DY 33: Fluid Dynamics and Turbulence

Time: Wednesday 10:00–13:15 Location: ZEU 160

DY 33.1 Wed 10:00 ZEU 160

Characterization and optimization of devices for active flow control — •Max Huber[1,3], Andreas Zienert[2], Hans-Reinhard Berger[1], and Jörg Schuster[3] — [1]Institute of Physics, Technische Universität Chemnitz, Chemnitz, Germany — [2]Center for Microtechnologies, Technische Universität Chemnitz, Chemnitz, Germany — [3]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany

Synthetic jet actuators (SJAs) are used for active flow control to achieve reduction of drag and noise as well as lift enhancement for airplane wings. The devices consist of a movable piezoelectric diaphragm and a closed cavity with a small orifice. The synthetic (i.e. zero net mass flux) jet is generated by the oscillation of the diaphragm and transfers momentum to the surrounding medium.

The present work studies a one dimensional analytical model for SJAs. The single parts of the actuator are described by a coupled set of mechanical and hydrodynamical equations. The model is used to analyse quantitatively the measured relation between diaphragm vibration and fluid flow through the orifice for different SJAs. In addition, an optimization of the cavity volume with respect to the resonance frequency of the diaphragm was carried out to maximize the performance of the device.

DY 33.2 Wed 10:15 ZEU 160

Unsteady dynamics of the flow around an adaptive chamber profile visualized by high speed PIV — •Tom T. B. Wester, Gerd Gülker, Michael Hölling, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg, Germany

Wind turbines are subjected to severe inflow fluctuations during their operation. These dynamics lead to high load changes and can result in defects of single components within the system (e.g. pitch actuator, generator or airfoils).
In order to minimize these loads a chambered airfoil could be used. This airfoil is designed to alleviate high loads and is therefore expected to be less susceptible to defects caused by a turbulent inflow. This is done by a coupled moving leading and trailing edge of the airfoil. A segment of such an airfoil is investigated in a defined and reproducible turbulent inflow. This inflow is generated in our wind tunnel by an active grid and is based on statistics of measured atmospheric wind fields.
To visualize the aerodynamics around the airfoil segment, high speed PIV is used. With this technique it is possible to measure the occurring flow dynamics in a highly spatial and temporal resolved manner. This makes it possible to connect the known inflow conditions directly to flow situations (e.g. flow separation) around the airfoil.
In our presentation we will show first PIV results of the flow around the airfoil and characteristics of the modulated inflow conditions.

DY 33.3 Wed 10:30 ZEU 160

Generation of reproducible 2D atmospheric turbulence in a closed wind tunnel test section — •Johannes Krauss, Tom Wester, Michael Hölling, Joachim Peinke, and Gerd Gülker — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg, Germany

Changes in the inflow conditions of wind turbines cause fatigue loads and they have an important influence on the turbines lifetime. Important aspects are variations of the angle of attack and gusts that lead to aerodynamic effects such as dynamic stall and sudden changing moments and forces.

We will present a technique which makes it possible to reproduce wind speed time series measured in the turbulent atmospheric boundary layer in a closed test section of a wind tunnel. With this technique, we can generate quasi-2D flows which mimic the real atmospheric inflow acting on an outside wind energy converter. The quasi-2D properties of the wind flow are meant to enable its usage for flow analysis at airfoil segments and to simplify the identification of complex aerodynamic phenomena. The technique is based on independently moving vanes affecting the laminar inflow of the wind tunnel in a controllable and reproducible manner. For flow modulation, different situations are modelled and characterized. To capture the entire temporal and spatial dynamic of the system high speed PIV and hotwire measurements are used. In this presentation, first measurements and conclusions are shown.

DY 33.4 Wed 10:45 ZEU 160

Multi-Scale Analysis of Lagrangian Properties of Turbulence — •Michael Wilczek and Cristian Lalescu — Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Deutschland

Turbulence is a multi-scale problem in space and time with a broad range of strongly interacting degrees of freedom. Lagrangian tracer particles advected with the flow sample this spatio-temporal complexity. This naturally leads to the question of how Lagrangian properties are affected by the scales of turbulence. We attempt to answer this question numerically and theoretically adopting a filtering approach. In an extensive DNS (direct numerical simulation) study, we track tracer particles advected by spatially filtered velocity fields. This allows to distinguish the impact of large-scale sweeping effects and small-scale intermittency on Lagrangian aspects of turbulence. In this presentation we will present results on Lagrangian particle dispersion and velocity fluctuations for various filtering scales. The results will furthermore be discussed in the context of Eulerian-Lagrangian bridging relations.

DY 33.5 Wed 11:00 ZEU 160

Discrete exterior calculus for the surface Navier-Stokes equation - the interplay of topology, geometry and flow properties — •Axel Voigt, Ingo Nitschke, and Sebastian Reuther — Institut für Wissenschaftliches Rechnen, TU Dresden, Germany

We consider a numerical approach for the incompressible surface Navier-Stokes equation. The approach is based on the covariant form and uses discrete exterior calculus (DEC) in space and a semi-implicit discretization in time. We compare computational results with a vorticity-stream function approach for surfaces with genus $g(S) = 0$ and demonstrate the interplay between topology, geometry and flow properties. Our discretization also allows to handle harmonic vector fields, which we demonstrate on a torus.

15 min. break

DY 33.6 Wed 11:30 ZEU 160

An Extended Transfer Operator Approach to Identify Separatrices in Open Flows — •Benedict Johannes Lünsmann and Holger Kantz — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Deutschland

Eddies, mesoscale masses of coherent fluid volume, are considered to have a substantial impact on the transport of heat, nutrition and oxygen in the ocean. Yet, due to their Lagrangian nature detecting these structures is highly nontrivial. In this respect transfer operator approaches have proven to provide useful tools: Approximating a possibly time-dependent flow as a discrete Markov process in space and time, information about coherent structures are contained in the operator's eigenvectors which is usually extracted by employing clustering methods. Here, we propose an extended approach that refrains from machine learning techniques such as clustering and uses physical arguments instead. We show, that this technique is suited to reconstruct separatrices in stationary flows and can be used to probe regions for coherent structures individually.

DY 33.7 Wed 11:45 ZEU 160

Wetting dynamics beneath fluid drops impacting on hot surfaces — •Kirsten Harth[1], Michiel A. J. van Limbeek[1], Minori Shirota[1], Chao Sun[1,2], and Detlef Lohse[1] — [1]Physics of Fluids, Universiteit Twente, Enschede, The Netherlands — [2]Center for Combustion Energy, and Department of Thermal Engineering, Tsinghua University, China

Fluid droplets encountering a phase transition when they impact a target surface are involved in many applications, e.g., spray cooling or painting / coating, ink-jet and 3D printing, soldering, firefighting using sprinklers. Drop impact on hot plates is an emerging topic, involving a complex interplay of hydrodynamics, heat flux and the occurring phase transition, involving large spatial and temporal gradients. Whether and to what extent droplets touch the surface is of immense importance for the overall heat transfer. High-speed total internal reflection imaging allows us to discriminate wetted and vapor-covered regions of the substrate. We study the transient wetting behaviour of the plate by varying the latent heat of the droplet. The characteristic cooling time of the plate is not solely determined by the plate properties. In addition to current literature, we show that in those cases the wetting pattern is both spatially and temporally inhomogeneous.

DY 33.8 Wed 12:00 ZEU 160

Detailed finite element method modeling of evaporating multi-component droplets — •Christian Diddens — Eindhoven University of Technology, The Netherlands

The evaporation of sessile multi-component droplets is modeled with a finite element method. The model comprises the coupled processes of mixture evaporation, multi-component flow with composition-dependent fluid properties and thermal effects. Based on representative examples of water-glycerol and water-ethanol droplets, regular and chaotic examples of solutal Marangoni flows are discussed. Furthermore, the relevance of the substrate thickness for the evaporative cooling of volatile binary mixture droplets is pointed out. It is shown how the evaporation of the more volatile component can drastically decrease the interface temperature, so that ambient vapor of the less volatile component condenses on the droplet.

DY 33.9 Wed 12:15 ZEU 160

Evaporation-triggered microdroplet nucleation and the four life phases of an evaporating Ouzo drop — Huanshu Tan[1], •Christian Diddens[2], Pengyu Lv[1], Hans Kuerten[1,2], Xuehua Zhang[3], and Detlef Lohse[1,4] — [1]University of Twente, The Netherlands — [2]Eindhoven University of Technology, The Netherlands — [3]Royal Melbourne Institute of Technology University — [4]Max Planck Institute for Dynamics and Self-Organization

While the evaporation of pure liquid droplets and binary mixture droplets has been intensively studied, the evaporation of ternary mixture droplets with different volatilities and mutual solubilities has not yet been explored. Here, we show that the evaporation of such ternary mixtures can trigger a phase transition and the nucleation of microdroplets of one of the components of the mixture. As a model system, we pick a sessile Ouzo droplet (as known from daily life) and reveal and theoretically explain its four life phases: In phase I, the spherical cap-shaped droplet remains transparent while the more volatile ethanol is evaporating, preferentially at the rim of the drop because of the singularity there. This leads to a local ethanol concentration reduction and correspondingly to oil droplet nucleation there. This is the beginning of phase II, in which oil microdroplets quickly nucleate in the whole drop, leading to its milky color that typifies the so-called Ouzo effect. Once all ethanol has evaporated, the drop, which now has a characteristic nonspherical cap shape, has become clear again, with a water drop sitting on an oil ring (phase III), finalizing the phase inversion. Finally, all water has evaporated, leaving behind a tiny oil drop.

DY 33.10 Wed 12:30 ZEU 160

intermolecular mode coupling: insight from nonlinear THz spectroscopy of liquids — •mohsen sajadi, martin wolf, and tobias kampfrath — fritz-haber-institute of the max-planck society, berlin, germany

Low-frequency structural dynamics of liquids in the range of 0.1 to 10 THz (3 to 300 cm-1) is believed to strongly contribute to the outcome of chemical processes. The underlying molecular motions are very complex and include reorientations, vibrations and translations. Implemented techniques for gaining microscopic insight to such low-frequency molecular motions have mostly been limited to the off-resonant optical excitation of liquids via Raman processes. Using intense THz fields, we interrogate the structural dynamics of molecular liquids directly. We show that resonant excitation with strong THz pulses is capable of driving librational-reorientational modes of liquids through coupling to the permanent molecular dipole moments. We observe a hallmark of this light-matter interaction as a transient optical birefringence up to one order of magnitude higher than obtained with optical excitation. In light of a simple but generic model and excitation at different THz frequencies we discuss that the enhancement arises from resonantly driven librations and their coupling to reorientational motion, assisted by either the pump field or a cage translational mode.

DY 33.11 Wed 12:45 ZEU 160

Transmission of Ultracold Neutrons Through Cold Deuterium and Hydrogen – The Scattering Cross Sections — •Stefan Döge[1,2,3], Peter Geltenbort[2], Tobias Jenke[2], Christoph Morkel[1], Erwin Gutsmiedl[1], Winfried Petry[3], and Stephan Paul[1] — [1]Physik-Department, Technische Universität München, Garching, Germany — [2]Institut Laue–Langevin, Grenoble, France — [3]Forschungsneutronenquelle Heinz Maier-Leibnitz, Technische Universität München, Garching, Germany

Ultracold neutrons (UCNs) are a versatile tool for fundamental physics experiments, such as the exact determination of the free neutron lifetime or the search for a possible non-zero neutron EDM.

The precise knowledge of UCN cross sections in deuterium are pivotal to the design and improvement of new UCN sources, which promise to provide higher UCN densities than the current frontrunner – the "turbine" at Institut Laue–Langevin (ILL).

The total UCN cross sections in hydrogen and deuterium were measured in transmission geometry with a time-of-flight (TOF) setup and were corrected for several side effects like UCN scattering on surfaces etc. We present energy-dependent cross section data (σ^{scatt}) for UCNs in liquid and solid deuterium and hydrogen and discuss newly detected phenomena.

[1] S. Döge et al., Phys. Rev. B 91, 214309 (2015) and arXiv:1511.07065 [nucl-ex]

[2] S. Döge et al., ISINN-23 Proceedings, p. 119-130, Dubna/Russia (2016)

DY 33.12 Wed 13:00 ZEU 160

Pattern-fluid interpretation of chemical turbulence — •Gerd E. Schröder-Turk[1,2], Christian Scholz[2], and Klaus Mecke[2] — [1]Murdoch University, Perth, WA, Australien — [2]Friedrich-Alexander Universität Erlangen-Nürnberg Erlangen

The formation of heterogeneous patterns is a hallmark of many nonlinear systems. The standard model for pattern formation in general, and for Turing patterns in chemical reaction-diffusion systems in particular, are deterministic nonlinear partial differential equations where an unstable homogeneous solution gives way to a stable heterogeneous pattern. However, these models fail to explain the experimental observation of turbulent patterns with spatio-temporal disorder in chemical systems. Here we introduce a pattern-fluid model as a concept where turbulence is interpreted as a weakly interacting ensemble obtained by random superposition of stationary solutions to the underlying reaction-diffusion system. The transition from turbulent to stationary patterns is interpreted as a condensation phenomenon, where the nonlinearity forces one single mode to dominate the ensemble. This model leads to better reproduction of the experimental concentration profiles for the 'stationary phases' and reproduces the turbulent chemical patterns observed by in Ouyang and Swinney [1]. This results presented here have been published in ref [2].

[1] Ouyang and Swinney, Chaos 1, 411 (1991)
[2] Scholz et al, Physical Review E 91, 042907 (2015)