Cássio Oishi (Unesp-Presidente Prudente, poster)

Title: Numerical methods for solving high Weissenberg number viscoelastic fluid flows

Abstract:

This work presents a numerical study of a generic conformation tensor transformation for addressing the High Weissenberg Number Problem (HWNP). This problem is typically observed in computational rheology. In this formulation the conformation constitutive law for a viscoelastic fluid is transformed by introducing the kernel conformation tensor which is defi ned by any continuous, invertible and differentiable matrix transformation function. In this work, in order to investigate the accuracy of this formulation for the high-Weissenberg number flows, a numerical study is performed on different viscoelastic fluid flow problems.

Paul Krause (UFSC, short talk)

Title: On the influence sampling of unstable flow events

Abstract:
A novel sampling scheme for the state of a system modeled by ordinary differential equations (o.d.e.), the Influence Sampling - Monte Carlo (ISMC) scheme, is presented for o.d.e. systems with determining variables. The ISMC sampling scheme uses control values for determining variables of an o.d.e. system to perturb the sample values of the trailing variables in order to accomodate them closer to their events. The ISMC scheme is set in prediction mode for prediction tests to be conducted with it and the L63 (Lorenz, 1963) and L63+ systems of o.d.e., the latter being a nonautonomous perturbation of the L63 system through source terms (sine functions). Compared to plain Monte Carlo (MC) sampling, the ISMC scheme is found in the tests to increase the predictability of two unstable events among solutions of the L63 and L63+ systems and mark the strong predictability periods of these events, meaning the periods of predictability of their variability, with greater robustness and confidence in the estimates. As such it may find a good use to increasing and assessing the strong predictability of unstable events. In particular, the ISMC scheme is expected to find a good use to data assimilation, especially for large systems with hidden fields of variables, whenever a good estimate is made available for a list of determining variables.
This is investigated with the moist-convective rotating shallow-water (mcRSW) model of Lambaerts et al [1].

[1] J. Lambaerts, G. Lapeyre, V. Zeitlin, Moist versus dry barotropic instability in a shallow-water model of the atmosphere with moist convection, J. Atmos. Sci., 68 (2011) 1234-1252

Qingtian Zhang (PSU, short talk and poster)

Title: Uniqueness of conservative weak solution to Camassa-Holm equation via characteristics

Abstract:
Camassa-Holm equation is an approximate model to describe water waves. In this talk, I will introduce some classical results of Camassa-Holm equation, and present our recent result concerning th uniqueness of conservative solution to Camassa-Holm equation. This is a joint work with Alberto Bressan and Geng Chen.

Matthew Mizuhara (PSU, short talk and poster)

Title: A Ginzburg-Landau Model of Cell Motility

Abstract:
The study of eukaryotic cell motility along substrates has been of recent interest to biologists as well as mathematicians. In order to investigate this complex process, we study a model consisting of a scalar Ginzburg-Landau PDE coupled with a vectorial parabolic reaction-diffusion equation. Gradient coupling and non-local volume preservation prevent the use of gradient ow methods and maximum principles when deriving the equation of motion at the interface limit. We develop novel techniques to compute the interface equation of motion, which is a competition between volume-preserving mean curvature motion and a non-linear force. Numerical simulations of the new interface equation will be shown. We develop an efficient algorithm to solve the resultant non-linear and non-local equation. These simulations give evidence of non-uniqueness of solutions and development of singularities of the normal velocity of the interface. This work is progress under Ph. D. adviser Leonid Berlyand in collaboration with Lei Zhang and Volodymyr Rybalko.

Stefanella Boatto (UFRJ, short talk)

Title: Point-Vortex dynamics on surfaces of revolution

Abstract:
Many key features of the motion of satellites, planets, stars, even galaxies can be captured by point mass dynamics. Likewise, many key features of fluid motion such as atmospheric storms, ocean eddies, super fluid vortices, and early stages of mass aggregation in gravitational systems can be captured by point vortex dynamics. Yet, serious mathematical challenges remain. Systems consisting of more than a few points are non-integrable, and complexity increases dramatically with the number of particles. Furthermore, the underlying geometry has a profound influence on the particle motion, as has only just begun to be investigated. Indeed one of today' s challenges is a formulation of the N-vortex dynamics on Riemann surfaces. There are formulations over surfaces with constant Gaussian curvature, and lately, for surfaces with not constant Gaussian curvature,conform to the sphere. We present some results about vortex dynamics on surfaces of revolution (among others the sphere and the ellipsoid of rotation). We obtain a Vortex equivalence principle : variations of the Gaussian curvature generate dynamics. A single vortex on a ellipsoid would move.

In collaboration with David Dritschel and Jair Koiller.

Eleonora Moura (UFRJ, short talk)

Title: The vortex-wave system with a finite number of vortices as the limit of the Euler-alpha model.

Abstract:

In this talk I will discuss solutions of the two-dimensional Euler-alpha model when the initial vorticity is the superposition of a finite number of point vortices and a bounded background vorticity. Finally I will show that these solutions converge, as alpha tends to zero, to a weak solution of the vortex-wave system, introduced by Marchioro and Pulvirenti (1991). This is a joint work with Helena J. N. Lopes and Milton C. Lopes Filho (UFRJ).

Oleksandr Iaroshenko (PSU, short talk and poster)

Title: Reduction from full Ginzburg-Landau to harmonic map functional in a circular domain

Abstract:
We consider a superconductor in a weak magnetic field and the corresponding minimization problem for the Ginzburg-Landau energy in a circular domain with a tiny hole at the center. Under a certain range of values of the external magnetic field, size of the hole, and Ginzburg-Landau parameter, we rigorously prove that, in terms of the vorticity, this minimization problem can be effectively replaced by the harmonic map problem (minimization of GL energy in the class of S^1-valued functions). Thus, the degree of the hole vortex for the minimizer of the full problem coincides with the degree of the hole vortex for the minimizer of the harmonic map problem.

Maicon Benvenutti (UNICAMP, short talk)

Title: Global nonlinear stability for some steady solutions of three-dimensional incompressible Euler equations with helical symmetry and in the absence of vorticity stretching

Joint work with Milton C. Lopes Filho and Helena J. Nussenzveig Lopes

Abstract:
We present a class of steady and L^p-stable vorticities for the Euler equations with helical symmetry and with no swirl. More precisely, Burton in [B] proved stability of steady flows of an ideal fluid in a bounded, simply connected, planar region, that are strict maximisers of kinetic energy on an isovortical surface. In this work, we use the helical symmetry to extend Burton's result to the 3-D helical Euler equations. A related stability theorem as shown in [W] is also proved in our case.

[B] Burton G., *Global nonlinear stability for steady ideal fluid flow in bounded planar domains*, Arch. Rat. Mech. Anal **176** 149-163 (2005).
[W] Wan Y., Pulvirenti M., *Nonlinear stability of circular vortex patches*, Commun, Math. Phys. **99,** 435-450 (1985).

Valerii Vinokur (Argonne Nat Lab)

Title: Vortex pinning: static and dynamic effects

Abstract:
We review physics of an ensemble of the vortex lines subject to quenched disorder. We discuss the concept of collective pinning and its implications for the thermodynamic (equilibrium) properties of the vortex lattice, paying special attention to disorder-induced phase transitions in the vortex system. We consider dynamic properties of the vortex ensembles driven through disordered media and talk in detail about thermally activated dynamics, vortex creep, that exhibits highly nonlinear (and even non-analytical) response to the infinitesimal applied force. Finally, we touch upon some new developments in the vortex physics.

André Nachbin (IMPA)

Title: A hydrodynamic pilot wave model.

Abstract:
This problem is very recent and addresses a new dynamical system for a wave-particle pair. Yves Couder and coworkers reported on walking droplets on the surface of a vibrating bath and discussed their properties previously thought to be peculiar to the microscopic, quantum realm . John Bush and coworkers reproduced and extended laboratory experiments which were compared to theoretical predictions made with their reduced dynamical systems. In this presentation I will briefly review some of their work and introduce our hydrodynamic wave model which is coupled to the trajectory equation for the bouncing droplet/particle. The wave dynamics starts from rest while the fluid domain is vibrated according to the Faraday theory. Through an appropriate forcing term surfacewaves are generated. Inspired by the lab experiments the following questions arise. Will our wave-particle model capture the bifurcation mechanism which differentiates a steady-bouncing from a walking-droplet regime? Will this model generate and accordingly propagate pilot waves which guide a bouncing droplet? These are some of the questions of our ongoing work. Work in collaboration with John Bush (MIT/Math), Paul Milewski (Univ. Bath/Math) and Carlos Galeano Rios (IMPA).

Russ Caflisch (UCLA)

Title: The Search for Singularities

Abstract:
This talk will review the past and ongoing search for singularity formation in the 3D Euler equations of incompressible, inviscid fluid flow. The presentation will include numerical studies, analytic constructions, and rigorous necessary conditions for singularity formation. The recent numerical results of Hou and Luo will be a highlight.

David Dritschel (Univ. St Andrews)

Title: Dynamics and equilibrium statistics of point vortex flows on the sphere

David D. Dritschel (University of St Andrews, UK) Marcello Lucia and Andrew C. Poje (City University of New York, USA).

Abstract:
We discuss the equilibrium statistics and dynamical evolution of moderately large (N = 100 - 1000) numbers of interacting point vortices on the unit sphere under the constraint of zero mean angular momentum to explore Onsager's (1949) theory for the self-organization of two-dimensional flows. We consider a binary gas consisting of equal numbers of vortices with positive and negative circulations. When the circulations are chosen to be inversely proportional to the square root of N, the energy partition function, p(E), converges rapidly with N to a universal form with a single maximum.

Ensemble-averaged kinetic-energy wavenumber spectra of the non-singular velocity field induced by the point vortices exhibit the expected 1/k behavior at small scales for all energies. The spectra at the largest scales vary smoothly with the inverse temperature 1/T of the system and show a transition from positively sloped to negatively sloped as T becomes negative. The dynamics are ergodic and, regardless of the initial configuration of the vortices, statistical measures simply relax towards microcanonical ensemble measures -- at all observed energies or temperatures. As such, the direction of any cascade process measured e.g. by the evolution of the kinetic energy spectrum depends only on the relative differences between the initial spectrum and the ensemble mean spectrum at that energy; not on the energy, or temperature, of the system.

Any statistical evolution has just one objective: relaxation. This is independent of the system's temperature. And, our results confirm that Onsager's assumption of ergodicity likely applies to point vortex dynamics on a sphere. Hence, Onsager's theory in this context is no more than a statement of relaxation. It is wrong to interpret negative temperatures with clustering and the formation of large scales in two-dimensional turbulence.

Paolo Antonelli (Gran Sasso Science Institute)

Title: Analysis of finite energy weak solutions for a class of systems in Quantum Hydrodynamics

Abstract:

In this talk I will give an overwiev of some results concerning the Cauchy problem for a class of systems describing quantum fluids. Such models arise in many physical contexts, such as the description of superfluidity phenomena, the dynamics of Bose-Einstein condensates or the modelling of semiconductor devices. I will discuss the existence of finite energy weak solutions by exploiting the analogy with a class of nonlinear Schrödinger equations through the Madelung transformations. The main advantage of this approach is that it does not need to define the velocity in the vacuum region. I will conclude the exposition by discussing some further research perspectives. These results are done in collaboration with P. Marcati.

Etienne Sandier (Univ. Paris XII)

Title:"Logarithmic interaction energy for infinitely many points in the plane, Coulomb gases and weighted Fekete sets."

Abstract:
I will describe results obtained with S. Serfaty on an energy describing the interaction of infinitely many positive charges in the plane with a uniform negative background (a system sometimes reffered to as a jellium) and its relation to Coulomb gases and weighted Fekete sets. I will also describe recent results obtained with Y.Ge which give a partial answer to the question of which configurations of points have finite energy.

Tiziana Giorgi (New Mexico State Univ)

Title: Symmetric vortex solutions for Ginzburg-Landau type models

Abstract:
We will present a review of our work on symmetric vortex solutions for Ginzburg-Landau models. We will focus on uniqueness of physically relevant solutions, and show how the methods of proof can be applied to show uniqueness of solutions in other physical parameter regimes. Shortcomings of this approach in connection to similar questions in the theory of liquid crystals will be underlined. The talk is based on joint works with Stan Alama, Lia Bronsard and Robert Smits

Monika Nitsche (Univ. New Mexico)

Authors: Monika Nitsche and Ling Xu

Title: Vortex Shedding and Lower Order Models

Abstract:
Highly resolved direct numerical simulations of viscous flow past a flat plate moving in direction normal to itself reveal details of the vortical structure of the flow. For example, for accelerated plate velocities, the flow consists initially of a Raleigh boundary layer of vorticity of almost constant thickness, surrounding the plate. After this initial period, vorticity concentrates near the tip. The starting vortex grows and eventually separates from the boundary vorticity. Using the simulations, we obtain values for the shed circulation, vortex trajectory and vortex sizes as a function of time and Reynolds number. Obtaining numerical solutions to the full Navier-Stokes equations, such as these, is computationally costly. In practice, lower order inviscid models are often used to simulate separated flows. Examples are vortex sheet and point vortex models, which are based on simple algorithms to satisfy the Kutta condition at sharp edges. In this talk we compare the viscous results for accelerated flow past a flat plate with results obtained using the vortex sheet model, and determine the extent to which the model reproduces the flow.

Milton C Lopes Filho (UFRJ)

Title: On the vortex-wave system

Abstract:
The vortex-wave system is a coupling of the two-dimensional vorticity equation with the point-vortex system of ODEs. This terminology was introduced by C. Marchioro and M. Pulvirenti, who proved existence and uniqueness of a weak solution when the continuous part of the vorticity is a bounded, compactly supported function whose support is disjoint from the initial vortices. In this talk we will explore what is known about this system and discuss avenues for future inquiry.

Dan Spirn (Univ. Minnesota)

Title: Vortex liquids and phase transition equations

Abstract:
Vortices arise naturally in complex-valued phase transition theories, especially those that model superconductivity, superfluids, and Bose-Einstein Condensates. I will discuss the mean field behavior of the vortices in the dynamical setting as the number these vortices grow asymptotically large.

Thierry Gallay (Univ. de Grenoble)

Title: Infinite energy solutions of the two-dimensional Navier-Stokes equations

Abstract: To understand the distribution of energy in two-dimensional large scale flows, it is useful to study the solutions of the Navier-Stokes equations in the whole plane R^2, assuming that the velocity field and the pressure are merely bounded. Global well-posedness is known for that problem, but uniform boundedness of the solutions is an interesting open question. In this talk, we consider the simplified situation where periodicity is assumed in one space dimension. If the initial velocity is bounded, we prove that the solution remains uniformly bounded for all times, and that the vorticity distribution converges to zero as t tends to infinity. We deduce that, after a transient period, the system enters a laminar regime where the solution converges rapidly to a shear flow which satisfies the one-dimensional heat equation. Our approach is constructive and gives explicit estimates on the size of the solution and the lifetime of the turbulent period in terms of the initial Reynolds number. This is a joint work with S. Slijepcevic (Zagreb, Croatia).

Leonid Berlyand (PSU)

Title: Phase Separation of Multiple Ginzburg-Landau Vortices Pinned by Small Holes

Leonid Berlyand, Department of Mathematics and Materials Research Institute, Penn State University

Abstract:
We consider a homogenization problem for magnetic GL functional in domains with a large number of small holes. For sufficiently strong magnetic field, a large number of vortices are pinned by the holes. We establish a scaling relation between sizes of holes and the magnitude of the external magnetic field when pinned vortices form a hierarchy of nested subdomains with different multiplicity that manifests a physical phenomenon of vortex phase separation. We will discuss a conjecture on the equivalence of the vorticity patterns for the full and a reduced GL functional. These are joint works with V. Rybalko, V. Vinokur and O. Iaroshenko.

Fabrice Bethuel (Univ. Paris VI)

Title: "Various problems related to the dynamics of the Gross-Pitaevskii equation "

Abstract:

The Gross-Pitaevslii equation is a non linear Schrôdinger equation of defocusing type, where non vanishing conditions are imposed at infinity. It is used as a model in several areas of low temperature physics. I will review some recent results, obtained in particular with Philippe Gravejat, Jean-Claude Saut, and D. Smets and raise some open problems. The emphasis will be put on solitons and traveling waves.

Evelyn Lunasin (USNA)

Title: Image restoration using equations of fluid dynamics

Evelyn Lunasin

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Abstract:
We investigate fluid dynamics equations for restoring damaged images. We begin by giving a brief review of the elegant analogy between the image intensity function for the image inpainting problem and the stream function in 2D incompressible fluid first introduced by Bertalmio et al in 2001. We compare several models and show which one allows for a more efficient numerical algorithm when automating the inpainting process.

Dragos Iftimie (Univ.Lyon I)

Title: Can an obstacle change the large time behavior of a viscous incompressible fluid?

Abstract:
We consider the incompressible Navier-Stokes equations with the Dirichlet boundary condition in a 2D or 3D exterior domain. We compare the long-time behaviour of the solutions to this initial-boundary value problem with the long-time behaviour of the solutions of the analogous Cauchy problem in the whole plane or space.

Jon Chapman (Oxford Univ.)

Title: Interaction of spiral waves in the Complex Ginzburg-Landau equation

Abstract:
Solutions of the general cubic complex Ginzburg-Landau equation comprising multiple spiral waves are considered, and laws of motion for the centres are derived. The direction of the motion changes from along the line of centres to perpendicular to the line of centres as the separation increases, with the strength of the interaction algebraic at small separations and exponentially small at large separations. The corresponding asymptotic wavenumber and frequency are also determined, which evolve slowly as the spirals move.

Evelyne Miot (École Polytéchnique)

Title: Some examples of dynamics for nearly parallel vortex filaments

Abstract:
A system of equations combining the 1D Schrödinger equation and the point vortex system has been derived by Klein, Majda and Damodaran in order to describe the evolution of nearly parallel vortex filaments in 3D incompressible fluids. In this talk I will present some dynamics for this system such as travelling waves, collisions and finite-time blow-up. I will finally consider the case of pairs of filaments. This is joint work
with Valeria Banica and Erwan Faou.

Gene Wayne
SHORT COURSE (Advanced), MARCH 17-21

Eugene Wayne (Boston University, USA)

Vortex solutions in two dimensional fluid flows.

Lecture 1: The Oseen vortex.
Lecture 2: Vortex models for two-dimensional viscous flows.
Lecture 3: Classical mechanics and point vortex methods.

Lia Bronsard
SHORT COURSE (Advanced), MARCH 17-21

Lia Bronsard (McMasters University, Canada)

Vortices in Ginzburg-Landau systems.

Topics: Local structure of vortices in Ginzburg-Landau models with complex vector order parameters. Classical quantized vortices. Coupled systems of two Ginzburg-Landau equations. Stability and instability of degree-one equivariant vortex solutions.

Jon Chapman

TUTORIAL (Basic), MARCH 12-14, **Jon Chapman** (Oxford University, UK), **An introduction to Ginzburg-Landau vortices**. **Topics:** Physical phenomena of superconductivity: Perfect conductivity, perfect diamagnetism. Critical field. Intermediate state. Regularisation via Ginzburg-Landau energy functional. Surface energy of a normal-superconducting interface. Negative surface energy for Type-II superconductors. Magnetic field quantisation. Single quantum rectilinear vortex solution. Bifurcation analysis of the Ginzburg-Landau model. Mixed state. Upper critical field. Lower critical field. Law of motion for rectilinear vortices. Equilibrium solutions. Homogenisation into a vortex density. Simple solutions. Vortex nucleation at boundaries. Zero magnetic field vortices. Degree boundary conditions. Law of motion. Equilibrium solutions. Vortex pinning by inhomogeneities. Critical state models. Three dimensional vortices. Law of motion. Simple solutions. Analogies with fluid vortices.

Evelyne Miot

TUTORIAL (Basic), MARCH 12-14, **Evelyne Miot** (École Polytechnique, France), **Introduction to vortex dynamics in two-dimensional or three-dimensional incompressible flows**. **Lecture 1:** Vortices in incompressible fluids. **Lecture 2:** Convergence of the point vortex system to the two-dimensional Euler equation. **Lecture 3:** Vortex filaments.