions which satisfy the following adhesion or sticky particle principle: if two particles of the fluid do not interact, then they move freely keeping constant velocity, otherwise they join with velocity given by the balance of momentum. For initial data given by a finite number of particles pointing each in a given direction, in general dimension, it is easy to show that a global sticky particle solution always exists and is unique. In dimension one, sticky particle solutions have been proved to exist and be unique. In dimension greater or equal than two, it was shown that as soon as the initial data is not concentrated on a finite number of particles, it might lead to non-existence or non-uniqueness of sticky particle solutions. In collaboration with S. Bianchini, we show that even though the sticky particle solutions are not well-posed for every measure-type initial data, there exists a comeager set of initial data in the weak topology giving rise to a unique sticky particle solution. Moreover, for any of these initial data the sticky particle solution is unique also in the larger class of dissipative solutions (where trajectories are allowed to cross) and is given by a trivial free flow concentrated on trajectories which do not intersect. In particular for such initial data there is only one dissipative solution and its dissipation is equal to zero. Thus, for a comeager set of initial data the problem of finding sticky particle solutions is well-posed, but the dynamics that one sees is trivial. Our notion of dissipative solution is lagrangian and therefore general enough to include weak and measure-valued solutions.

Dissipation-enhancing flows and applications

Yuanyuan Feng

Penn State University, USA

We consider the advection diffusion equation where the advecting vector field is assumed to be sufficiently mixing and quantitatively study the interaction between diffusion and mixing. We then study the dissipation enhancement of shear flows and planner helical flows and apply these flows to 2D or 3D Kuramoto Sivashinsky and Keller-Segel equations to get global existence.

Borderline regularity for the long-time solvability of the rotating Euler equations

Lucas C. F. Ferreira

Universidade Estadual de Campinas, Brazil

We consider the rotating Euler equations (RE) and show long-time solvability in Besov spaces for high speed of rotation Ω and arbitrary initial data. For that, we obtain Ω-uniform estimates and a blow-up criterion of BKM type in our setting. Our initial data class is larger than previous ones considered for (RE) and covers borderline cases of the regularity. The uniqueness of solutions is also discussed.

Joint work with Prof. Vladimir Angulo-Castillo (UNAL, Colombia).

AMS MSC: 35Q31, 76U05, 76B03, 35A07, 42B35

Key: Euler equations; Coriolis force; Long-time solvability; Blow up; Besov-spaces

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Energy balance for weak solutions of the 2D Incompressible Euler equations

Milton C. Lopes Filho

Universidade Federal do Rio de Janeiro, Brazil

In 2016, Cheskidov et al. proved that physically realizable weak solutions of the incompressible 2D Euler equations on a torus conserve kinetic energy. Physically realizable weak solutions are those that can be obtained as limits of vanishing viscosity. The key hypothesis was boundedness of the initial vorticity in $L^p, p > 1$. In this talk we explore an extension of this result to flows subject to external forcing. We seek conditions on the regularity of the forcing to derive the corresponding energy conservation identity.

Local and global well-posedness in contour dynamics

Francisco Gancedo

University of Seville, Spain

In this talk we discuss about new results for the Muskat problem and Surface Quasi-Geostrophic (SQG) fronts. Muskat models the evolution of an incompressible fluid filtered in porous media driven by gravity. We show that initial Lipschitz graphs of arbitrary size provide global-in-time well-posedness for the stable problem. On the other hand, SQG models the dynamics of atmospheric and oceanic flows. Temperature front solutions show numerical evidence of finite-time curvature blow-up. We construct fronts with unbounded curvature providing a local-in-time well-posedness theory.

Wave-structure interactions, oscillating water columns in shallow water

Jiao He

Universit d'Evry val d'Essonne, France

Wave energy converters (WECs) are devices that convert the energy associated with a moving ocean wave into electrical energy. In this talk we present a mathematical model of a particular wave energy converter, the so-called oscillating water columns in shallow water regime. This model can be reformulated as two transmission problems: one is related to the wave motion over the stepped topography and the other one is related to the wave-structure interaction where a fixed partially immersed structure is installed. We analyze the evolution of the contact line between the surface of the water and the surface of the structure and we show how to formulate the transmission problem as an initial boundary value problem with a semilinear boundary condition given by an ordinary differential equation. A rigorous well-posedness result of this coupled PDE-ODE will be given as well. Finally, we use the characteristic equations of Riemann invariants to obtain the discretized transmission conditions and show some numerical simulations in the end.

KAM theory for active scalar equations

Taoufik Hmidi

University of Rennes 1, France

We shall discuss the emergence of periodic and quasi periodic solutions for active scalar equations and particularly for generalized SQG equations. We prove that invariant tori survive when the exponent of the singular operator in Biot-Savart law belongs to a suitable Cantor set. The proof is based on several tools from KAM theory and pseudo-differential operators.

Vortex sheets in the half-plane and the α-Euler equations

Dragos Iftimie

Université de Lyon I, France

In this talk I will discuss the limit $\alpha \to 0$ for the α-Euler equations in the context of vortex sheets in a half-plane. This is a joint work with V. Busuioc, M. Lopes Filho and H. Nussenzveig Lopes.

Anomalous Dissipation in Passive Scalar Transport

Gautam Iyer

Carnegie Mellon University, USA

In this talk we study anomalous dissipation for passively transported scalars. The main result produces an explicit example of a bounded velocity field which is $C^\infty([0,T) \times \mathbb{T}^d)$ and also $L^1([0,T];C^{1-}(\mathbb{T}^d))$ for which the passively advected scalar exhibits anomalous dissipation. As a result we also obtain a simple example of non-uniqueness of transport equations for velocity fields in this class.

Our proof provides an criterion that guarantees anomalous dissipation provided the solutions of the associated inviscid equation grow so that the H^2 norm is bounded by the square of the H^1 norm. This is joint work with T. Drivas, T. Elgindi and I-J Jeong.

Sticky Particle Methods for the 1D Euler Alignment System

Trevor Leslie

University of Southern California, USA

The Euler Alignment system is a hydrodynamic version of the celebrated Cucker–Smale ODE's of collective behavior. It can have a hyperbolic or parabolic character, depending on the specified nonlocal interaction protocol; this talk concerns the hyperbolic case in 1D. It is well-established that solutions may lose regularity in finite time, but it has been unknown until recently how to continue to evolve the dynamics after a blowup. After brief orientation on the special structure of these equations, I will describe a recent joint work with Changhui Tan (University of South Carolina), where we developed a theory of weak solutions. Inspired by Brenier and Grenier's work on the pressureless Euler equations, we show that the dynamics of our system are captured by a nonlocal scalar balance law. We generate the unique entropy solution of a discretization of this balance law by introducing the 'sticky particle Cucker–Smale' system to track the shock locations. Our approximation scheme for the density converges in the Wasserstein metric; it does so with a quantifiable rate as long as the initial velocity is at least Hölder continuous.

2D Navier-Stokes in bounded domains with holes and Navier boundary conditions

Helena J. Nussenzveig Lopes

Universidade Federal do Rio de Janeiro, Brazil

We will discuss the large time behavior of solutions of 2D Navier-Stokes in bounded domains which are not necessarily simply connected, when we impose Navier friction boundary conditions. We establish exponential time decay, for both velocity and vorticity, under various assumptions on the friction coefficient relative to curvature of the boundary, for different types of domains. We also discuss the special role, played by the disk and the annulus, in this analysis. This is joint work with Christophe Lacave, Milton Lopes Filho and Jim Kelliher.

Existence of solutions for a non-isothermal Navier-Stokes-Allen-Cahn system with thermo-induced coefficients

Juliana Honda Lopes

Universidade Estadual de Campinas, Brazil

This work aims to study the existence of solutions for a non-isothermal Navier-Stokes-Allen-Cahn system with thermo-induced coefficients. The system can be considered as a model describing the motion of a mixture of two viscous incompressible fluids with viscosity, thermal conductivity and interfacial thickness being temperature-dependent. This system consists of Navier-Stokes equations coupled with a phase-field equation given by a convective Allen-Cahn equation and an energy transport equation. More precisely, we investigate the existence of solutions to the following problem

$$u_t + u \cdot \nabla u - \nabla \cdot (\nu(\theta) Du) + \nabla p = \lambda\Big(-\nabla \cdot (\varepsilon(\theta)\nabla\phi) + \frac{1}{\varepsilon(\theta)} F'(\phi)\Big)\nabla\phi - \alpha\Delta\theta\nabla\theta, \tag{1}$$

$$\nabla \cdot u = 0, \tag{2}$$

$$\phi_t + u \cdot \nabla\phi = \gamma\Big(\nabla \cdot (\varepsilon(\theta)\nabla\phi) - \frac{1}{\varepsilon(\theta)} F'(\phi)\Big), \tag{3}$$

$$\theta_t + u \cdot \nabla\theta = \nabla \cdot (k(\theta)\nabla\theta), \tag{4}$$

in $\Omega \times (0, \infty)$, where Ω is a bounded domain of $\mathbb{R}^2$ with smooth boundary $\partial\Omega$. Observe that the strong non-linear couplings between those equations due to the temperature dependence brings new mathematical difficulties that only allows working in dimension two.

Hidden symmetries in fluid dynamics

Alexei A. Mailybaev

IMPA, Brazil

We will discuss the existence of hidden scaling symmetries in equations of fluid dynamics and models of turbulence. These symmetries originate from noncommuting spatiotemporal symmetries, and are intrinsically related to intermittency in turbulence. Then we verify hidden symmetries in solvable simplified models and numerical simulations of developed turbulence.

Point vortex dynamics in bounded domain

Donati Martin

Institut Camille Jordan, Université Claude Bernard Lyon 1, France

We study the 2D Euler flow in the singular context of point vortices. We will focus on the influence of the boundary over the dynamics via the decomposition of the Green's function. The main result is that for almost every initial data, the point vortex system has a global solution. We use conformal maps as a crucial tool in this proof.

On Euler equations with in-flow and out-flow boundary conditions

Anna Mazzucato

Penn State University, USA

I will discuss recent results concerning the well-posedness and regularity for the incompressible Euler equations when in-flow and out-flow boundary conditions are imposed on parts of the boundary. This is joint work with Gung-Min Gie (U. Louisville, USA) and James Kelliher (UC Riverside, USA).

Long-term accuracy of numerical approximations of SPDEs

Cecilia Mondaini

Drexel University, USA

We consider a general framework for obtaining uniform-in-time rates of convergence for numerical approximations of SPDEs in suitable Wasserstein distances. The framework is based on two general results under an appropriate set of assumptions: a Wasserstein contraction result for a given Markov semigroup; and a uniform-in-time weak convergence result for a parametrized family of Markov semigroups. We provide an application to a suitable space-time discretization of the 2D stochastic Navier-Stokes equations in vorticity formulation. Specifically, we obtain that the Markov semigroup induced by this discretization satisfies a Wasserstein contraction result which is independent of any discretization parameters. This allows us to obtain a corresponding weak convergence result towards the Markov semigroup induced by the 2D SNSE. The proof required technical improvements from the related literature regarding finite-time error estimates. Finally, our approach does not rely on standard gradient estimates for the underlying Markov semigroup, and thus provides a flexible formulation for further applications. This is a joint work with Nathan Glatt-Holtz (Tulane U).

Capturing the flow structure beneath rotational waves

Andre Nachbin

MPA, Brazil

We address the problem of capturing the flow structure beneath rotational water waves in the presence of a sheared current of constant vorticity. This problem was brought to our attention by Adrian Constantin (Vienna). Analysts were interested in the presence of singular points in the bulk of the fluid and the associated critical layer beneath periodic nonlinear waves. Our investigation is performed numerically using ingredients of 2D potential theory. We first consider traveling rotational waves, and the respective vorticity regimes, exhibiting stagnation points in the submarine phase portrait. We also consider the associated pressure anomalies. We will also present a recent work in which we consider non-stationary rotational waves over a bottom topography. The main goal is to study the persistence of the Kelvin cat eye structure under the topographic forcing.

Landau damping in the weakly collisional regime

Toan Nguyen
Penn State University, USA

The talk is to present a recent joint work with Sanchit Chaturvedi and Jonathan Luk (both from Stanford University), where the nonlinear Landau damping and enhanced dissipation were established for a threshold of Sobolev data near Maxwellians in the weakly collisional plasmas modeled by the physical Vlasov-Poisson-Landau system with Coulomb interaction, a fundamental model that is widely used in plasma physics. This provides an analytical framework to capture mixing and entropic relaxation, a method that combines several classical ideas including Guo's weighted energy method to treat collisional kinetic models, Villani's hypocoercive energy method to make use of the interplay between phase mixing and entropic relaxation, and Klainerman's vector field method to derive uniform decay estimates that respect the underlying symmetry in the physical systems.

The role of small frequencies in the large time behaviour of the damped wave equation

César Niche
Universidade Federal do Rio de Janeiro, Brazil

Properties concerning the decay of solutions to the linear damped wave equation are essential tools for studying decay of solutions to their semilinear and nonlinear counterparts. Using the decay character of initial data, we extend and improve classical results by Matsumura for linear damped wave equations. We then apply these estimates to improve decay results for the damped wave equation with absorption for initial data in different function spaces. This is joint work with Armando S. Cárdenas (UFRJ).

On alpha-Navier-Stokes-Vlasov and alpha-Navier-Stokes-Vlasov-Fokker-Planck systems

Gabriela Planas
Universidade Estadual de Campinas, Brazil

We consider the alpha-Navier-Stokes equations coupled with a Vlasov type equation to model the flow of an incompressible fluid containing small particles. We prove the existence of global weak solutions to the coupled system subject to periodic boundary conditions. Moreover, we investigate the regularity of weak solutions and the uniqueness of regular solutions. The convergence of its solutions to that of the Navier-Stokes-Vlasov equations when alpha tends to zero is also established. Results are extended to the model with the diffusion of spray, i.e., to the alpha-Navier-Stokes-Vlasov-Fokker-Planck equations.

Work in collaboration with Cristyan Pinheiro (Unicamp)

Complete and incomplete similarity for the mean velocity profile of turbulent pipe and channel flows at extreme Reynolds number

Fabio Ramos

Universidade Federal do Rio de Janeiro, Brazil

The recent availability of experimental data on turbulent pipe flows in the extreme Reynolds number range has shown strong evidence that when $Re \gg O(10^5)$, the flow exhibits a transition to new scaling laws for important physical quantities, such as the friction factor and the Reynolds stress. In this work, we discuss a transition concerning the scaling of the mean velocity profile (MVP) of turbulent pipe and channel flows. We show that for sufficiently large Re number, the MVP exhibits complete similarity asymptotics in bulk coordinates, as $U/\bar{U} \to \Psi_E^{(1)}(\eta)$. Then, using a recent friction power-law formulation for extreme-Re flows, we show that this is equivalent to an incomplete similarity asymptotics, as $u^+ \to Re_\tau^{12}\Phi_E^{(1)}(y^+/Re_\tau)$. We then use the incomplete similarity asymptotics to relate the representation of the flow in bulk coordinates, $(\eta, U/\bar{U})$, to the representation of the flow in inner coordinates, (y^+, u^+), so that u^+ can be approximated by a Re_τ-dependent functional as $u^+ \approx \Phi_E(y^+, Re_\tau)$. We also propose a multiscale polynomial model of the MVP, which yields excellent approximations of available data in both bulk and inner coordinates.

On the equivalence between Lagrangian and Eulerian invariances in infinite dimensional systems

Ricardo M. S. Rosa

Universidade Federal do Rio de Janeiro, Brazil

A recent result on optimal minimax-type bounds for mean quantities of nonlinear dynamical systems relies on the equivalence of two types of invariance conditions for measures m pushed forward by the semigroup $\{S(t)\}$ associated with a differential equation $u_t = F(u)$. One is the classical notion of invariance in Ergodic Theory, i.e. $m(S(t)^{-1}(E)) = m(E)$, for any nonnegative time t and any measurable set E; this is termed Lagrangian invariance. The other requires that the mean value of $F(S(t)u)g'(u)$ with respect to the measure m is equal to zero, for all appropriate test functionals g; this is termed Eulerian invariance. The equivalence between the two notions is easy to prove for systems of ODEs. This has also been essentially proved for the two-dimensional Navier-Stokes equations. We will discuss the intricacies present in the case of partial differential equations and present generalizations of this result for other such equations.

Joint work with Roger Temam (Indiana University).

Viscous MHD vorticity-current equations with data in $L^1(R^2)$

Marco Sammartino

University of Palermo, Italy

In this talk we shall prove that the viscous MHD equation in the vorticity-current formulation, and with initial data in L^1, admit a unique global-in-time regular solution.

Hypocoercive dynamics of Fokker-Planck-Alignment equations

Roman Shvydkoy

University of Illinois at Chicago, USA

In this talk we will discuss a new approach to the problem of emergence in hydrodynamic systems of collective behavior. The problem seeks to establish convergence to a flocking state in a system with self-organization governed by strictly local laws of communication. The typical results in this direction insist on propagation of flock connectivity which translates into a quantitative non-vacuum condition on macroscopic level. With the introduction of small noise one can relax such a condition considerably, and even allow for vacuum, in the context of the corresponding Fokker-Planck-Alignment equations. The flocking behavior becomes the problem of establishing hypocoercivity and relaxation of solutions to the global Maxwellian. We will describe a model which does precisely this in the non-perturbative settings.

Finite Energy Weak Solutions of the Navier-Stokes-Korteweg equations

Stefano Spirito

University of L'Aquila, Italy

In this talk I will present some results concerning the analysis of the existence of finite energy weak solutions of the Navier-Stokes-Korteweg equations, which model the dynamic of a viscous compressible fluid with degenerate viscosity and capillarity tensor. These kind of model are useful to study the dynamic of fluid near vacuum regions. A general theory of global existence is still missing, however for some particular cases of physical interest, it is possible to prove global existence of weak solutions. In particular, I will present two results regarding the case when the capillarity coefficient is constant and when the capillarity coefficient gives the Bohm potential. Moreover, in the cases under consideration the viscosity coefficient in the stress tensor are degenerating at the vacuum. The talk is based on a series of joint works with Paolo Antonelli (GSSI - Gran Sasso Science Institute, L'Aquila)

Hidden scale invariance in Navier-Stokes intermittency

Simon Thalabard

Instituto de Matemática Pura e Aplicada, Brazil

In this talk, we describe a very general hidden symmetry of the 3D Navier-Stokes equations, formally arising in the vanishing viscosity limit. The symmetry relies on a dynamical rescaling which represents a change to a quasi-Lagrangian reference frame with subsequent spatial scaling and suitably defined clock associated to the local flow intensity. From the point of view of symmetries, the transformation preserves the usual rotation, parity and time-translation symmetries of the NS system and projects the remaining ones onto a reduced parametric set of "hidden" scaling and translation symmetries. For the fully developed turbulence, this means that hidden scaling symmetry may be restored statistically in the inertial interval, although the scaling symmetries in the usual sense are statistically broken by intermittency.

Poster Session

Global well-posedness for the fractional BoussinesqCoriolis system with stratification in a framework of FourierBesov type

Leithold Louis Aurazo Alvarez

Institución Educativa Integrada Intercultural Bilingüe "Alberto Acosta Herrera", Peru

In this work was established the global well-posedness of the 3D fractional BoussinesqCoriolis system with stratification in a framework of Fourier type, namely spaces of FourierBesov type with underlying space beingMorrey spaces (FBM-spaces, for short). Under suitable conditions and rescaled density fluctuation, the result is uniform with respect to the Coriolis and stratification parameters. We cover the critical case of the dissipation, namely half-Laplacian, in which the nonlocal dissipation has the same differential order as the nonlinearity and balances critically the scaling of the quadratic nonlinearities. As a byproduct, considering trivial initial temperature and null stratification, we also obtain well-posedness results in FBM-spaces for the fractional NavierStokesCoriolis system as well as for the NavierStokes equations with critical dissipation. Moreover, since small conditions are taken in the weak norm of FBM-spaces, we can consider some initial data with arbitrarily large Sobolev spaces norms with nonnegative index. This is a jointly work with prof. Dr. Lucas C. F. Ferreira (IMECC-UNICAMP).

Global gradient estimate for a divergence problem and its application to the homogenization of magnetorheological fluids

Thuyen Dang

University of Houston, USA

We present our new L^∞ estimate for the gradient of solution of a divergence problem with Dirichlet boundary condition, where the coefficients are discontinuous. The estimate is uniform with respect to the small scale. Then this regularity result is used to derive the homogenization of magnetorheological fluids.

On the long-time persistence of hydrodynamic memory

Miguel Villegas Diaz

Universidad Central de Venezuela, Venezuela

The Basset-Boussinesq-Oseen (BBO) equation correctly describes the nonuniform motion of a spherical particle at a low Reynolds number. It contains an integral term with a singular kernel which accounts for the diffusion of vorticity around the particle throughout its entire history. Moreover, if there are any departures in either rigidity or shape from a solid sphere besides the integral force with a singular kernel, the Basset history force, we should add a second history force with a non-singular kernel, related to the shape of the particle. In this note, we introduce a fractional generalized Basset-Boussinesq-Ossen equation which includes both history terms as fractional derivatives. Using the Laplace transform, an integral representation of the solution is obtained. For a driven single-particle, the solution shows that memory effects persist indefinitely under rather general driving conditions.

Global Existence of Measure-valued Solutions To the MHD Equations

Leonardo Epiphanio Galvão

IMECC - Unicamp, Brazil

We adapt the framework of measure-valued solutions developed in the context of the incompressible Euler Equations to the ideal incompressible MHD Equations. As a consequence, we can recover the global existence of a very weak notion of solution to this problem, by properly manipulating sequences of Leray-Hopf-type solutions to related systems.

A homogenization approach to a system of multi-species transport equations in a porous medium

Nibedita Ghosh

IIT Kharagpur, India

We study the diffusion-reaction of mobile chemical species together with the dissolution and precipitation of immobile species in a porous medium at the micro-scale. This leads to a system of semilinear parabolic partial differential equations coupled with an ordinary differential equation modelling dissolution and precipitation at the grain boundary. The novelty of this work is to deal with the multi-valued dissolution rate term and nonlinear precipitation term. Firstly, we show the existence of a unique positive global weak solution for the coupled system using some regularization techniques and fixed point arguments. Then, we apply two-scale convergence and the time-dependent unfolding method to obtain the homogenized model.

L^2-Density of Wild Initial Data for the Hypodissipative Navier-Stokes Equations

Michele Gorini

GSSI, Italy

In this paper we deal with the Cauchy problem for the hypodissipative Navier- Stokes equations in the three-dimensional periodic setting. We prove wild non- uniqueness in $L^2_t H^\theta_x$ for an L^2-dense set of Hölder continuous initial data in the class of Hölder continuous admissible weak solutions for all exponents below 1/3. This improves previous results of wild non-uniqueness and generalizes previous results on density of wild initial data obtained for the Euler equations.

Non-existence of self-similar blowup for the supercritical SQG equation

Ricardo Martins Mendes Guimarães

UNICAMP, Brazil

The present project aims to study the self-similar solutions of the supercritical 2D-SQG equation and to prove the non-existence of the self-similar blowup for a given supercritical range. The study of self-similar solutions is important because using the blowup criterion demonstrated by Constantin Majda and Tabak we conclude that these solutions have a potential finite time singularity formation, which is interesting to analysis because the global well-posedness or existence of finite time singularity for the supercritical case is still an open problem.

Homogenization Of An Incompressible Stokes/Cahn-hilliard System Using The Binary-fluid Model In Porous Media

Nitu Lakhmara

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR, India

In our study a phase-field model for two-phase immiscible, incompressible porous media flow with surface tension effects is considered. The pore-scale model consists of a strongly coupled system of stationary Stokes-Cahn-Hilliard equations. The fluids are separated by an evolving diffuse interface of finite width depending on the scale parameter ε in the model. First we derive some a-priori estimates for proving the existence and uniqueness. Using unfolding operator and two-scale convergence approach we obtain homogenized equations for the model.

A Lagrangian Finite Difference Scheme for viscoelastic constitutive equations

Débora de Oliveira Medeiros

Instituto de Ciências Matemáticas e de Computação ICMC - USP, Brazil

We present a new finite difference scheme to approach problems modeled by the upper-convected time derivative. The upper-convected time derivative, commonly present in constitutive equations that model viscoelastic problems, is reformulated in the context of the generalized Lie derivative giving approximations of second-order in time to solve simplified constitutive equations. Theoretical analysis of the truncation errors of the methods are carried out, considering linear and quadratic interpolation operators based on Lagrangian framework. Finally, numerical results are presented for the model equation defined in one and two dimensions in order to elucidate the theoretical results.

The Brinkman-Fourier System with Ideal Gas Equilibrium

Jan-Eric Sulzbach

Illinois Institute of Technology, USA

In this work, we will introduce a general framework to derive the thermodynamics of a fluid mechanical system, which guarantees the consistence between the energetic variational approaches with the laws of thermodynamics. In particular, we will focus on the coupling between the thermal and mechanical forces. We follow the framework for a classical gas with ideal gas equilibrium and present the existences of weak solutions to this thermodynamic system coupled with the Brinkman-type equation to govern the velocity field.

A physicist's perspective on the problems of fluid dynamics

Giorgio Torrieri

IFGW - Unicamp, Brazil

I discus fluid dynamics from the perspective of statistical mechanics, from which fluid dynamics should emerge as an effective theory. I argue , focusing on relativistic fluids, that a full connection is still missing, and argue that such a connection could help in clarifying foundational problems of the field. Based on https://arxiv.org/abs/2007.09224 and ongoing work.

Nonlinear shallow water model for an oscillating water column with time-dependent air pressure

Gaston Vergara-Hermosilla

Université de Bordeaux, France

We propose in this poster a new nonlinear mathematical model of an oscillating water column. The one-dimensional shallow water equations in the presence of this device are essentially reformulated as two transmission problems: the first one is associated with a step in front of the device and the second one is related to the interaction between waves and a fixed partially-immersed structure. By taking advantage of free surface Bernoulli's equation, we close the system by deriving a transmission condition that involves a time-dependent air pressure inside the chamber of the device, instead of a constant atmospheric pressure as in a previous work. We then show that the second transmission problem can be reduced to a quasilinear hyperbolic initial boundary value problem with a semilinear boundary condition determined by an ODE depending on the trace of the solution to the PDE at the boundary. Local well-posedness for general problems of this type is established via an iterative scheme by using linear estimates for the PDE and nonlinear estimates for the ODE. Finally, the well-posedness of the transmission problem related to the wave-structure interaction in the oscillating water column is obtained as an application of the general theory.

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