Water Waves and Related Fluid Models
September 28 – October 2, 2015

Abstracts of Talks

Thomas Alazard (ENS Paris)

Title: Control of water waves

Abstract: Water waves are disturbances of the free surface of a liquid. They are, in general, produced by the immersion of a solid body or by impulsive pressures applied on the free surface. The question we discuss in this talk is the following: which waves can be generated by blowing on a localized portion of the free surface. Our main result asserts that one can generate any small amplitude, periodic in x, two-dimensional, gravity-capillary water waves. This is a result from control theory. More precisely, we prove the local exact controllability of the incompressible Euler equation with free surface. This is a joint work with Pietro Baldi and Daniel Han-Kwan.

Peter Constantin (Princeton University)

Title: Nonlinear bounds for the fractional Laplacian with Dirichlet boundary conditions, and electroconvection.

Abstract: Electroconvection is the motion of charged fluids driven by electrical forces. The fractional Laplacian in bounded domains appears naturally in modelling electroconvection. I will discuss nonlinear bounds for the fractional Laplacian, in the spirit of the nonlinear maximum principle, and applications to regularity issues for electroconvection.

Diego Cordoba (ICMAT)

Title: Active scalars: IPM and SQG

Abstract: In this talk I will present recent results for the incompressible porous media equation (IPM) and the surface Quasi-geostrophic equation (SQG).

Daniel Coutand (Heriot Watt University)

Title: Can a solid body hit the bottom of an inviscid lake?

Abstract: The problem of a solid body moving in an inviscid fluid governed by the Euler equations will be discussed. This is an interaction problem between solid and fluid phases, which is subject to the classical zero normal velocity condition for fluid particles at the bottom of the lake. In particular, will be discussed the question of finite time contact (which would imply the formation of a cusp singularity in the fluid phase) with the bottom of the lake.

Javier Gomez-Serrano (Princeton University)

Title: Splash singularities for the incompressible free boundary Navier-Stokes

Abstract: In this talk we will address the formation of finite time splash singularities for the incompressible free boundary Navier-Stokes equations. The singularities appear in the form of the interface self-intersecting and were previously proved for the free boundary Euler equations. We show that viscosity can not prevent them. Moreover, we will also report on further directions and future work. This is a joint work with A. Castro, D. Cordoba, C. Fefferman and F. Gancedo.

Alex Ionescu (Princeton University)

Title: On global solutions of water wave models

Abstract: I will discuss some recent work, joint with Yu Deng, Benoit Pausader, and Fabio Pusateri, on the construction of global solutions of several water wave models. Our work concerns the capillary model in 2D and the gravity-capillary model in 3D. I will also discuss the more general two-fluid interface problem.

Alexander Kiselev (Rice University)

Title: Regularity and blow up in models of fluid mechanics

Abstract: I will discuss a family of modified SQG equations that varies between 2D Euler and SQG with patch-like initial data defined on half-plane. The family is modulated by a parameter α that sets the degree of the kernel in the Biot-Savart law. The value $\alpha = 0$ corresponds to the 2D Euler equation, while $\alpha = 1/2$ to the SQG case. The main result I would like to describe is the phase transition in the behavior of solutions that happens at $\alpha = 0$. Namely, for 2D Euler equation the patch solution stays globally regular, while for a range of small $\alpha > 0$ there exist regular initial data that lead to finite time blow up. The finite time blow up involves either loss of regularity of the boundary, or touching of different patches, or patch self-intersection. This talk is based on a joint work with Lenya Ryzhik, Yao Yao and Andrej Zlatos.

David Lannes (Université de Bordeaux)

Title: Preventing Kelvin-Helmholtz singularities for two fluid interfaces

Abstract: The formation of singularities (in particular splash and splat singularities) for the water waves equations has attracted a lot of interest in recent years. In this talk, we will consider a related problem consisting in studying the motion of the interface between two fluids of different densities. The scenario of singularity formation in this context is drastically different. Moreover, a new kind of singularity has to be taken into account, namely, the Kelvin-Helmholtz instabilities. We will comment on several mechanisms that prevent in some cases the formation of these singularities, hereby allowing several physical phenomena (eg internal waves).

Victor Lie (Purdue University)

Title: Formation of singularities and long term regularity for certain fluid models

Abstract: We will discuss two results:

1) On the absence of splash singularities in the case of two-fluid interfaces (joint with C. Fefferman and A. Ionescu): We show that the water-wave splash scenario discovered by Castro-Cordoba-Fefferman-Gancedo-Gomez-Serrano cannot develop in the case of locally smooth solutions of the two-fluid interfaces in two dimensions.

2) Electron Euler-Maxwell system in 3D with vorticity (joint with A. Ionescu): We show that for small enough initial data, the solution for the Euler-Maxwell system in 3D with vorticity exists for a time T which is inverse proportional relative to the size (properly measured) of the vorticity.

Nader Masmoudi (Courant Institute)

Title: Mixing and enhanced dissipation in the inviscid limit of the Navier-Stokes equations near the 2D and 3D Couette flows

Abstract : It is well known that the 3D Couette flow is stable for the Navier-Stokes dynamics. However, the main question is to find the size of the allowed perturbation depending on the viscosity. In this talk, we will discuss the dynamics of small perturbations of the plane, periodic Couette flow in the 3D incompressible Navier-Stokes equations at high Reynolds number. For sufficiently regular initial data, we determine the stability threshold for small perturbations and characterize the long time dynamics of solutions below this threshold. The primary stability mechanisms are an anisotropic enhanced dissipation effect and an inviscid damping effect of the velocity component normal to the shear, both a result of the mixing caused by the large mean shear. After detailing these linear effects, we will discuss some of the important steps in the proof, such as the analysis of the weakly nonlinear (potential) instabilities connected to the non-normal nature of the linearization. Joint work with Jacob Bedrossian and Pierre Germain.

Benoit Pausader (Princeton University)

Title: Decay for 3D gravity-capillary water waves

Abstract: We show decay of small localized perturbations of a flat interface for the infinite-depth 3D gravity-capillary water wave equations,
assuming energy estimates.

Fabio Pusateri (Princeton University)

Title: On the global regularity of water waves

Abstract: We will discuss the problem of global regularity for water waves. In particular we will present a result, joint with Deng, Ionescu and Pausader, about global existence of smooth solution for the 3d gravity-capillary water waves system in infinite depth.

Jalal Shatah (Courant Institute, New York University)

Title: The large box limit of nonlinear Schrödinger equations in weakly nonlinear regime

Abstract: We study the long time dynamics of solutions to nonlinear Schrödinger equations with periodic boundary conditions as the length of the period becomes infinite. We isolate the effects of resonant interactions and derive new evolution equations whose dynamics approximate the long time dynamics of localized solutions. We will show that this approximation is valid on a long time scale determined by the size of the solution and the length of the period.

Chongchun Zeng (Georgia Institute of Technology)

Title: Wind-driven water waves and unstable manifolds of the Euler equation

Abstract: In this talk, we start with the mathematical theory of wind-generated water waves in the framework of the interface problem between two incompressible inviscid fluids under the influence of gravity. This entails the careful study of the stability of the shear flow solutions to the interface problem of the two-phase Euler equation. Based on a rigorous derivation of the linearized equations

about shear flow solutions, we obtained rigorously the linear instability criterion of Miles due to the presence of the critical layer in the steady shear flows. Our analysis is valid even in the presence of surface tension and a vortex sheet (discontinuity in the tangential velocity across the air-sea interface). We are thus able to give a unified equation including the Kelvin-Helmholtz and quasi-laminar models of wave generation put forward by Miles. While the rigorous nonlinear instability proof is not complete for this problem yet, we are aiming at a stronger statement — constructing local unstable manifolds of the full nonlinear system of the interface problem of the Euler equation. If time permits, we will discuss the unstable manifolds of steady states of the Euler equation on fixed domains. Suppose the linearized equation at a steady state v_* has an exponential dichotomy with a finite dimensional unstable subspace. By rewriting the Euler equation as an ODE on an infinite dimensional manifold in, H^k, k > $\frac n2$ + 1, the unstable manifold of v_* is constructed under certain conditions on the Lyapunov exponents of the vector field v_*. In particular, this leads to the desired nonlinear instability of v_* in the sense that small H^k perturbations can lead to L^2 derivation of the solutions.