Turbulence on the Banks of the Arno

Report of Contributions

Contribution ID: **1** Type: **not specified**

Registration

Wednesday, 31 January 2024 08:00 (1 hour)

Contribution ID: **2** Type: **not specified**

Coti Zelati - Lecture 1

Wednesday, 31 January 2024 09:00 (2 hours)

Contribution ID: **3** Type: **not specified**

Nualart Batalla

Wednesday, 31 January 2024 11:30 (30 minutes)

In this talk we consider the long-time behavior of solutions to the two dimensional non-homogeneous Euler equations under the Boussinesq approximation posed on a periodic channel. We prove inviscid damping for the linearized equations around the stably stratified Couette flow using stationary-phase methods of oscillatory integrals. We discuss how these oscillatory integrals arise, what are the main regularity requirements to carry out the stationary-phase arguments, and how to achieve such regularities.

Contribution ID: **4** Type: **not specified**

Del Zotto

Wednesday, 31 January 2024 12:00 (30 minutes)

The Boussinesq equations are a fundamental tool for describing the behavior of stratified fluids. This model possesses an intrinsic oscillating structure, which can be viewed as a stabilizing mechanism. When we consider a stable linear stratification combined with a background Couette flow in a three-dimensional unbounded channel, we will demonstrate how this oscillating structure contributes to both linear and nonlinear stability. Specifically, we will explore the role of these oscillations in phenomena such as inviscid damping, enhanced dissipation, and the transition threshold. Additionally, we will address how these oscillations effectively eliminate a well-known 3D instability phenomenon referred to as the 'lift-up effect.'

Contribution ID: **5** Type: **not specified**

Bec - Lecture 1

Wednesday, 31 January 2024 14:00 (2 hours)

Contribution ID: **6** Type: **not specified**

Boutros

Wednesday, 31 January 2024 16:30 (30 minutes)

Onsager's conjecture states that 1/3 is the critical (Hölder) regularity threshold for energy conservation by weak solutions of the incompressible Euler equations. We consider an analogue of Onsager's conjecture for the hydrostatic Euler equations (also known as the inviscid primitive equations of oceanic and atmospheric dynamics). The anisotropic nature of these equations allows us to introduce new types of weak solutions and prove a range of independent sufficient criteria for energy conservation. Therefore there probably is a 'family' of Onsager conjectures for these equations. Furthermore, we employ the method of convex integration to show the nonuniqueness of weak solutions to the inviscid and viscous primitive equations (and also the Prandtl equations), and to construct examples of solutions that do not conserve energy in the inviscid case. Finally, we present a regularity result for the pressure in the Euler equations, which is of relevance to the Onsager conjecture in the presence of physical boundaries. As an essential part of the proof, we introduce a new weaker notion of boundary condition which we show to be necessary by means of an explicit example. These results are joint works with Claude Bardos, Simon Markfelder and Edriss S. Titi.

Contribution ID: **7** Type: **not specified**

Inversi

Wednesday, 31 January 2024 17:00 (30 minutes)

The incompressible Euler equations govern the evolution of an ideal fluid. It is well known that the total kinetic energy is preserved along the time evolution of a regular fluid flow. However, when the motion is very rough, there is theoretical and experimental evidence of formation of chaotic structures that support the dissipation of kinetic energy. Mathematically, this problem translates into finding the critical regularity for weak solutions to the incompressible Euler equations to have conservation or dissipation of kinetic energy (Onsager's conjecture). Currently, the Onsager conjecture is almost solved. It has been been proved that energy is conserved in any subcritical class and there are examples of solutions in any supercritical class violating the energy conservation. In a joint paper with Luigi De Rosa, we gave the first proof of energy conservation for weak solutions to the incompressible Euler system in a critical space, both in absence and presence of physical boundary. This is the first energy conservation result that holds in the incompressible case and fails in the compressible setting.

Contribution ID: **8** Type: **not specified**

Abbate

Wednesday, 31 January 2024 17:30 (30 minutes)

The α-Euler equations feature remarkable relevance from a theoretical point of view, among Large Eddy Simulation approximating schemes. The analysis for the limit of the solutions as α goes to zero has been widely studied in literature. In our work, we employ Langrangian techniques on this system to examine the convergence of its solutions to solutions of the Euler equations on the two-dimensional torus. In particular, given an initial vorticity in Lebesgue spaces, we prove the convergence to Langrangian and energy conserving solutions. Moreover, given a bounded initial vorticity, we are able to compute a quantitative rate of convergence. This is a joint work with S. Spirito (University of L'Aquila) and G. Crippa (University of Basel). Link to the preprint: arXiv:2306.06641v1.

Contribution ID: **9** Type: **not specified**

Coti Zelati - Lecture 2

Thursday, 1 February 2024 09:00 (2 hours)

Contribution ID: **10** Type: **not specified**

Johansson

Thursday, 1 February 2024 11:30 (30 minutes)

We study dissipation enhancing properties of the advection-diffusion equation advected by a class of Hamiltonian flows with a non-degenerate elliptic point which are quantitatively close to radial flows. Namely, we aim at establishing a convergence towards the streamline average on sub-diffusive timescales. However, for our class of Hamiltonians, contrary to radial flows, the average along the streamlines is in general not conserved. In this work, we prove that the solutions of the advection-diffusion equation are quantitatively close to the streamline average on sub-diffusive timescales. The precise timescale is given as a function of the asymptotic behaviour of the period function. In particular, we recover the enhanced dissipation rates for radial flows. Our proof is based on spectral techniques applied to a model problem (for which we can consider more general Hamiltonian flows such as the cellular flow) where several new challenges have to be handled. This is a joint work with M. Dolce and M. Sorella.

Contribution ID: **11** Type: **not specified**

Sorella

Thursday, 1 February 2024 12:00 (30 minutes)

In this talk, we present a new result of a 2d autonomous divergence free velocity field in C^α (for alpha <1 arbitrary but fixed) for which solutions of the advection diffusion equation exhibit anomalous dissipation for some initial data. We will focus on the proof for a simplified version of the velocity field which is just bounded. The proof relies on proving spontaneous stochasticity using a stochastic Lagrangian approach. This is a joint work with Carl Johansson.

Contribution ID: **12** Type: **not specified**

Bilotto

Thursday, 1 February 2024 16:30 (30 minutes)

In the context of geostrophic models, the study of stationary features is of particular interest, as they characterize most of the oceanic and atmospheric currents responsible for major climate events. This work illustrates some numerical results on the stability and characteristics of stationary states of viscous flows over a topography, both in laminar and turbulent cases. Using a classical argument for the stability of dynamical systems [Arn65], we compute stationary states of the inviscid flow as eigenstates of the relation linking the stream-function to the potential vorticity. We find that eigenstates with higher eigenvalues are more complicated and can be classified by the location and the number of couples of opposing vortices. Furthermore, letting the eigenstates evolve without forcing under a viscous dynamics, each state decays to the lowest eigenstate sharing its symmetries. This shows that, in practical situations, there is no one state more stable than the others but, given the right initial conditions, complicated configurations can survive viscous dissipation. We generalize the prediction of vorticity condensations in 2D turbulence [Kra67, SY94] to the case of flows over a topography, through several simulations of randomly forced fields. The turbulent dynamics stirs the system towards the most stable flow configurations, which collocates vortices in areas of great depth, as predicted by Bretherton and Haidvogel [BH76]. A further effect of the topography is observed, as the lack of space for the fluid obstructs the vorticity condensation. This phenomenon exhibits a finite-size effect generated by the competition between the repulsion of opposite vortices and their attraction to valleys. This work was carried out under the supervision of R. Verzicco and A. Vulpiani.

Contribution ID: **13** Type: **not specified**

Bechtold

Thursday, 1 February 2024 17:00 (30 minutes)

We study the surface quasi-geostrophic equation driven by a generic additive noise process W. By means of convex integration techniques, we establish existence of weak solutions whenever the stochastic convolution z associated with W is well defined and fulfills certain regularity constraints. Quintessentially, we show that the so constructed solutions to the non-linear equation are controlled by z in a linear fashion. This allows us to deduce further properties of the so constructed solutions, without relying on structural probabilistic properties such as Gaussianity, Markovianity or a martingale property of the underlying noise W. Based on joint work with T. Lange and J. Wichmann: arXiv:2311.00670

Contribution ID: **14** Type: **not specified**

Yaroslavtsev

Thursday, 1 February 2024 17:30 (30 minutes)

Thanks to the work of Arnold, Crauel, and Wihstutz it is known that for any self-adjoint operator T acting on a finite dimensional space with the negative trace the corresponding linear equation $dx_t = Tx_t dt$ can be stabilized by a noise, i.e. there exists operator-valued Brownian motion W such that the solution of $dx_t + dWx_t = Tx_t dt$ vanishes a.s. for any initial value $x_0 = x$. The goal of the talk is to extend this theorem to infinite dimensions. Namely, we prove that the equation $du_t = \Delta u_t dt$ can be noise stabilized and that an arbitrary large exponential rate of decay can be reached. The sufficient conditions on the noise are shown to be satisfied by the so-called Kraichnan model for stochastic transport of passive scalars in turbulent fluids. This talk is based on joint work with Prof. Benjamin Gess (MPI MiS and Bielefeld University).

Contribution ID: **15** Type: **not specified**

Bec - Lecture 2

Thursday, 1 February 2024 14:00 (2 hours)

Contribution ID: **16** Type: **not specified**

Coti Zelati - Lecture 3

Friday, 2 February 2024 09:00 (2 hours)

Contribution ID: **17** Type: **not specified**

Cocciaglia

Friday, 2 February 2024 11:30 (30 minutes)

The statistical properties of turbulent flows are fundamentally different from those of systems at equilibrium due to the presence of an energy flux from the scales of injection to those where energy is dissipated by the viscous forces: a scenario dubbed "direct energy cascade". From a statistical mechanics point of view, the cascade picture prevents the existence of detailed balance, which holds at equilibrium, e.g. in the inviscid and unforced case. Here, we aim at characterizing the non-equilibrium properties of turbulent cascades by studying an asymmetric time-correlation function and the relaxation behavior of an energy perturbation, measured at scales smaller or larger than the perturbed one. We will make use of a reduced model for turbulence, called SABRA shell model, which relies on the subdivision of k-space into spherical shells followed by some simplifications. The introduced asymmetric correlation functions acquire an interesting interpretation in terms of time-asymmetric energy transfers among different scales, while the response functions are able to detect the presence and direction of the underlying energy cascade process. We shall contrast the behaviors obtained in the non-equilibrium (i.e. forced and dissipated) case with the results found in the equilibrium (unforced and inviscid) counterpart. Finally, we shall show that equilibrium and non-equilibrium physics coexist in the same system, namely at scales larger and smaller, respectively, of the forcing scale.

Contribution ID: **18** Type: **not specified**

Ertel

Friday, 2 February 2024 12:00 (30 minutes)

Random Vortex Methods are a class of Monte Carlo algorithms that aim to approximate the solution to the incompressible Navier-Stokes equation (NSE) using a system of interacting Stochastic Differential Equations. Such methods have originally been introduced and mathematically analyzed for homogenous 2D NSE on the full plane, however extensions to more pracically interesting regimes such as the 3D case and for bounded domains have been developed in recent years. In this talk we focus on an extension to the inhomogenous setting, i.e. when the modelled fluid flow is influenced by an external force. We first derive a novel representation of the solution of the NSE by a field valued McKean–Vlasov equation, which allows for computationally efficient approximations. Next we show well posedness of this class of McKean–Vlasov equations. Finally we discuss quantitative convergence results for a class of numerical schemes using a combination of grid discretization and interacting particle systems. This talk is based on joint work with Prof. Zhongmin Qian and Vladislav Cherepanov (both University of Oxford).

Contribution ID: **19** Type: **not specified**

Bec - Lecture 3

Friday, 2 February 2024 14:00 (2 hours)

Contribution ID: **20** Type: **not specified**

Poster session

Friday, 2 February 2024 16:30 (1h 30m)