DY 13: Fluid Dynamics and Turbulence I

Time: Tuesday 10:15–12:45 Location: ZEU 118

Topical Talk DY 13.1 Tue 10:15 ZEU 118

Aggregation and Fragmentation of fractal-like particles in synthetic turbulent flows — •Ulrike Feudel, Jens Zahnow, and Joeran Maerz — ICBM, Carl von Ossietzky University Oldenburg

Inertial particles in fluid flows are of increasing interest in different disciplines of science such as dynamical systems theory, atmospheric and marine science as well as engineering. In many cases particles are not only transported passively by advection but exhibit a dynamics of their own as they can form larger particles upon collision or can break up. Examples of particle dynamics are raindrop formation in clouds, sedimentation of particles in lakes and the ocean or flocculation of marine aggregates and cells. We present a coupled model for advection, aggregation and fragmentation that is based on the dynamics of individual, spherical and fractal-like inertial particles in synthetic turbulent flows. Due to the particle inertia advection leads to the preferential concentrations of the particles in certain spatial regions. The collision of the particles leads to aggregation and larger aggregates are formed. These can in turn fragment due to shear forces in the flow. We find that the combination of aggregation and fragmentation leads to an asymptotic steady state for the size distribution of the aggregates which depends crucially on the considered mechanism of fragmentation. We discuss the dependence of the final size distributions on the properties of the aggregates as well as of the flow.

DY 13.2 Tue 10:45 ZEU 118

Travelling wave solutions for multiphase flow in porous media — •Oliver Hönig[1] and Rudolf Hilfer[1,2] — [1]Institut für Computerphysik, Universität Stuttgart, 70569 Stuttgart, Deutschland — [2]Institut für Physik, Universität Mainz, 55099 Mainz, Deutschland

We study travelling wave solutions of multiphase flow in one-dimensional porous media on a macroscopic scale. Therefore, fractional flow formulations with coupled flow functions and capillary diffusion are employed to formulate a dynamical system. This system is discussed with analytical and numerical methods.

DY 13.3 Tue 11:00 ZEU 118

Generation and quantitative analysis of thickness modulations on micron sized liquid sheets — •Paul Steffen and Stephan Herminghaus — MPI for Dynamics and Self-Organization, Göttingen

The destabilization of liquids and liquid sheets by surface deformations is a major mechanism for the production of micron sized droplets. We investigate periodic thickness modulations on moving liquid sheets of different viscosities, at thicknesses below 100 microns and surrounded by air. The excitation of the thickness modulations is obtained by piezo driven velocity oscillations at the outlet of an annular nozzle. The analysis of the modulations is performed by direct observation of the liquid/air-interface and by employing the diffraction effects of the sheet on a transmitted laser beam. Quantitative measurements of the amplitude and wave length of the thickness modulations as a function of the frequency and strength of the excitation are presented. For thickness modulation depths up to 30% of the sheet thickness we mainly excite thickness oscillations and interference between the resulting capillary waves. The modulation wave length is as expected. For larger amplitudes up to the break up of the sheet we observed lateral structures as well. Their interpretation is still under investigation.

DY 13.4 Tue 11:15 ZEU 118

Nematic electroconvection under time-reversed excitation — •Dirk Pietschmann, Thomas John, and Ralf Stannarius — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

We investigate experimentally nematic electrohydrodynamic convection (EHC) as a paradigm for a dissipative pattern formation system. We construct periodical waveforms which are reversed in time (forward and backward) to the same control parameter amplitudes. The standard model of EHC is described by a set of two linear differential equations (Carr-Helfrich mechanism). Because of additional symmetries in the equations, EHC belongs to the special class of dynamical systems, in which no differences in the threshold voltages for forward and backward excitation are expected. But our experimental investigations shows in certain parameter regions different threshold voltages for forward and backward excitations. This can not be explained with the standard model for electrohydrodynamic convection. Traveling rolls and localized structures (worms) are observed in the transition regime between the thresholds.

D. Pietschmann, Th. John and R. Stannarius, Phys. Rev. E 82, 046215 (2010).

DY 13.5 Tue 11:30 ZEU 118

Artificial Microfluidic Squirmers — •Shashi Thutupalli[1], Ralf Seemann[1,2], and Stephan Herminghaus[1] — [1]MPI for Dynamics and Self-organisation, Göttingen — [2]Physik Fakultät, University des Saarlandes, Saarbrücken

While there is a growing consensus on the propulsion mechanisms of swimmers at low Reynolds' numbers, many questions remain open regarding the hydrodynamic effects on such swimmers, in particular the coupling between swimmers. Here we present experiments on artificial swimmers, where hydrodynamics is seen to be responsible for a wide range of collective behavior and interactions. Using droplet microfluidics with a surfactant laden continuous oil phase, we create monodisperse aqueous droplets containing chemicals that produce a steady source of Bromine ions. The surfactant (mono-olein) reacts at the droplet interface with the Bromine produced within the droplets, and a dynamic instability leads to gradients of interfacial tension at the droplet interface. These gradients set up Marangoni flows propelling the droplets, in a manner similar to the classical squirmer model of swimming. The flow around the swimmers as well as its effect on the droplet motion are measured using particle image velocimetry (PIV). The PIV analysis reveals the far field flows generated by the swimmers in the surrounding liquid, leading to the emergence of bound states and oriented clusters. We discuss the interaction mechanisms and compare it to previous theoretical work and simulations.

DY 13.6 Tue 11:45 ZEU 118

Numerical study of inertial microfluidics using stochastic rotation dynamics — •Michael Gierlak and Holger Stark — Technische Universität Berlin

The method of stochastic rotation dynamics is an efficient solver for the Navier-Stokes equations which captures hydrodynamic interactions between objects suspended in a viscous fluid as well as thermal fluctuations. It is therefore particularly suited to study microfluidic systems. Recently, inertial microfluidics has been established where colloidal suspensions at non-zero Reynolds number are studied with applications for particle sorting and filtering [1].

We present numerical results for colloid flow through a cylindrical microchannel at moderate Reynolds numbers (1-90), where inertial effects become important. In this range, inertial focusing is observed, where a uniform colloid concentration turns into an annular concentration profile with a peak situated between the channel axis and wall[2].

We investigate the formation of these concentration profiles as a function of flow velocity and colloid size. Due to this inertial focusing, colloids migrate away from the channel axis. Using feedback control with external fields, we try to revert this effect and stabilize the colloids near the channel center.

[1] D. Di Carlo, J. F. Edd, K. J. Humphry, H. A. Stone, and M. Toner, Particle segregation and dynamics in confined flows, Phys. Rev. Lett. 102, 094503 (2009)

[2] Segre G, Silberberg A, Nature 189:209*210.(1962)

DY 13.7 Tue 12:00 ZEU 118

Magnetic spatial forcing of a ferrofluid layer — •Thomas Friedrich, Ingo Rehberg, and Reinhard Richter — Experimentalphysik 5, Universität Bayreuth

Historically, spatial forcing of a pattern forming system was first studied experimentally in electroconvection [1]. More recently, inclined layer convection was measured under the influence of lamellar surface corrugations [2]. In both cases, stripes are the first convection pattern beyond a threshold.

The Rosensweig instability in a layer of ferrofluid can provide a primary instability to hexagons if a homogeneous magnetic field normal to the flat surface is applied [3,4]. In case of a tilted magnetic field, a primary instability to stripes can be observed [5]. As a consequence, switching between these two basic types is possible in one single system. We explore how both configurations respond to a stripe like modulation of the magnetic induction. To detect the fluid's response to the different configurations of magnetic fields, x-ray imaging technique [6] is used.

[1]M. Lowe et al, Phys. Rev. Lett., **51**(9):786–789, 1983
[2]G. Seiden et al, Phys. Rev. Lett., **101**(21):214503, 2008.
[3]M. D. Cowley and R. E. Rosensweig, J. Fluid Mech.,**30**:671, 1967.
[4]R. Richter, Physik Journal, **7**:39–44, 2008.
[5]B. Reimann et al, Phys. Rev. E, **71**:055202(R), 2005.
[6]R. Richter, J. Bläsing, Rev. Sci. Instrum. **72**:1729-1733 (2001)

DY 13.8 Tue 12:15 ZEU 118

Measuring the onset of the Rayleigh-Taylor instability in a rotating magnetic field — •Andreas Pöhlmann, Ingo Rehberg, and Reinhard Richter — Experimentalphyisk V, Universität Bayreuth, Germany

If a dense fluid is supported by a less dense fluid, the flat interface separating them is subject to the Rayleigh-Taylor instability. The interface tension between the fluids suppresses the growth of all unstable modes with wavenumbers greater than the critical wavenumber. This gives rise to a maximum experimental interface diameter (size of boundary) at which the flat interface is stable.

In the case of one of the fluids being magnetic, an azimuthally rotating magnetic field can be used to stabilize modes with wavenumbers smaller than the critical wavenumber [1]. This allows for the preparation of the flat interface with greater interface diameters. When switching off the field, all unstable modes, which are not suppressed by the size limitation of the experiment, start to grow. Consequently, a precise study of the Rayleigh-Taylor instability should be possible.

In our experiment a magnetic fluid is covered by a more dense transparent one. The flat interface is stabilized by a rotating magnetic field. The interface size is restricted to a circular shape. For different diameters the field strength is lowered to a threshold level, so that the stability boundaries can be observed. They are compared with the predictions of Ref.[1].

[1] D. Rannacher and A. Engel, Phys. Rev. E, **75**, 016311 (2007).

DY 13.9 Tue 12:30 ZEU 118

Magnetization model for magnetorheological fluids — •Hanna Lagger, Joël Peguiron, Claas Bierwisch, and Michael Moseler — Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany

Typical magneto-rheological fluids (MRF) consist of micron-sized magnetically permeable particles (mostly iron) dispersed in carrier oil. MRF are increasingly being considered in variety of devices such as dampers, vibration insulators, brakes or clutches. The activation of an external magnetic field causes a fast and dramatic change in the viscosity of the MRF. Chains of magnetized particles are formed within a few milliseconds. The flow properties of the MRF change from liquid to solid.

A magneto-rheological clutch can be built by placing the MRF between the two inner surfaces of the clutch. In the solidified state of the MRF large torque transmission is possible, which makes it interesting for the application in automotive clutches.

In this study, numerical simulations based on the Discrete-Element-Method (DEM) are used to model magneto-rheological fluids.

To accurately treat the magnetic interaction between particles, an appropriate anhysteretic magnetization model for the particles is implemented. DEM-simulations of the MRF with different volume fractions are carried out and the resulting magnetization curves are compared with experimentally measured data. From simulations with different sets of parameters we get useful insights for the optimization of the MRF with regard to high torque transmission.