Tuesday

09:00 – 09:45 Keynote Lecture

Speaker:
Gallavotti, Giovanni; Universita` di Roma, La Sapienza, Italy.

Title:
Statistical ensembles out of equilibrium: the turbulence case

Abstract:
How to formulate a theory of ensembles analogous to that for the equilibrium ensembles (eg. canonical or microcanoniocal ensembles) to describe the stationary states out of equilibrium? A proposal is suggested by the example of the Navier-Stokes equation. The NS equation will be considered for an incompressible fluid in a periodic box and subject to a stirring force constant in time and acting at large scale (ie at the scale of the container). Stationary states depend on a single parameter R=Reynolds number=inverse of viscosity and form a family E of probability distributions on the velocity fields. The possibility will be discussed of existence of other equations whose stationary states have -exactly- the same distributions through a mechanism analogous to that for the the equivalence of equilibrium states of different ensembles (which will be proposed to be similar to the equivalence in the thermodynamic limit which in the NS case will correspond to the ultraviolet regularization N ->infinity).

09:45 – 10:05

Speaker:
Dubrulle, Berengere; CEA Saclay, France.

Title:
Irreversibility and singularities

In a viscous fluid, the energy dissipation is the signature of the breaking of the time reversal symmetry (hereafter TSB) t-> -t, u-> -u, where u is the velocity. This symmetry of the Navier- Stokes equations is explicitly broken by viscosity. Yet, in the limit of large Reynolds numbers, when flow becomes turbulent, the non-dimensional energy dissipation per unit mass becomes independent of the viscosity, meaning that the time reversal symmetry is spontaneously broken. Natural open questions related to such observation are: what is the mechanism of this spontaneous symmetry breaking? Can we associate the resulting time irreversibility to dynamical processes occurring in the flow? Can we devise tools to locally measure this time irreversibility?
In this talk, I first show that the TSB is indeed akin to a spontaneous phase transition in the Reversible Navier-Stokes equations, a modification of the Navier-Stokes equation suggested by G. Gallavotti to ensure energy conservation and relevance of statistical physics interpretation. I then discuss the mechanism of the TSB in Navier-Stokes via quasi-singularities that create a non-viscous dissipation and exhibit the tools to track them. I apply them to time and space-resolved Lagrangian and Eulerian velocity measurements in a turbulent von Karman flow. I finally compare Eulerian and

Lagrangian signatures of irreversibility, and link them with peculiar properties of the local velocity field or trajectories.

Work in collaboration with S. Thalabard, V. Shukla, G. Krstulovic, S. Nazarenko and EXPLOIT team (P. Debue, V. Valori, T. Chaabo, A. Cheminet, Y. Ostovan Ch. Cuvier J-P. Laval, J-M Foucaut, C. Wiertel, V. Padilla, F. Daviaud)

10:05 – 10:25

Speaker:
Cencini, Massimo; Istituto dei Sistemi Complessi -CNR, Italy.

Title:
Time irreversibility in reversible and irreversible shell models of turbulence

Abstract:
The irreversible energy cascade of fully developed turbulence is a prototype for systems far from equilibrium. Recently, time irreversibility in turbulence has been discovered at the level of single Lagrangian trajectory, whose rate of kinetic energy change --i.e. the Lagrangian power-- displays an asymmetric distribution with a power-law dependence on the Reynolds number. In this talk we shall consider time irreversibility in the context of a shell model for turbulence and its generalization with a modified viscous term which does not break explicitly the time reversibility. Moreover, we will briefly discuss the equivalence of reversible and irreversible non-equilibrium ensembles, conjectured by Gallavotti, in the context of the reversible and irreversible shell models.

10:25 – 10:45

Speaker:
Ray, Samriddhi S.; ICTS-TIFR, India.

Title:
Many-body chaos in a thermalised fluid

Abstract:
We use a new measure of many-body chaos for classical systems---{\it cross-correlators}---to show that in a thermalised solution of the truncated-Burgers equation characterised by a temperature T and N_G degrees of freedom, the Lyapunov exponent λ scales as $N_G\sqrt{T}$. This bound, obtained from detailed numerical simulations and theoretical estimates, provides compelling evidence not only for recent conjectures $\lambda \sim \sqrt{T}$ for chaotic, equilibrium, classical many-body systems, as well as, numerical results from frustrated spin systems, but also, remarkably, show that λ scales linearly with the degrees of freedom in a finite-dimensional, classical, chaotic system.

10:45 – 11:15

Tea/Coffee break

11:15 – 11:35

Speaker:

Verma, Mahendra K.; IIT Kanpur, India.

Title:

Variable energy flux in turbulence

Abstract:

Kolmogorov's theory for hydrodynamic turbulence predicts constant energy flux and $k^{-5/3}$ energy spectrum in the inertial range. This theory, however, is not applicable in the presence of additional forces or walls. The effects of additional forces can be captured using variable energy flux in which the flux in the inertial range varies with wavenumber depending on the nature of the scale-dependent force. We will show in this talk that the buoyancy-driven stably-stratified flows show $k^{-11/5}$ spectrum. In the thermally-driven turbulence, the velocity field follows Kolmogorov's law, and the thermal plates have a profound influence on the temperature spectrum. In rotating flows, rotation makes a major part of a turbulent flow laminar. I will also relate the above to polymer drag reduction, and formulate a general theory of turbulent drag reduction.

11:35 – 11:55

Speaker:

Alexakis, Alexandros; ENS Paris, France.

Title:

Energy fluxes in quasi-equilibrium flows

Abstract:

We examine the relation between the absolute equilibrium state of the spectrally truncated Euler equations (TEE) predicted by Kraichnan (1973) to the forced and dissipated flows of the spectrally truncated Navier-Stokes (TNS) equations. In both of these idealized systems a finite number of Fourier modes is kept contained inside a sphere of radius k_{max}. We show, using an asymptotic expansion of the Fokker-Planck equation, that in the limit of small viscosity ν and fixed maximum wavenumber k_{max} the flow approaches the absolute equilibrium solution of Kraichnan with such an effective `temperature' that there is a balance between the energy injection and the energy dissipation rate. We further investigate the TNS system using direct numerical simulations. The simulations demonstrate that, at steady state with large-scale forcing and dissipation acting only at small-scales, the TNS reproduce the Kolmogorov energy spectrum if the viscosity is large enough so that the Kolmogorov dissipation wavenumber k_ν is smaller than $\kmax$. As viscosity becomes smaller then a bottleneck effect appears taking the form of the equipartition spectrum $E(k)=k^2$ at small scales. As ν is decreased even further the equipartition spectrum occupies all scales approaching the asymptotic equilibrium solutions found before. If the forcing is applied at small scales and the dissipation acts only at large scales then the equipartition spectrum appears at all scales for all values of ν. In both cases a finite forward or inverse

flux is present independent of the amplitude of the viscosity even for the cases where the flow is close to the equilibrium state solutions.

Joint work with Marc-Etienne Brachet

11:55 – 12:15

Speaker:
Herbert, Corentin; CNRS - ENS de Lyon, France.

Title:
Abrupt transition in atmospheric jets through Reynolds stress resonance

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12:15 – 12:35

Speaker:
Perlekar, Prasad; TIFR Hyderabad.

Title:
Pseudo-turbulence in three-dimensional buoyancy driven bubbly flows

Abstract:
We present direct numerical simulation (DNS) study of buoyancy driven bubbly flows. We study PDF of the velocity fluctuations in the liquid phase and make quantitative comparison with the experiments. To investigate spectral properties, we derive the scale-by-scale energy budget equation. We show that the Reynolds number (Re) controls different scaling regimes in the energy spectrum. For low Reynolds number the balance of viscous and buoyancy forces leads to energy spectrum $E(k) \sim k^{-3}$ for length scales larger than the bubble diameter. On the other hand, at high Reynolds number, the k^{-3} spectra appears for scales smaller than the bubble diameter arises due to the balance of viscous and surface tension forces.

12:35 – 14:00

Lunch @ Conference venue

14:00 – 14:30

Speaker: **Falkovich, Gregory**; Weizmann Institute of Science, Israel.
Title: No weak turbulence for old men.
Abstract:
This is a short overview of an information theory of turbulence. In particular, I shall analyze singularities of non-equilibrium measures as applied to wave turbulence.

14:30 – 14:50

Speaker:
Chevillard, Laurent; ENS de Lyon and CNRS, France.

Title:
On the stochastic modeling of Lagrangian velocity and acceleration in turbulent flows

Abstract:
We propose to answer the following question: can we build up an infinitely differentiable stochastic process, such that asymptotically, when the Reynolds number goes to infinity, it becomes irregular (in a Holder sense) and intermittent (in a way we will precise)? This has importance while modeling velocity and acceleration of particles following their trajectories in a turbulent flow.

Joint work with B. Viggiano, J. Friedrich, R. Volk, M. Bourgoin, B.R. Cal.

14:50 – 15:10

Speaker:
Kumar, Krishna; Indian Institute of Technology Kharagpur, India.

Title:
Features of turbulent magnetoconvection in nanofluids

Abstract:
We discuss features of turbulent magnetoconvection in nanofluids in the presence of uniform vertical magnetic field. The power spectral density (PSD) of the Nusselt number with frequency f approximately as f^{-2} . The probability distribution function (PDF) of the fluctuating part of the Nusselt number is nearly normal distribution with slight asymmetric tails. For a fixed values Rayleigh number Ra and thermal Prandtl number Pr, the time averaged Nusselt number < Nu (Q) > decreases logarithmically with Chandrasekhar number Q for Q > Q_c, which depends on Ra and Pr. The normalized Nusselt number Nu r =<Nu(Q)>/<Nu(0)> rises sharply, reaches a maximum slightly above unity and then start decreasing very slowly to unity as the value of a dimensionless parameter $[Ra/(QPr)]^{1/2}$ is raised. The PDF of the local thermal flux in the vertical direction is found to be asymmetric and non-Gaussian with a cusp at its maximum.

15:10 – 15:20

Free time

15:20 – 15:40

Speaker:
Petrelis, Francois; Ecole Normale Supérieure, France.

Title:
Growth rate distribution and intermittency in kinematic turbulentdynamos: Which moment predicts the dynamo onset?

Abstract:
We consider the generation of magnetic field by a turbulent flow. For the linear induction equation (the kinematic dynamo problem), we show that the statistical moments of the magnetic field display multiscaling and in particular moments of different order turn unstable for different values of the control parameter.
On a canonical example, we map the problem onto the calculation of the injected power by a time correlated fluctuating force acting on a Brownian particle. We are then able to calculate analytically the growth rate of the moments of the magnetic field and explain the origin of this intermittency. We finally show that the onset for the nonlinear problem is predicted by the linear onset of the moment of order 0+

Joint work with K. Seshasayanan, SPEC, CEA, Saclay, France.

Published paper: EPL 122 (2018)

15:40 – 16:00

Speaker:
Bouchet, Freddy; ENS de Lyon and CNRS, France.

Title:
Rare transitions in barotropic and baroclinic turbulence

Abstract:
The statistical physics of atmospheric jet transitions is investigated using a rare event algorithm, in both a simple barotropic quasigeostrophic model forced by additive white noise, or a deterministic baroclinic forced by north-south temperature gradient. Both system exhibit robust bimodality with abrupt transitions between states having two eastward jets and states having three eastward jets. We show that new eastward jets can spontaneously nucleate from westward jets with an exponentially small probability as the Ekman dissipation as the Ekman dissipation decreases. This strongly suggests the existence of an Arrhenius law. We will also discuss the unexpectedly rich structure of the long term variability, with the possibility to observe up to six metastable jets with multiple transition paths.

16:00 – 16:30

Tea/Coffee break

16:30 – 17:30 Special Lecture

Speaker:
Newell, Alan; University of Arizona, USA.

Title:
Wave turbulence: Open challenges

Abstract:
A brief overview of the premises on which the derivation of the wave turbulence closure is based and a discussion of several open challenges.