DY 25: Fluid dynamics II

Time: Thursday 14:45–16:30 Location: ZEU 118

DY 25.1 Thu 14:45 ZEU 118

Endwall effects on traveling waves in Taylor-Couette flow
— •Kerstin Hochstrate, Matti Heise, Jan Abshagen, and Gerd Pfister — Institute of Experimental and Applied Physics, Kiel, Germany

One of the classical hydrodynamic systems for the study of bifurcation events is the flow consisting of a viscous fluid confined in the gap between two concentric rotating cylinders. Because of the simplicity of this Taylor-Couette experiment the boundary conditions can be controlled and modified precisely. In an infinitely long system, often considered in theoretical investigations, the basic flow consists of a pure azimuthal shear flow which is invariant in the axial direction. In experimental realizations this invariance is broken, because of rigid endplates that confine the flow in the axial direction. At stationary endplates, which are often used, the velocity of the flow is zero. This changes the basic flow and leads to diverse finite-length effects.

Here we analyze experimentally the influence of rotating endplates on the basic flow and on spiral vortex flow. Spirals appear as primary instability for counter-rotating cylinders and travel in the axial direction in the infinite system. In particular, we focus on the interaction of spirals and boundary-driven vortices leading to spatial defects, which are not present in the infinite system. By rotating the endplates these defects can be eliminated and, moreover, the symmetries and the bifurcation behavior of the spirals are influenced.

DY 25.2 Thu 15:00 ZEU 118

Energetic consideration of the reflection of water jets on superhydrophobic surfaces
— •Sören Kaps[1], Michael Scharnberg[2] und Rainer Adelung[1] — [1]Functional Nanomaterials, Technical Faculty, University of Kiel, Kaiserstr. 2, 24143 Kiel, Germany — [2]Chair for Multicomponent Materials, Technical Faculty, University of Kiel, Kaiserstr. 2, 24143 Kiel, Germany

After impinging onto biological and artificial superhydrophobic surfaces water jets are observed to flow across the surface for a distance equal to several jet diameters before they are reflected off the surface as coherent jets under an angle that is close to or smaller than the angle of incidence. To understand the mechanisms of water jet reflection the conversion of surface energy to kinetic energy and vice versa is considered. A simple model based on these energetic considerations was derived to fit the experimental data. The geometry of the water surface is a critical parameter in this model. Different approaches to this geometry will be discussed.

DY 25.3 Thu 15:15 ZEU 118

A phase field model for coalescence of droplets with miscible liquids
— •Rodica Borcia and Michael Bestehorn — Lehrstuhl Statistische Physik/ Nichtlineare Dynamik, Brandenburgische Technische Universität Cottbus, Deutschland

We investigate the dynamics of interfaces between droplets of miscible liquids using a phase field model. This application is motivated by recent experimental observations showing that sessile droplets of completely miscible liquids do not instantaneously coalesce after peripheral contact if their contact angles are sufficiently small. Instead, after lateral contact, a microscopically thin liquid bridge connects the droplets and delays the droplet fusion. The droplets exchange liquids through this film, but they remain separated. Only after some time (up to minutes) the droplets finally merge into a single droplet and the fluid comes to rest [1]. The coalescence dynamics is obviously influenced by surface forces (Marangoni effects) and depends on the contact angle. 2D computer simulations are performed in order to understand the mixing behavior of different liquids for low and high contact angles at the solid substrate.

[1] H. Riegler, P. Lazar, Langmuir Vol. 24 (2008) 6395-6398.

DY 25.4 Thu 15:30 ZEU 118

On the parametric resonances of layered immiscible fluids
— •Bernhard Heislbetz — DLR Lampoldshausen, Institut für Raumfahrtantriebe, D-74239 Hardthausen, Germany

As a generalization of the well known Faraday-Instability of a free fluid surface, we theoretically investigate the parametric resonances of stratified immiscible fluid layers under the action of an external time periodic excitation.

Considering the full viscous hydrodynamic system, we show that the dynamics of the interface between two layers of viscous fluids can be reduced to an equation of the Mathieu-type, including several temporal non-local memory integrals. Due to analytical approximations and numerical calculations we characterize the the stability behaviour of a parametrically excited interface between two fluid layers of arbitrary viscosity.

Furthermore we discuss the stability problem for the interfaces of a three-layer configuration. Within the framework of ideal fluids the temporal evolution of the interface deformations are governed by coupled Mathieu differential equations. Including fluids viscosity, we show that the interfacial dynamics is determined by a set of coupled integro-differential equations. Resonant instability domains associated to the stability of subharmonic and harmonic solutions of the problem were calculated using Floquet Theory. The characteristics of the obtained stability zones were explained by means of a multiple-time scale analysis.

DY 25.5 Thu 15:45 ZEU 118

Dynamically Adaptive Coordinate System for Binary Mixture Thin Films
— •Ion Dan Borcia and Michael Bestehorn — Lehrstuhl für Theoretische Physik II, Brandenburgische Technische Universität, Cottbus, Germany

A binary mixture with deformable upper surface is numerically studied. Other numerical methods for hydrodynamics involving time-depending boundaries imply the calculation of the integration grid using spline algorithms (boundary-fitted coordinate solving method [1]). In our case the thin film equation [2] gives directly the integration grid for the 3D concentration equation. Linear and non-linear results using this method are presented.

[1] J.F. Thompson et al., J. Comput. Phys. 47, 1 (1982)
[2] A. Oron et al., Rev. Mod. Phys. 69, 931 (1997)

DY 25.6 Thu 16:00 ZEU 118

Development of a hybrid simulation approach for microfluidics
— •Martin Hecht, Jens Harting, and Calin Dan — Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany

We have developed a hybrid molecular dynamics (MD) and lattice Boltzmann (LB) simulation method to simulate fluid flow for applications in microfluidics. MD is capable to take detailed interactions between a fluid and a solid surface into account. However, the time and length scales relevant for experimental setups are far above those reachable by MD simulations. Therefore, several mesoscopic simulation methods (LB, DPD, MPC. . .) have been developed, which can deal with larger system sizes and larger simulation times. They use a coarse grained description in which molecular details cannot be captured. In many cases it is unclear how interactions with the surrounding solid walls can be mapped to the coarse grained description. Therefore, we compare rheological data from MD simulations with data obtained in LB simulations and calibrate the interactions in the coarse grained (LB) description. Moreover, for cases in which such a coarse graining can not be applied close to the wall, we develop a hybrid simulation method which couples an MD region close to the wall with a LB region in the bulk. The interactions with the wall are treated in full molecular detail in the MD simulation whereas the fluid flow in the bulk is described on the coarse grained level of the LB simulation. Thus, the computational effort for the bulk can be reduced considerably while maintaining the full details of the fluid-wall interactions.

DY 25.7 Thu 16:15 ZEU 118

stochastic modeling of wetting effects in fluid displacement in porous media
— Rafael Rangel and •Sergio Rojas — Physics Department, Universidad Simón Bolívar, Valle de Sartenejas, Edo. Miranda, Venezuela

The displacement of a viscous fluid by another that preferentially wets a porous medium is modeled with the aim to simulate a cooperative invasion processes that has been found in experiments of immiscible wetting displacement. In our model we consider the *non-local* effects of the Laplacian pressure field and the capillary forces. This is achieved with Diffusion Limited Aggregation **DLA**-type Montecarlo computations that simulate both the hydrodynamic equations in the Darcy regime with a boundary condition for the pressure at the interface. The boundary condition contains two different types of disorder: the capillary term which constitutes an additive random disorder, and a term containing an effective random surface tension which couples to a curvature (it constitutes a multiplicative random term that carries non-local information of the whole pressure). We claim that this multiplicative random disorder together with the non-local coupling causes a short range scaling regime that reveals itself in a roughness exponent $\alpha \approx 0.80$. Additionally, we find a **DLA**-type scaling regime with a roughness exponent $\alpha \approx 0.60$ at the largest scales. These types of scaling was found by Geromichalos, Mugele and Herminghaus [Phys.Rev.lett.**89**,104503(2002)]. At intermediate scales, a regime with $\alpha \approx 0.70$ has been found that has similarities with to Invasion Percolation with Trapping.