CoScaRa Workshop

Deterministic and Stochastic Advection in Fluid Dynamics

July 21–23, 2025 — University of Basel, Switzerland

Schedule

Monday, July 21, 2025

12:30–14:15	Registration & light lunch
14:15–14:30	Opening
14:30–15:30	**Paolo Bonicatto** (University of Trento, Italy)
15:30–16:30	**Anne Bronzi** (University of Campinas, Brazil)
16:30–17:00	Coffee break
17:00–18:00	**Michele Coti Zelati** (Imperial College London, UK)

Tuesday, July 22, 2025

9:00–10:00	**Camilla Nobili** (University of Surrey, UK)
10:00–11:00	**Francesco Fanelli** (BCAM Bilbao, Spain)
11:00–11:30	Coffee break
11:30–12:30	**Theresa Lange** (Scuola Normale Superiore di Pisa, Italy)
12:30–14:30	Lunch break
14:30–15:30	**Rishabh Gvalani** (ETH Zürich, Switzerland)
15:30–16:00	Coffee break
19:00	Social dinner

Wednesday, July 23, 2025

9:00–10:00	**Piotr Mucha** (University of Warsaw, Poland)
10:00–11:00	**Umberto Pappalettera** (Bielefeld University, Germany)
11:00–11:30	Coffee break
11:30–12:30	**Tommaso Rosati** (University of Warwick, UK)

Abstracts

Paolo Bonicatto

University of Trento, Italy

Title: Geometric Transport Equation for currents: recent developments

I will report on recent results concerning the Geometric Transport Equation for k-dimensional currents in $\mathbb{R}^n$. This equation generalises the classical continuity and transport equations to model the motion of geometric objects such as lines and surfaces. I will discuss well-posedness results for Lipschitz vector fields, highlighting a deep connection with the decomposability bundle of a measure introduced by Alberti and Marchese. This theory further extends to the time-dependent setting with minimal regularity in time of the vector field, thus offering a unified framework for the evolution of geometric data under non-smooth flows.

Anne Bronzi

University of Campinas, Brazil

Title: Statistical solutions to evolution equations

In this talk, we will present a general framework for trajectory statistical solutions that generalizes the concept of statistical solutions, initially introduced for the three-dimensional incompressible Navier-Stokes equations, to a wide range of evolution equations. Our main results include the existence of trajectory statistical solutions for initial value problems and the convergence of families of trajectory statistical solutions associated with regularized problems. We will illustrate the applicability of the theory with the incompressible Navier-Stokes equation, a reaction-diffusion equation, a nonlinear wave equation, and the inviscid limit of the Navier-Stokes equations to the Euler equations in both two- and three-dimensional cases. This is joint work with Cecilia Mondaini (Drexel University, USA) and Ricardo Rosa (Universidade Federal do Rio de Janeiro, Brazil).

Michele Coti Zelati

Imperial College London, UK

Title: Alpha-unstable flows and the fast dynamo problem

The fast dynamo problem concerns the generation and maintenance of magnetic fields by fluid motion through the process of electromagnetic induction. In passive vector advection, this can be formulated as the exponential growth of the magnetic energy, at a resistivity-independent rate. In this talk, I will provide a construction of a Lipschitz, divergence-free and time-independent velocity field that is a fast dynamo on the whole space.

Camilla Nobili

University of Surrey, UK

Title: Buoyancy-Driven Flow in 2D Boussinesq Systems with Navier Slip: Scaling Laws and Long-Time Behavior

In this talk, we consider the two-dimensional Boussinesq equations on a bounded domain with Navier-slip boundary conditions, both in the presence and absence of thermal diffusion. The first part of the talk focuses on the derivation and interpretation of scaling laws for the Nusselt number in the context of Rayleigh–Bénard convection. In particular, we examine how the nature of the boundary conditions influences heat transport.
In the second part, we turn to the large-time behaviour of solutions in absence of thermal diffusion. We show that, in appropriate norms, solutions converge to the hydrostatic equilibrium, and we establish its linear stability when the background temperature profile is an increasing affine function of height—that is, under stable vertical stratification.

Francesco Fanelli

BCAM Bilbao, Spain

Title: Geometric features in the dynamics of non-homogeneous incompressible inviscid fluids

This talk focuses on the analysis of the incompressible Euler equations with variable density. Their homogeneous counterpart, which is given by the classical incompressible Euler system, is well-known to be globally well-posed in the case of space dimension $d = 2$, both in the strong solutions framework and in the Yudovich (weak) solutions framework. No results of that kind are known in the case of density variations. In this talk, we will show that both problems (that is, global well-posedness and weak solutions theory à la Yudovich) can be reduced to the study of a non-linear geometric quantity, which encodes the regularity of the vorticity and the density along suitably defined striated regularity structures.

Theresa Lange

Scuola Normale Superiore di Pisa, Italy

Title: Non-uniqueness of Leray-Hopf solutions for the 3D fractional Navier-Stokes equations perturbed by transport noise

For the 3D fractional Navier-Stokes equations perturbed by transport noise, we prove the existence of infinitely many Hölder continuous analytically weak, probabilistically strong Leray-Hopf solutions. In the deterministic case, global existence is known ever since the seminal works by Leray (1934) and Hopf (1950), yet recent results show non-uniqueness via the method of convex integration. In contrast to the active field of regularisation by transport noise, we demonstrate that the convex integration method applies also in the presence of such random perturbations, and derive global-in-time solutions which satisfy the energy inequality pathwise on a non-empty random interval. This is joint work with Marco Rehmeier (TU Berlin) and Andre Schenke. The activity was carried out within the project: NoisyFluid "Noise in Fluids", Grant Agreement 101053472, CUP E53C22001720006.

Rishabh Gvalani

ETH Zürich, Switzerland

Title: Mixing by random fluid flows

We consider the question of exponential mixing for random dynamical systems on arbitrary compact manifolds without boundary. We put forward a robust, dynamics-based framework that allows us to construct space-time smooth, uniformly bounded in time, universal exponential mixers.
The framework is then applied to the problem of proving exponential mixing in a classical example proposed by Pierrehumbert in 1994, consisting of alternating periodic shear flows with randomized phases. This settles a longstanding open problem on proving the existence of a space-time smooth (universal) exponentially mixing incompressible velocity field on a two-dimensional periodic domain while also providing a toolbox for constructing such smooth universal mixers in all dimensions.

Piotr Bogusław Mucha

University of Warsaw, Poland

Title: Construction of weak solutions to compressible viscous fluid models

This talk presents novel methods for constructing weak solutions to compressible viscous fluid models in three spatial dimensions. We focus on the existence of weak solutions for compressible systems with barotropic pressure, introducing an alternative approximation scheme that replaces the classical viscosity regularization of the continuity equation (e.g., $-\Delta\rho$) with direct truncations and regularizations of nonlinear terms and the pressure. This approach is designed to align with the Bresch-Jabin compactness criterion for the density. We provide a rigorous revisitation of this criterion, demonstrating its applicability at every level of our approximation. Additionally, we discuss a complementary synthesis of the Feireisl technique with the Bresch-Jabin framework.

The presented results are joint work with Nilasis Chaudhuri, Milan Pokorný, and Ewelina Zatorska.

Umberto Pappalettera

Bielefeld University, Germany

Title: Anomalous dissipation and regularization in Gaussian isotropic turbulence

In this work we study several properties of the solutions to the stochastic transport and the stochastic continuity equations constructed by Le Jan and Raimond in [Ann. Probab. 30(2): 826-873, 2002]. Our results hold true in the general case of Gaussian, space-homogeneous and isotropic noise, with α-Hölder regularity in space, $\alpha \in (0, 1)$. We can cover the full range of compressibility ratios giving spontaneous stochasticity of particle trajectories. In particular, we are not limited to the incompressible case. Based on joint work with Theodore Drivas and Lucio Galeati.

Tommaso Rosati

University of Warwick, UK

Title: Upper bounds to energy dissipation in passive scalar advectio

We introduce an approach to obtain for the first time lower bounds to Lyapunov exponents of stochastic PDEs, in connection to the Batchelor Scale problem and other questions in the study of passive scalar advection in stochastic fluid dynamics. Our proof relies on the introduction of a Lyapunov functional for the projective process associated to the equation, based on the study of dynamics of spectral level sets and on high-frequency stochastic instability. Joint work with M. Hairer, S. Punshon-Smith and J. Yi.