DY 37: Fluid Dynamics and Turbulence

Time: Thursday 15:00–16:30 Location: ZEU 146

DY 37.1 Thu 15:00 ZEU 146

Dynamic emptying and dynamic wetting transitions in dragged meniscus problems — •Uwe Thiele[1,2], Mariano Galvagno[1], Hender Lopez[3], and Dmitri Tseluiko[1] — [1]Department of Mathematical Sciences, Loughborough University, UK — [2]Institut für Theoretische Physik, Universität Münster, Germany — [3]School of Physics, University College Dublin, Ireland

We study the transfer of a non-volatile liquid from a bath onto a flat plate that is drawn out of the bath. After reviewing previous works [1,2] we use a long-wave mesoscopic hydrodynamic model that incorporates wettability via a Derjaguin (disjoining) pressure to analyse steady meniscus profiles as the plate velocity is changed. We identify four qualitatively different dynamic transitions between microscopic and macroscopic coatings that are out-of-equilibrium equivalents of equilibrium unbinding transitions, namely, continuous and discontinuous dynamic emptying transitions and discontinuous and continuous dynamic wetting transitions [3]. We discuss several features that have no equivalent at equilibrium, e.g., we show that the change from the continuous to the discontinuous dynamic emptying transition involves the emergence of exponential snaking caused by the existence of infinitely many heteroclinic orbits close to a heteroclinic chain in an appropriate 3d phase space [4].

[1] A. O. Parry et al., Phys. Rev. Lett. 108:246101, 2012; [2] J. Ziegler, J. H. Snoeijer, J. Eggers. Eur. Phys. J.-Spec. Top. 166:177-180, 2009; [3] M. Galvagno et al., arxiv.org/abs/1311.6994; [4] M. Galvagno, D. Tseluiko, U. Thiele, arxiv.org/abs/1307.4618

DY 37.2 Thu 15:15 ZEU 146

Stokes flow in complex domains — •Andreas Lemmer and Rudolf Hilfer — Institut für Computerphysik, Universität Stuttgart, Allmandring 3, D-70569 Stuttgart

Numerically solving the Stokes equation in complex domains like porous media is computationally difficult because of the large number of unknowns, the complicated domain geometry and the velocity-pressure coupling. We present a domain decomposition method on a uniform, staggered grid which is completely parallelized using only non-blocking communication, therefore achieving high parallel efficiency[1]. This method is used to numerically solve the Stokes equation on a synthetic sample of a laboratory sized Fontainebleau sandstone. The cubic sample with side length $15mm$ is discretized with resolutions from $117\mu m$ down to $458nm$, resulting in sample sizes from 128^3 to 32768^3 grid cells[2]. The flow calculation on the sample with 2048^3 grid cells and over $5 \cdot 10^9$ unknowns on the bwGrid Cluster, HLRS Stuttgart on 512 processors took 30 hours.

[1] A. Lemmer, R. Hilfer, to be published

[2] R. Hilfer, T. Zauner: High-precision synthetic computed tomography of reconstructed porous media, Phys.Rev.E, 84, 062301 (2011)

DY 37.3 Thu 15:30 ZEU 146

Evolution equations for two dimensional elliptic shaped gaussian vortices — •Markus Blank-Burian — Institut für Physikalische Chemie, WWU Münster, Deutschland

The easiest model to describe two dimensional vortices in turbulent flows is the point vortex model. This model has an inherent problem, as it can not describe either attraction or repulsion of two vortices. By studying numerical and experimental data, one can see, that in first approximation two interacting vortices maintain a nearly elliptic gaussian shape for a rather long time. Vortices with the same sign attract each other and orientate themselves parallel with an angle of approximately 45° to their connecting vector. Vortices with different sign orient themselves nearly perpendicular to each other while moving in the same direction.

Based on an idea in [1], one can derive equations of motion for two interacting elliptically shaped gaussian vortices, describing their evolution in time. This model then correctly predicts attraction and repulsion of two vortices, depending on the strenth and orientation of the vortices. The characteristic angles of 45° are found stable as well. The famous Lamb-Oseen vortex is contained as a limiting case of symmetric shape.

[1] Friedrich, Friedrich: Generalized vortex-model for the inverse cascade of two-dimensional turbulence, http://arxiv.org/abs/1111.5808

DY 37.4 Thu 15:45 ZEU 146

The solar wind as a turbulence laboratory- some new quantitative points of contact between theory and solar wind observations — •Sandra Chapman[1,2,3], Khurom Kiyani[4,1], Kareem Osman[1], Bogdan Hnat[1], and Ersilia Leonardis[1] — [1]CFSA, Physics, University of Warwick, UK — [2]MPIPKS, Dresden, Germany — [3]Mathematics and Statistics, UIT, Norway — [4]Laboratoire de Physique des Plasmas, Ecole Polytechnique, Saclay, France

The solar wind flow has a Reynolds number of order 10ˆ5. Single point sattelite observations of plasma parameters suitable for the study of turbulence are on timescales from below ion kinetic scales up to days. We will present methodology to quantify the scaling properties of turbulence from in-situ satellite observations in the solar wind that address the problems of scaling over a finite range and restricted sampling of rare extreme events.

Ideal fluid turbulence is characterized by non-Gaussian distributions of fluctuations which become progressively fat-tailed on smaller scales, and which exhibit a multifractal scale invariance, a behaviour also seen in the MHD inertial range of turbulence in the solar wind. We show that below the ion kinetic scales there is instead a cross-over to a quantitatively distinct global scale invariance and discuss the implications for the physics of kinetic range turbulence. Solar wind plasma turbulence is anisotropic due to the presence of a background field. We will discuss how this anisotropy also orders the scaling properties seen in solar wind turbulence.

DY 37.5 Thu 16:00 ZEU 146

Generation of turbulence with an active grid — •Lars Kröger, Nico Reinke, Gerd Gülker, and Joachim Peinke — ForWind, Center for Wind Energy Research, University of Oldenburg, D-26129 Oldenburg, Germany

Turbulent fluid flows are omnipresent in our everyday life. Especially turbulence in the atmospheric boundary layer is a very important topic for wind energy research. As experiments in nature are somewhat limited and could mostly not take place under reproducible circumstances, wind tunnel measurements are necessary. Placing grids behind the wind tunnel nozzle is a common way to generate turbulence in a laboratory experiment. So called active grid consisting of horizontal and vertical oscillating rods with flaps are used in some investigations providing an improved option to generate dynamically driven turbulence with a wide range of statistical behaviour. Reproducible and statistical well defined turbulence could be generated with defined excitation protocols of the active grid flaps. In our experiments, we are using active grids in two wind tunnels with different dimensions. In this presentation hotwire and PIV measurements of the grid wakes are presented in order to investigate the scaling ability of the turbulent flow. For this, the decaying turbulence of different excitation protocols of the two mentioned grids is characterized by measurements of the velocity, the power spectra and turbulence intensity.

DY 37.6 Thu 16:15 ZEU 146

Hierarchy of structure function relations for locally isotropic MHD turbulence — •Jan Friedrich[1], Holger Homann[2], Tobias Schäfer[3], and Rainer Grauer[1] — [1]Theoretische Physik I, Ruhr-Universität, 44780 Bochum, Germany — [2]Laboratoire J.-L. Lagrange, Universite de Nice-Sophia Antipolis, CNRS, France — [3]Department of Mathematics, College of Staten Island, CUNY, USA

We investigate the structure of locally isotropic magnetohydrodynamic (MHD) turbulence by means of exact equations for magnetic and velocity structure functions. To this end we make use of the calculus of isotropic tensors for MHD turbulence introduced by Chandrasekhar [1]. A hierarchy of structure function equations is obtained, beginning with the MHD analagon of Kolmogorov's four-fifths law of hydrodynamics. The influence of the mean-magnetic field is discussed within the context of the Iroshnikov-Kraichnan phenomenology [2], [3]. The next order equation relates the third- and fourth-order structure functions and is the first order which provides a direct dependence between the longitudinal and the transverse structure functions based on the dynamics. At this order, we have to deal for the first time with pressure contributions. The influence of the additional magnetic pressure is discussed in comparison to the hydrodynamic case and the obtained relations are checked by direct numerical simulations of three-dimensional MHD turbulence.

[1] S. Chandrasekhar, Proc. R. Soc. Lond. A, 204, 1079 (1951)
[2] P.S. Iroshnikov, Sov. Astron. 7, 566-71 (1964)
[3] R.H. Kraichnan, Phys. Fluids 8, 1385-7 (1965)