Shanks Workshop

Dynamics of Interfaces and Structures in Fluid Flows

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Organizers: Emmanuele DiBendetto, Misha Perepelitsa, Gieri Simonett

Abstracts

David Ambrose
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On weak solutions for interfacial flows with surface tension

Abstract: We consider the problem of existence of global weak solutions for interfacial flows with surface tension. Since the surface tension force is supported only on the free surface and enters via curvature (for smooth flows), it can be difficult to write a weak formulation. We introduce such a formulation, finding a transport equation coupled to the Navier-Stokes or Euler equations. This transport equation describes not just how the location of the free surface moves, but also how the tangent directions to the free surface move. We will discuss existence of weak solutions for the problem using this formulation; while we are not able to prove global existence of weak solutions for the full system, we will present partial results in this direction. This is joint work with Helena Nussenzveig Lopes, Milton Lopes Filho, and Walter Strauss.

Gui Qiang Chen
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Compressible vortex sheets and free boundary problems

Abstract: Compressible vortex sheets are fundamental waves, along with shock and rarefaction waves, in entropy solutions to multidimensional hyperbolic systems of conservation laws. Understanding the behavior of compressible vortex sheets is an important step towards our full understanding of fluid motions and the behavior of entropy solutions.

In this talk, we will show how the existence and stability of compressible vortex sheets can be formulated as a free boundary problem and will discuss some recent developments in the study of such a problem for compressible vortex sheets in multidimensional gas dynamics and magnetohydrodynamics. Further remarks, trends, and open problems in this direction will also be addressed.

Alex Cheskidov
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On the maximal enstrophy growth rate for solutions to the 3D Navier-Stokes equations

Abstract: Due to a supercritical nature of the 3D Navier-Stokes equations, the best known estimates on the enstrophy growth rate do not rule out the existence of finite time singularities. Recently Doering and Lu numerically showed that these estimates are sharp. I this talk I will present some analytical results in this direction as well as related regularity criteria in critical spaces.

Peter Constantin
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The Onsager equation in metric spaces and complex fluids

Abstract: I will discuss equilibrium theory for interacting particles with finitely many degrees of freedom and the zero temperature limit. I will give examples and make connection with nonlinear Fokker-Planck-Navier-Stokes systems describing complex fluids.

Giovanni P. Galdi
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On the motion of a rigid body in a Navier-Stokes liquid under the influence of a time-periodic driving mechanism

Abstract: This talk is devoted to the mathematical investigation of the motion of a rigid body in an infinite Navier-Stokes liquid, under the action of a time-periodic driving mechanism. This latter can be, for example, a time-periodic force acting along a given constant direction, or time-periodic boundary data. The main objective is to find conditions under which the body is propelled by the driving mechanism, namely, conditions that ensure that the body can cover a given trajectory in a finite time interval. This research is in collaboration with Ana L. Silvestre (IST Lisbon, Portugal).

Misha Perepelitsa
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Instantaneous boundary tangency and cusp formation in two-dimensional fluid flows

Abstract: We show that, for solutions of a model of two-dimensional, viscous, compressible fluid flow, curves which are initially transverse to the spatial boundary and across which the fluid density is discontinuous become tangent to the boundary instantaneously in time. We also show by similar techniques that, for the Euler equations of two-dimensional, inviscid, incompressible flow and for a large class of initial data corresponding to vortex patches with corners, these corner singularities become cusp-like instantaneously in time (joint work with D.Hoff, Indiana University).

Steve Shkoller
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A hyperbolic free-boundary problem for 3D compressible Euler flow in physical vacuum

Abstract: We prove well-posedness for compressible flow with free-boundary in physicalvacuum, modeled by the 3D compressible Euler equations. The vanishing of thedensity at thevacuum boundary induces degenerate hyperbolic equations that becomecharacteristic, requiring a separate analysis of time, normal, and tangentialderivatives to handle the manifest 1/2-derivative loss. Unfortunately, themethods for incompressible flow do not work for the degenerate compressibleregime; a priori nonlinear estimates are obtained using the geometric structureof the Euler equations,and an existence theory is developed using a novel approximation schemeemploying an artificial phase. This result is in collaboration with Coutand and Lindblad.

Roman Shvydkoy
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On the energy balance relations for incompressible singular flows

Abstract: It is known that the energy of a weak solution to the Euler equation is conserved if it is slightly more regular than the Besov space $B^{1/3}_{3,\infty}$ as predicted by Onsager. When the singular set of the solution is (or belongs to) a smooth manifold, we will present various space-time regularity criteria dimensionally equivalent to the critical one. In particular, if the singular set is a hypersurface the energy of u is conserved provided the one sided non-tangential limits to the surface exist and the non- tangential maximal function is L^3 integrable, while the maximal function of the pressure is $L^{3/2}$ integrable. As a consequence, the classical vortex sheets in both 2D and 3D conserve energy. We will also discuss the related problem of energy equality for weak solutions to the Navier-Stokes equation.