Geometrical Aspects of Hydrodynamics Workshop Talk Schedule

Events for:
Monday, May 19th - Friday, May 23rd

Monday, May 19th

8:00am **Breakfast/registration begins - SCGP Lobby and Cafe**

9:00am **Dennis Sullivan - SCGP 102**

Title: Compression of continuum models of ideal 3D fluids into a combinatorial framework

Abstract: We transfer the Lie bracket of vector fields into a Lie infinity structure on combinatorial 1-chains and define a combinatorial curl on the cubical decompositions of periodic 3-space. Then we can write the combinatorial Euler evolution at each level of subdivision and have consistent maps between our models at different scales.

10:00am **Coffee Break - SCGP Cafe**

10:30am **Keith Moffatt - SCGP 102**

Title: Vortex reconnection and associated destruction of helicity

Abstract: Based on experimental evidence that vortex reconnection commences with the approach of nearly antiparallel segments of vorticity, a linearised model is developed in which two Burgers-type vortices are driven together and stretched by an ambient irrotational strain field induced by more remote vorticity. When these Burgers vortices are exactly antiparallel, they are annihilated on the strain timescale, independent of kinematic viscosity in the limit ? -->0. When the vortices are skew to each other, they are annihilated under this action over a local extent that increases exponentially in the stretching direction, with clear evidence of reconnection on the same strain timescale. The initial helicity associated with the skewed geometry is eliminated during the process of reconnection. The model applies equally to the reconnection of weak magnetic flux tubes under the action of a strain field, when Lorentz forces are negligible. [Work in collaboration with Y.Kimura]

11:30am **Short Break**

11:45am **V. Parameswaran Nair - SCGP 102**

Title: Group Theory and Hydrodynamics: Formalism, Gauge Fields and Anomalies

Abstract: Lagrange obtained the equations of fluid dynamics by starting with Newton's equations for a collection of point-particles and carrying out a simple coarse-graining. From the modern point of view, a point-particle is a unitary irreducible representation of a group which is the Poincar\'e group times the internal symmetry group (which may be Abelian or nonabelian). We will describe how one can formulate fluid dynamics from this point of view. Since symmetry is foundational in this approach, it provides a natural framework for relativistic magnetohydrodynamics (with magnetic moment and spin-orbit interactions), nonabelian magnetohydrodynamics (with transport of nonabelian charges), and anomalous effects in fluid dynamics such as the chiral magnetic and chiral vorticity effects.

12:45pm **Lunch - SCGP Cafe**

2:15pm **Sergei Kuksin - SCGP 102**

Title: Weakly non-linear resonant hamiltonian PDEs and the problem of wave turbulence

Abstract: I will discuss long-time behaviour of small oscillations in a non-linear Shroedinger equation on a torus, perturbed by random force and linear dissipation. The equation is scaled in such a way that its solutions are small, but their limiting dynamics is non-trivial. The limiting behaviour turns out to be described by another damped/driven Hamiltonian PDE, where the new Hamiltonian is constructed out of the resonant terms of the original one. Next I will discuss behaviour of the new system under the limit "space-period goes to infinity". Using heuristic approximation, commonly used in the weak turbulence, I will derive for the second limit a KZ-type kinetic equation which leads to KZ energy spectra. I will present numerics which support the predictions concerning the second limit.

3:30pm **Tea Time - SCGP Lobby**

4:00pm **Alexander Abanov - SCGP 102**

Title: On the Hamiltonian description of relativistic hydrodynamics with quantum anomalies

Abstract: We show that the equations of relativistic fluid with chiral anomaly are Hamiltonian. The corresponding Poisson structure can be obtained by a simple change of variables from the conventional Poisson structure of relativistic hydrodynamics. We illustrate the construction for hydrodynamics in 1+1 and 3+1 dimensions.

Tuesday, May 20th

8:00am **Breakfast begins - SCGP Cafe**

9:00am **Dam Son - SCGP 102**

Title: A 2+1 dimensional anomalous superfluid hydrodynamics

Abstract: We construct a theory of a 2+1 dimensional superfluid, which describes the dynamics of a superfluid Goldstone boson at zero temperature. The Goldstone boson is described by a dual gauge field. This theory has nontrivial topological properties - a shift and a Hall viscosity, which are encoded in the coefficient of a Chern-Simons type term in the action. We calculate the linear response of the theory to external perturbations.

10:00am **Coffee Break - SCGP Cafe**

10:30am **Jonatan Lenells - SCGP 102**

Title: Geometry of the Hunter-Saxton system

Abstract: TBA

11:30am **Lunch - SCGP Cafe**

1:00pm **Boris Dubrovin (Joint workshop/SCGP weekly talk) - SCGP 102**

Title: Topology of moduli spaces of algebraic curves and integrable PDEs

Abstract: TBA

2:30pm **Alexios Polychronakos - SCGP 102**

Title: Phase space fluids and the droplet bosonization method

Abstract: TBA

3:30pm **Tea Time - SCGP Lobby**

5:30pm **'Stitches' Exhibition Lecture by Artist Daina Taimina - SCGP Lobby and SCGP 103**

Wednesday, May 21st

8:00am **Breakfast begins - SCGP Cafe**

9:00am **Darryl Holm - SCGP 102**

Title: Dynamics of Peakons, Jetlets and G-strands

Abstract: Please see website for PDF abstract.

10:00am **Coffee Break - SCGP Cafe**

10:30am **Piotr Surowka - SCGP 102**

Title: Various aspects of 2+1 dimensional (super)fluid flows

Abstract: TBA

11:30am **Short Break**

11:45am **Daniel Peralta-Salas - SCGP 102**

Title: KAM theory and the 3D Euler equation

Abstract: We will show that the dynamical system defined by the hydrodynamical Euler equation on any closed Riemannian 3-manifold is not ergodic. To prove this result we introduce a family of functionals on the space of divergence-free vector fields, which are integrals of motion of the 3D Euler equation. These functionals measure the part of the manifold foliated by ergodic invariant tori of fixed isotopy types, so KAM theory is the main tool to analyze some continuity properties of these new conservation laws. This is based on joint work with Boris Khesin and Sergei Kuksin.

12:45pm **Lunch - SCGP Cafe**

2:15pm **Paul Wiegmann - SCGP 102**

Title: Anomalous hydrodynamics of vortex flow

Abstract: TBA

3:30pm **Tea Time - SCGP Lobby**

4:00pm **Alexander Shnirelman - SCGP 102**

Title: Analytical structures of the Euler equations

Abstract: I'm going to consider the following subjects: (1) Complexification of the Euler-Lagrange equations; (2) Analyticity of the particle trajectories; (3) Complex singularities of steady flows; (4) Complex singularities of nonstationary solutions.

6:00pm **Workshop Banquet - SCGP Cafe**

Thursday, May 22nd

8:00am **Breakfast begins - SCGP Cafe**

9:00am **Gregory Falkovich - SCGP 102**

Title: On multi-point correlations and symmetries in turbulence

Abstract: We discuss general features of the operator product expansion and use it to infer multi-point manifestations of the energy cascade in turbulence. Considering then the inverse cascade in two dimensions, we show that if the energy flux does not have long-range multi-point correlations and the vorticity statistics is scale invariant, it could not be conformal invariant. We show first-ever data on three-point vorticity correlation function obtained in direct numerical simulations. (Joint work with Alexander Zamolodchikov)

10:00am **Coffee Break - SCGP Cafe**

10:30am **Gerard Misiolek - SCGP 102**

Title: Examples of ill-posedness for Euler and Navier-Stokes equations

Abstract: TBA

11:30am **Short Break**

11:45am **Krzysztof Gawedski - SCGP 102**

Title: Fate of inverse cascade in hyperbolic-plane turbulence

Abstract: I will discuss the joint work with Gregory Falkovich exploring the behavior of stochastically forced Navier-Stokes equation in the background of two-dimensional hyperbolic geometry.

12:45pm **Lunch - SCGP Cafe**

2:15pm **Annalisa Calini - SCGP 102**

Title: Methods of integrable systems for vortex filament flow

Abstract: TBA

3:30pm **Tea Time - SCGP Lobby**

4:00pm **Peter Topalov - SCGP 102**

Title: Shallow water waves with asymptotic conditions at infinity

Abstract: TBA

Friday, May 23rd

8:00am **Breakfast begins - SCGP Cafe**

9:00am **Peter Michor - SCGP 102**

Title: Approximating Euler's equation on the full diffeomorphism group, and soliton-like solutions.

Abstract: This is based on joint work with David Mumford. We study a family of approximations to Euler's equation depending on two parameters $\epsilon,\eta \ge 0$. When $\epsilon=\eta=0$ we have Euler's equation and when both are positive we have instances of the class of integro-differential equations called EPDiff in imaging science. These are all geodesic equations on either the full diffeomorphism group ${Diff}_{H^\infty}(\mathbb R^n)$ or, if $\epsilon = 0$, its volume preserving subgroup. They are defined by the right invariant metric induced by the norm on vector fields given by $$ \|v\|_{\epsilon,\eta} = \int_{\mathbb R^n} \langle L_{\ep,\et} v, v \rangle\, dx $$ where $L_{\epsilon,\eta} = (I-\frac{\eta^2}{p} \triangle)^p \circ (I-\tfrac1{\epsilon^2} \nabla \circ div)$. All geodesic equations are locally well-posed, and the $L_{\epsilon,\eta}$-equation admits solutions for all time if $\eta>0$ and $p\ge (n+3)/2$. We tie together solutions of all these equations by estimates which, however, are only local in time. This approach leads to a new notion of momentum which is transported by the flow and serves as a generalization of vorticity. We also discuss how delta distribution momenta lead to``vortex-solitons", also called ``landmarks" in imaging science, and to new numeric approximations to fluids. Maybe, an extension of these results to the space of immersions from a compact manifold into Euclidean space instead of the diffeomorphism group will also be presented.

10:00am **Coffee Break - SCGP Cafe**

10:30am **Gregory Eyink - SCGP 102**

Title: Spontaneous Stochasticity and Dissipation Anomalies in Fluid Turbulence

Abstract: TBA

11:30am **Short Break**

11:45am **Leon Takhtajan - SCGP 102**

Title: Weil-Petersson geometry of the universal Teichmuller space

Abstract: TBA

12:45pm **Lunch - SCGP Cafe**

1:45pm **Gregory Eyink - SCGP 102**

Title: Onsager: Life and Science

Abstract: TBA

3:30pm **Tea Time - SCGP Lobby**