DY 18: Fluid physics and turbulence

Time: Tuesday 10:00–13:00 Location: H20

Invited Talk DY 18.1 Tue 10:00 H20

Bursting, amplitude explosions and mixed mode oscillations at the onset of shear flow turbulence — •Björn Hof[1], Chaitanya Paranjape[1], Yohann Duguet[2], Vasudevan Mukund[1], and Nazmi B Budanur[1] — [1]IST Austria — [2]LIMSI-CNRS

In pipe and channel flows turbulence appears abruptly and the dynamics is immediately high dimensional. Where exactly turbulence originates from and how the turbulent patches characteristic for low Reynolds number turbulence develop has remained an open question for over a century. I will here discuss the different stages of the transition process starting from spatially localized exact coherent structures. In particular I am going to highlight the interplay between the fast fluctuation time scale and the slow recovery of shear, inherent to these structures. Following an explosive increase in fluctuation amplitude, a sharp rise in the attractor dimension is observed and subsequently a boundary crisis to transient chaos. This transition scenario results in localized turbulent transients that through interaction become sustained at a directed percolation phase transition.

DY 18.2 Tue 10:30 H20

Annihilation of Point Defect Pairs in Fluid Films — •Amine Missaoui[1], Kirsten Harth[1,2], and Stannarius Ralf[1] — [1]Otto von Guericke University Magdeburg, Inst. of Physics, ANP, Magdeburg, Germany. — [2]Physics of Fluids and Max Planck Center for Complex Fluid Dynamics, University of Twente, Enschede, The Netherlands

Liquid crystals (LC) are one of the most valuable systems for studying the coarsening dynamics of topological defects. Disclinations in LC, pointlike defects, can be created and observed easily. They are excellent models to study fundamental properties of defect interactions, which are relevant in a wide range of research fields like cosmology or particle physics. In contrast to experiments in nematic LCs, which are 3D and much more complex, freely suspended smectic C films behave like quasi 2D polar nematics and are thus an ideal model system for studying quasi 2D systems.

We study defect annihilation in free-standing SmC freely suspended films experimentally. We prepare isolated defect pairs and we analyze their annihilation dynamics. The dynamics are strongly influenced by the orientation of the -1 defect with respect to the connecting axis, disorientation induces an orbital motion, dancing of the defects during the approach.

DY 18.3 Tue 10:45 H20

Long-wave analysis of liquid meniscus driven by surface acoustic waves — •Kevin David Joachim Mitas[1], Ofer Manor[3], and Uwe Thiele[1,2] — [1]Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Wilhelm Klemm Straße 9, D-48149 Münster, Germany — [2]Center of Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, Corrensstr. 2, D-48149 Münster, Germany — [3]Department of Chemical Engineering. Technion - Israel Institute of Technology, Haifa 32000, Israel

The behaviour of a meniscus of a partially wetting Newtonian liquid that is transfered from a bath onto a moving plate is well studied. We study the related system of a meniscus that is driven by a Rayleigh surface acoustic wave (SAW) propagating in the plate. This Landau-Levich-type problem is modeled by a thin-film equation that combines SAW driving [1] with the standard long-wave description for partially wetting liquids [2]. In our analysis, we first analyse the occurring transitions using the numerical path-continuation package pde2path [3] to obyain bifurcation diagrams for one-dimensional steady profiles and also discuss the corresponding stationary velocity profiles. Next, we briefly discuss time-periodic states corresponding to the deposition of line patterns. Finally, we present results for two-dimensional steady profiles that emerge beyond a transversal contact line instability. [1] M. Moronov et al., *Fluid Mech.*, 810:307–322, 2017; [2] M. Galvagno et al., *Phys. Rev. Lett.*, 112:137803, 2014; [3] H. Uecker et al., *Numer. Math. Theor. Meth. Appl.*, 7(1):58–106, 2014.

DY 18.4 Tue 11:00 H20

Investigation of different transition phenomena on airfoils by means of infrared thermography and PIV — •Enno Bösenberg, Tom T. B. Wester, Dominik Traphan, Gerd Gülker, and Joachim Peinke — ForWind, Institute of Physics, University of Oldenburg, Oldenburg, Germany

In fluid dynamic research phenomena like laminar separation bubble and transition in the boundary layer are known to be sensitive to the inflow and can change the entire flow topology. Consequently, they can induce changes in loads increasing fatique of e.g. wind turbines.

Due to a thin boundary layer, the transition zone is difficult to observe. Best practice methods, like pressure taps or oil-film, require some form of preparation on airfoils.

Thermography has proven to be a quick and easy way of visualising aerodynamic effects on airfoils while requiring little to no preparation. Experiments have been made to identify the effects of transition, separation bubble and turbulent flow from thermal images of airfoils. Now we are comparing the high temporal and spatial resolution in flow measurement of particle image velocimetry (PIV) to the surface-bound measuring technique of thermography.

Varying wind velocities, during combined triggered PIV and high speed thermographic measurements, enable us to assess the spatial and temporal accuracy of said events in thermography. First results suggest a high correlation with PIV.

DY 18.5 Tue 11:15 H20

Transitions between large-scale flow states in turbulent 3D Kolmogorov flow — •Cristian C Lalescu and Michael Wilczek — Max Planck Institute for Dynamics and Self-Organization, Göttingen

For most turbulent flows in nature, the idealization of statistical homogeneity and isotropy only applies to the small scales. The large scales are typically non-universal with pronounced inhomogeneities resulting from walls, large-scale driving etc. This motivates the investigation of the large-scale structure, turbulent fluctuations as well as their interaction in a canonical flow.

Here we present results on a generalized turbulent Kolmogorov flow in three-dimensional periodic domains with aspect ratios larger than one. The flow is forced on a single Fourier mode and is subject to large-scale friction. The flow develops large-scale vortex patterns similar to two-dimensional Kolmogorov flow, even in the presence of intense three-dimensional small-scale fluctuations. We characterize transitions between different large-scale flow states as the large-scale friction is modified, including a regime reminiscent of noise-suppressed hysteresis. In addition to the large-scale flow features, we address the question of small-scale isotropy in the presence of large-scale anisotropies in this flow. Our results help to clarify the role of fluctuations for transitions in fully developed turbulence.

15 min. break

DY 18.6 Tue 11:45 H20

Power-law scaling of friction in pipe flow — •Jose M. Lopez, Davide Scarselli, Balachandra Suri, and Bjoern Hof — Institute of Science and Technology (IST), Klosterneuburg, Austria

We present a study of the friction factor scaling for pipe flow at moderate Reynolds numbers (5000<Re<120 000) in experiments and highly resolved direct numerical simulations. The experimental and numerical data are in excellent agreement and we find that for Re<80 000 they do not follow the Karman-Prandtl friction relation. Instead the friction factor precisely follows the Blasius power law. This power law scaling can also be derived based on Kolmogorov's first hypothesis (assuming local isotropy) in line with an earlier study. Finally, we will show that the deviation of the friction factor from the power law scaling (Re>80 000) is related to the increasing dominance of the large scale motions in the logarithmic layer.

DY 18.7 Tue 12:00 H20

Nonlinear mode decomposition and optimal iterative estimation of Koopman modes — •Oliver Kamps and Tim Kroll — Center for Nonlinear Science, University of Münster

Complex systems composed of a large number of degrees of freedom can often be described on the macroscopic level by only a few interacting modes or coherent structures. In general many turbulent flows seem to be composed of a few coherent structures and it might be possible to find a low dimensional representation of the flow. This has to be done in most cases by means of data analysis methods since it is not possible to derive the low dimensional model from the basic equations of the complex system.

We present a nonlinear decomposition method that is able to extract coherent structures and their dynamics from data of turbulent flow fields. We apply this method to reversal dynamics in convection and to a flow past a cylinder in order to derive low dimensional representations of the systems. We also discuss the relation of our method to Koopman operator theory and dynamic mode decomposition and show how a special case of the presented method can be used to estimate Koopman modes and their dynamics.

DY 18.8 Tue 12:15 H20

Laboratory Study of the Bottleneck Effect in ultra-strong Turbulence — •Christian Küchler[1], Gregory P. Bewley[2], and Eberhard Bodenschatz[1,2,3] — [1]Max Planck Institute for Dynamics and Self-Organization — [2]Cornell University, Ithaca — [3]Georg August University Göttingen

The turbulent flows characteristic of the atmosphere as well as many engineering problems, are intrinsically a multi-scale phenomenon. While the large-scale motions depend on the turbulence forcing mechanism, and the small scales are dominated by viscosity, the intermediate scales are believed to depend only on the scale-to-scale energy transfer of kinetic energy. In this inertial range, the turbulence is suspected to follow universal laws, e.g. Kolmogorov's 1941 scaling of the energy spectrum $E(k) \sim k^{-5/3}$. However, deviations from this scaling are commonly observed, possibly revealing more complicated energy transfer mechanisms. We present the first laboratory study of one of these effects, namely the bottleneck effect - a pileup of energy at the transition from inertial to dissipative flow scales. In particular we show the dependence of this phenomenon on the turbulence intensity measured by the Taylor-scale Reynolds number R_λ. For this we devised a technique to examine energy spectra plagued by non-flat frequency responses of the hot-wire anemometer we use to measure flow speed. This is made possible by the unique mosaic active grid in the Variable Density Turbulence Tunnel. The active grid also permits the creation of $R_\lambda > 5000$, which is unmatched by any well-controlled laboratory flow with experimentally resolvable dissipative scales.

DY 18.9 Tue 12:30 H20

Turbulence in precessing flows — •Andreas Tilgner and Oliver Goepfert — Institut für Geophysik, Universität Göttingen

There are several geophysical and astrophysical applications for which precession driven flows are of relevance. For example, the rotation axis of the Earth is precessing and this induces a flow in the liquid iron core of the Earth which may be at the origin of the Earth's magnetic field. The problem of tidal flows is closely connected to precession driven flows. In both cases, we are faced with a rotating fluid exposed to a time periodic forcing. The talk will describe the known routes to instability and turbulence, among which figure triad resonances which excite inertial waves. Precession driven flows may thus be a good model system to study wave turbulence of inertial waves. During the search for a wave turbulent state, a different and much simpler state emerged, consisting mainly of a single vortex.

DY 18.10 Tue 12:45 H20

Drop dynamic due to condensation and evaporation in a thin Rayleigh-Bénard cell — •Stephan Weiss[1], Prasanth Prabhakaran[1,2], Alexei Krekhov[1], and Eberhard Bodenschatz[1,3] — [1]Max Planck Institute f. Dynamics and Self-Organisation, Göttingen — [2]Michigan Tech, Houghton, MI, USA — [3]Georg-August University, Göttingen

We report on condensation phenomena in a thin horizontal cell, heated from below and cooled from above, i.e., the well known Rayleigh-Bénard setup. We use Sulphur Hexaflouride (SF_6) as the working fluid with the pressure and temperatures of the plates set such that the bottom plate is above and the top plate below the liquid-vapor transition temperature of SF_6. As a result liquid condenses at the top plate forming a thin layer. This layer undergoes a Rayleigh-Taylor like instability, resulting in the formation of drops that arrange themselves into a hexagonal pattern. At sufficient strong heating from below, the drops are stable and are prevented from touching the bottom plate due to pressure caused by evaporation of the liquid at the bottom of the drops, similar to levitating Leidenfrost drops. When the amount of liquid in the cell is increased in the experiment, e.g., by increasing the pressure, the drops increase in size and form larger domains - puddles. Above a critical size, these puddles undergo another instability leading to the formation of wholes (chimneys) inside the liquid domain. The larger the liquid domain, the more such chimneys occur.