DY 38 Fluid Dynamics

Time: Wednesday 16:45–18:00 Room: SCH 251

DY 38.1 Wed 16:45 SCH 251

Asymptotic theory for a moving droplet driven by a wettability gradient — •Uwe Thiele[1] and Len M. Pismen[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]Department of Chemical Engineering and Minerva Center for Nonlinear Physics of Complex Systems, Technion – Israel Institute of Technology, Haifa 32000, Israel

An asymptotic theory is developed for a moving drop driven by a wettability gradient [1]. We distinguish the mesoscale where an exact solution is known for the properly simplified problem [2]. This solution is matched at both – the advancing and the receding side – to respective solutions of the problem on the microscale. On the microscale the velocity of movement is used as the small parameter of an asymptotic expansion in analogy to [3]. Matching gives the droplet shape, velocity of movement as a function of the imposed wettability gradient and droplet volume.

[1] L. M. Pismen and U. Thiele, preprint at http://arXiv.org/abs/physics/0509260.
[2] B. R. Duffy and S. K. Wilson, Appl. Math. Lett. **10**, 63-68 (1997).
[3] J. Eggers, Phys. Rev. Lett. **93**, 094502 (2004).

DY 38.2 Wed 17:00 SCH 251

Complex Singularities of the Euler Equation — •Walter Pauls — Observatoire de la Cote d'Azur, BP 4229, 06304 Nice Cedex 4, France — Fakultät für Physik, Universität Bielefeld, Universitätsstraße 25, 33615 Bielefeld

A detailed study of complex-space singularities of the two-dimensional incompressible Euler equation is performed in the short-time asymptotic regime when such singularities are very far from the real domain; this allows an exact recursive determination of arbitrarily many spatial Fourier coefficients. Using 35 to 100-digit high-precision arithmetic we find that the Fourier coefficients of the stream function are given over more than two decades of wavenumbers by $\hat{F}(\mathbf{k}) = C(\theta)k^{-\alpha}e^{-\delta(\theta)k}$, where $\mathbf{k} = k(\cos\theta, \sin\theta)$. The prefactor exponent α, typically between 5/2 and 8/3, is determined with an accuracy better than 0.01. It depends on the initial condition but not on θ. The vorticity diverges as $s^{-\beta}$, where $\alpha + \beta = 7/2$ and s is the distance to the (complex) singular manifold. This new type of non-universal singularity is permitted by the strong reduction of nonlinearity (depletion) which is associated to incompressibility. Spectral calculations show that the scaling reported above persists well beyond the time of validity of the short-time asymptotics. A simple model in which the vorticity is treated as a passive scalar is shown analytically to have universal singularities with exponent $\alpha = 5/2$.

DY 38.3 Wed 17:15 SCH 251

Propagating fronts in spiral Poiseuille flow — •Matti Heise, Jan Abshagen, and Gerd Pfister — Institute of Experimental and Applied Physics, University of Kiel, Germany

One of the classical hydrodynamic systems for the study of Hopf bifurcation with $O(2)$-symmetry is counter rotating Taylor Couette flow. This is the flow of a viscous liquid in the gap between two concentric rotating cylinders. We present the results of an experimental study on the transition between two different types of spiral vortices in counter rotating spiral Poiseuille flow, the Taylor Couette flow between two counter rotating cylinders in the presence of an axial through flow. As a result of an applied axial through flow the 'classical' Hopf bifurcation to spiral vortices splits up and a primary and secondary branch of down- and upward propagating spirals, respectively, as well as a transient quasiperiodic flow appear. The bifurcation structure observed in this open flow experiment is in qualitative agreement with predictions from theory of Hopf bifurcation with broken reflection symmetry and also in quantitative agreement with results from recent numerical calculations. We also observed the transition from upward to downward propagating spirals in form of a progagating front in spiral Poiseuille flow.

DY 38.4 Wed 17:30 SCH 251

Shear flow in freely suspended liquid crystal films induced by elastic stress — •Alexey eremin, christian bohley, and ralf stannarius — Otto-von-Guericke-Universität Magdeburg, Institut für Experimentalphysik

Hydrodynamic phenomena observed in liquid crystalline materials are far more complex than those in conventional Newtonian fluids. The reasons lies in the coupling of macroscopic translational motions to inner degrees of freedom, created by broken symmetries. We present an experimental and theoretical study of vortex flow in freely suspended smectic films that is induced entirely by elastic distortions of the orientational director field. By means of an external electric field, a periodically deformed director field is prepared, which, after the field is switched off, relaxed into a homogeneous state. Macroscopic flow is induced by this director reorientation. It is visualized by tracer particles imposed on the film surface. We discuss experimental results and theoretical models developed for different configurations of the director field. It is shown that the presence or absence of a central topological defect has essential influence on the relaxation dynamics of flow and director fields. From a quantitative analysis, shear viscosities of the material can be accessed.

DY 38.5 Wed 17:45 SCH 251

Statistics of temperature fluctuations measured by a new microscopic temperature sensor — •Florian Heidemann, Marco Munzel, and Achim Kittel — University of Oldenburg, D-26111 Oldenburg

The basic principals of turbulence are still not well understood. On the basis of the measurements in a homogeneous isotropic free jet it is possible to characterize its invariant parameters and investigate the nature of turbulence. We have analyzed a heated free jet of water in a water tank with a new developed fast thermosensor with a high spatial and temperature resolution at different positions and for different flow velocities. The used nozzle has a diameter of 2mm, which provides a laminar flow with a rectangular velocity profile at the outlet. The sensor is based on a miniaturized thermocouple and has an active area of approx. $0.05\mu m^2$ and a response time of approx.10 μs in water with a temperature resolution of 50mK (measured with a bandwidth of 100kHz). Our aim is to characterize the temperature fluctuations perpendicular and parallel to the symmetry axis of the free jet with power spectra and increment distributions depending on the position with respect to the nozzle. Furthermore the measured fluctuations are analyzed with the markov analysis.