MUFLOW12

Participant	Title	Abstract
Alexander Alexeev	Cross-stream migration of particles in channel flow	At small but non-zero Reynolds numbers, solid particles migrate and accumulate at an off-center position in a pressure-driven channel flow. This cross-stream particle migration is associated with the inertial, non-linear terms of the Navier-Stokes equations. We use three-dimensional computer simulations to probe the effects of particle elasticity and shape on the inertial migration in microfluidic channels. Our simulations reveal that both these parameters affect the equilibrium trajectories of particles, thereby allowing separation of particles upon compliance and shape. Thus, our results are useful for designing microfluidic devices for high-throughput separation of synthetic and biological particles, such as microcapsules, cells, and bacteria.
Andrew Archer	Using dynamical density functional theory to study solidification, dewetting and other phenomena in colloidal suspensions	Over the last few years, a number of dynamical density functional theories (DDFT) have been developed for describing the dynamics of the one-body density of both colloidal and atomic fluids. The DDFT is capable of describing the dynamics of the fluid down to the scale of the individual particles. DDFT is particularly successful for colloidal fluids, for which one may assume that the particles have stochastic equations of motion and from the resulting Fokker-Plank equation one is able to derive the DDFT. I will give an overview of the DDFT and show applications to various inhomogeneous fluid dynamical phenomena such as the evaporative dewetting of nanoparticle suspensions, which exhibit pattern formation and the description of solidification fronts in supercooled (colloidal) suspensions. The latter connects to the so called "phase-field crystal" models.
Michael Bestehorn	Non-variational surface patterns of thin liquid films	
Kurt Binder	Modeling transport in confined colloidal crystals in equilibrium and under compression and shear deformation	Langevin Dynamics simulations are used to study a model for a two-dimensional colloidal crystal confined by corrugated parallel walls. Both the case when a perfect triangular lattice structure with n = 30 rows parallel to the walls fit into the crystalline strip is considered, and the case when by compression a mismatch is created. This may lead (at constant particle number) to a transition from n to n - 1 rows, accompanied by the formation of a soliton staircase pattern along the corrugated walls and a jumpwise decrease in the stress {1,2,3,4}. It is found that already in equilibrium at temperatures far below melting diffusion of the particles occurs. In addition to the standard vacancy interstitial mechanism also cooperative rotation of ``rings'' of 3 or 6 particles is found to occur. In the case of compressed crystals with soliton patterns the motion of solitons creates additional mobility . When the corrugated walls are moved with a velocity v_ in opposite directions, a nonlinear velocity profile v(y) is created across the stripe. For small shear several rows along the walls are melted, while the central part of the stripe breaks up into large crystalline clusters, with somewhat misoriented lattice directions, slowly rearranging themselves and thus creating mobility in the flow direction. The temperature still stays essentially constant in the stripe. However, for strong shear the temperature gets enhanced near the walls, but only very few rows get disordered and mobile . Y.-H. Chui, S. Sengupta, and K. Binder, EPL \textbf, 58004 (2008) Y.-H. Chui, S. Sengupta, I. K. Snook and K. Binder, Phys. Rev. E\textbf, 020403 (R) (2010) Y.-H. Chui, S. Sengupta, I. K. Snook and K. Binder, J. Chem. Phys. \textbf, 074701 (2010) D. Wilms. N. B. Wilding, and K. Binder, Phys. Rev. E\textbf, 056703 (2012) D. Wilms, I. K. Snook, P. Virnau, and K. Binder, preprint. D. Wilms, P. Virnau, S. Sengupta, and K. Binder, preprint.
Tomas Bohr	Spontaneous Symmetry Breaking on Fluid Surfaces	Spontaneous symmetry breaking plays a major role in almost all branches of physics. Free surface flows are easy to excite and strongly nonlinear and thus provide spectacular examples. We shall discuss the breaking of axial symmetry in two examples: (1) the circular hydraulic jump on a plane, smooth horisontal surface and (2) the "rotating polygons" formed in strongly swirling free surface flows. In both cases "corners" are spontaneously generated which leads to polygon-like states, but since the Reynolds numbers differ by around two orders of magnitude, the mechanism of instability is very different.
Vasilis Bontozoglou	Periodic spatial forcing of inclined liquid film flow	Substitution of the flat substrate of classical film flow by one with specifically tailored topography is potentially a simple and efficient means of controlling the characteristics of the flow. Presently, the effect of periodic corrugations is examined, mainly experimentally, but also computationally and asymptotically. Results concern the steady flow, the primary instability and the post-threshold behaviour. Resonance between the wall forcing and capillary-gravity waves travelling against the flow results in strong periodic deformation of the free surface, which persists in a pseudo-steady fashion in the unstable regime. The primary, long-wave instability is postponed to significantly higher Re, and at intermediate-to-high inclinations is preceded by a short-wave, global mode. The exact shape of the wall corrugations affects the inclination at which the new mode appears and its wavelength at inception. Beyond the primary threshold, the wall topography appears to render the free surface dynamics more regular and persistently two-dimensional. Energy transfer from long to shorter scales is conjectured responsible both for the delay in the primary instability and for the regularization of the post-threshold dynamics.
Lorenzo Botto	Micromechanics of rod-like colloidal particles at fluid interfaces	Anisotropic microparticles of non-spherical shape, adsorbed at fluid-fluid interfaces, induce significant interface distortions that result in strong lateral capillary interactions. In this talk, I will report on experimental and numerical work, carried out in the group of Prof. K. J. Stebe at University of Pennsylvania, on the pair capillary interaction between rod-like microparticles. It will be shown that cylinders and ellipsoids, in spite of their similar shape, induce remarkably different near-field capillary interactions. This feature result from the strong dependence of the interface distortion on geometric details, and the presence, in the case of cylinders, of sharp edges that constrain the trajectory of two neighboring particles in contact. These results have implications for the micromechanics of chains composed by many particles. While chains of ellipsoids behave as elastic elements, chains of cylinders have a complex mechanical response characterized by a yield stress torque. These results represent a step towards understanding the rheological response of two-dimensional interfacial colloidal gels that form owing to capillary interaction.
Christophe Clanet	Inertial cavities	
Pierre Colinet	Regularization of contact line singularities by phase change	
Linda Cummings	New models and simulations for flows of nematic liquid crystal	
Frédéric Doumenc	Self-patterned deposit in dip-coating experiments	
Andre Galuschko	Molecular dynamics simulation of nano-droplets at and far from equilibrium	While the application of microfluidic devices grows, e.g. lab-on-chip, nano printing, etc., the understanding of the behavior of fluids on small scales like microflows and microdroplets is incomplete. Molecular dynamics simulation (MD) is a useful tool to study properties of liquids in contact with solid substrates. We employ a coarse-grained Lennard-Jones model with the DPD-thermostat to mimic the correct hydrodynamic properties. The obtained microscopic observables from MD are connected to macroscopic relevant observables (interface potentials, viscosity, slip length, evaporation rate), which are passed on to continuum theories, e.g. thin film equation and gradient dynamics formulation. I will present simulation results for thin films and droplets in and out of equilibrium. Three systems are considered: 1) thin film flows and droplets in contact with different surface topologies (work of Nikita Tretyakov) 2) stationary rolling droplets on reactive substrates (work of Murat Mülayim) 3) evaporation of simple and binary fluid droplets (work of Andre Galuschko)
Mariano Galvagno	Transitions from precursor films to Landau-Levich films: Dragging out a plate from a bath	In several types of coating processes a solid substrate is removed at a controlled velocity U from a liquid bath. The shape of the liquid meniscus and the thickness of the coating layer depend on U . These dependencies have to be understood in detail for non-volatile liquids to control the deposition of such a liquid and to lay the basis for the control in more complicated cases (volatile pure liquid, solution with volatile solvent). We study the case of non-volatile liquids employing a precursor film model that describes partial wettability with a Derjaguin (or disjoining) pressure. In particular, we focus on the relation of the deposition of (i) an ultrathin precursor film at small velocities and (ii) a macroscopic film of thickness h U2/3 (corresponding to the classical Landau- Levich film). Depending on the plate inclination, four regimes are found for the change from case (i) to (ii). The different regimes and the transitions between them are analysed employing numerical continuation of steady states and saddle-node bifurcations and simulations in time. We discuss the relation of our results to results obtained with a slip model.

Hanneke Gelderblom — Stokes flow near the contact line of an evaporating drop

The evaporative flux from a sessile drop with a contact angle below 90 degrees diverges in the vicinity of the contact line. Therefore, the description of the flow inside an evaporating drop has remained a challenge. Here, we resolve the nature of the flow near the contact line by analytically solving the Stokes flow field in a wedge geometry of arbitrary contact angle. We demonstrate that there are three contributions to the flow field: the evaporative flux from the drop surface, the downward motion of the liquid-air interface and the eigenmode solution which fulfils the homogeneous boundary conditions. Below a critical contact angle of 133.4 degrees, the evaporative flux solution will dominate, whereas for larger contact angles the eigenmode solution dominates. For contact angles above 127 degrees interesting flow structures appear: the flow separates into regions where it is reversing towards the drop centre.

Benjamin Goddard — Dynamical density functional theory with inertial and hydrodynamic interactions

We study the dynamics of a colloidal fluid including inertia and hydrodynamic interactions, two effects which strongly influence the non-equilibrium properties of the system. We derive a general dynamical density functional theory (DDFT) which shows very good agreement with full Langevin dynamics. In suitable limits, we recover existing DDFTs and a Navier-Stokes-like equation with additional non-local terms.

Elisabeth Guazzelli — The erosion of granular beds under the action of fluid shearing flows

The erosion of granular beds under the action of fluid shearing flows is a problem which has been continuously studied and discussed for over a century. This phenomenon is indeed encountered in a wide range of processes of important relevance in nature or industry such as sediment transport in rivers or oceans and slurry transport in the mining and petroleum industry.

We experimentally investigate the mobile layer of a granular bed composed of spherical particles in a pipe flow. We discuss two fundamental aspects: incipient motion of the bed and sediment transport by focusing on the determination of the particle flux. A two-phase continuum model having a frictional rheology to describe particle-particle interactions can capture most of the experimental observations. Rheological constitutive laws for the dense granular suspension are discussed.

This work has been done in collaboration with P. Aussillous, J. Chauchat, M. Medale, M. Ouriemi, M. Paihla, Y. Peysson

George Karapetsas — Dynamics of a surfactant-laden falling film

We investigate the dynamics of a thin film flowing down an inclined solid surface in the presence of soluble surfactants. Lubrication theory for the fluid motion, and advection-diffusion equations as well as chemical kinetic fluxes for the surfactant transport, lead to coupled evolution equations for the film thickness, interfacial concentrations of surfactant monomers and bulk concentrations of monomers. We solve numerically the evolution equations using the finite element method and we perform a full parametric study. The results of our simulations show that surfactants have a strong stabilizing effect on the flow due to the presence of Marangoni stresses. The wave patterns that arise differ significantly from the case of clean fluids. It will be shown that the dominant structures, even at high Re numbers, are sinusoidal traveling waves in direct agreement with experimental observations.

Edgar Knobloch — Pinning, self-pinning and depinning

Michael H. Köpf — Pattern formation during monolayer transfer: Control and understanding

The coating of solid substrates with regularly patterned surfactant monolayers is exemplary for the purposeful utilization of self-organized pattern formation. The withdrawal of a solid plate from a water-lled trough covered with a monolayer of the phospholipid DPPC endues the solid with a highly regular pattern with periods down to a few hundred nanometers. This phenomenon results from phase decomposition in the monolayer triggered by an interaction with the substrate at the contact line. It can be understood in terms of a model describing a receding contact line of a surfactant covered liquid lm in the vicinity of a monolayer phase transition [1, 2].
On the basis of this model, we discuss possibilities to control the properties of the transferred patterns. Chemically prepatterned substrates can be applied to yield structures of higher complexity, resulting from synchronization between the natural frequency of the system and a perturbation due to a periodic prestructure [3]. Furthermore, the patterns can be tuned by adjusting the water temperature as has been found in a combined theoretical and experimental study [4].
The bifurcations resulting in the pattern formation are analyzed by use of an amended Cahn-Hilliard equation [5]. By combination of numerical simulations and continuation methods, we nd that the onset of spatiotemporal pattern formation results from a homoclinic and a Hopf bifurcation at small and large substrate speeds, respectively. In the regime of low transfer velocities, the stationary solutions exhibit snaking behavior.

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Marie Le Merrer — Bubble dynamics in wet foams

Liquid foams are jammed suspensions of gas bubbles in a surfactant solution.
Describing the rheology of these complex fluids, which is crucial in many applications, requires to understand dissipation mechanisms that occur at microscopic scales, at the bubble or film level.

We study two examples of bubble dynamics in wet foams, close to the jamming point.

Bubble rearrangements in coarsening foams are investigated with a multiple light scattering probe. Their dynamics appear very dependent on interfacial rigidity (tuned by surfactant physico-chemistry) and confinement pressure, i.e. distance to jamming.

We also study how bubble layers slide along an inclined plane, providing insight on the mechanisms of wall slip for foams in the wet limit.

(Collaborators: R. Lespiat, S. Cohen-Addad, R. Höhler)

Te-Sheng Lin — Instabilities in thin hanging films

We study instabilities of Newtonian films within the framework of lubrication approximation. It is found that, under destabilizing gravitational force, a contact line, modeled by a commonly used precursor film model, leads to free surface instabilities without any additional natural or excited perturbation. In addition, there is also a coupling between the surface instabilities and the transverse (fingering) instabilities, lead to complex behaviors.

John Lister — Viscous currents spreading under an elastic lid

In lubrication theory, viscous gravity currents are controlled by the interior dynamics and the contact line is not a problem. By contrast, capillary-driven flows require a slip model or prewetting film to resolve the contact-line problem, though the influence of this model is weak. In this talk, I show that the contact-line problem for flow beneath an elastically deformable boundary is yet more acute and requires matched asymptotic solutions over a hierarchy of nested length and time scales.

This point is illustrated theoretically and experimentally by the injection and spread of viscous fluid beneath a flexible elastic lid with a prewetting film. The experimental measurements of surface elevation and radial propagation are in good agreement with lubrication calculations incorporating bending stresses and gravity. Remarkably, even this simple system evolves through four asymptotic regimes with successive radial spreading laws $r\sim t^{1/6}, t^{7/22}, t^{7/12}$ and $t^{1/2}$. Alternate problems without the prewetting film yields yet more exotic scalings. The analysis of wet and dry elastic peeling processes in these relatively simple problems gives insight for applications to more complex multiscale interfacial deformation problems such as cell adhesion, delamination, and the dynamics of MEMS.

Hender Lopez — Homogeneous and patterned deposition from a meniscus of an evaporating suspension onto a moving substrate

A dynamical model is used to study the deposition process observed when an inclined plate is drawn from a bath of a volatile solution or suspension. Based on the gradient dynamics formulation proposed by Thiele [Eur. Phys. J. Special Topics, 197 213 (2011)] we derived two coupled equations that describe the film height profile and mean solute concentration. These equations were solved numerically for a large parameter set and the effect of the plate velocity, U, was studied systematically.
Our model captures the two main regimens that have been observed in a wide range of experimental setups): at low U, the deposit thickness decreases with U (evaporative regime), and at high U, the deposit thickness increases with U (Landau-Levich regime). An important feature is that for a range of U in the evaporative regime we observe a stick-slip motion of the contact line that is related to the formation of regular lines deposits. This phenomenon is frequently reported in experiments, but often not covered by previous models.

Alvaro Marin — Hydrodynamic particle-particle interactions in confined shear flow

Multiphase flows in micro-confined geometries are non-trivial problems: drops and particles introduce a high degree of complexity into the otherwise linear Stokes flows. The presence of drops or particles introduces alterations in the pressure distribution and on the evolving boundary conditions opening the door to nonlinearity into the system.

		In this work we show an abnormal velocity distribution in confined shear-flows and non-homogeneous particle distribution. Although the results are preliminary, we identify such phenomena as the outcome of hydrodynamic particle-particle interactions, as recently suggested in simulations and models by different authors (Zurita et al. PRL 2012).
Klaus Morawetz	Theory of water bridges - catenary exposed to forces	The phenomena of liquid bridge formation due to an applied electric field is investigated. A new solution of a charged catenary is presented which allows to determine the static and dynamical stability conditions where charged liquid bridges are possible. The creeping height, the bridge radius and length as well as the shape of the bridge is calculated showing an asymmetric profile in agreement with observations. The flow profile is calculated from the Navier Stokes equation leading to a mean velocity which combines charge transport with neutral mass flow and which describes recent experiments on water bridges.
Roland Netz	Water at Interfaces: Wetting, slip and friction effects	The structural and dynamic properties of the interfacial water layer close to surfaces are relevant for many physico-chemical processes. Insight can be gained from all-atomistic simulations of water that nowadays reach the experimentally relevant length and time scales. This is demonstrated with a few examples: i) Hydrophobic (water-repelling) surfaces in contact with water show a pronounced depletion layer with a thickness of a few Angstroms within which the water density is highly reduced. This layer leads to unusual static and kinetic properties including a finite slip length, which means that water flows with much reduced friction over such surfaces. ii) On surfaces, the friction coefficient of bound peptides is very low on hydrophobic substrates, which is traced back to the presence of a depletion layer between substrate and water that forms a lubrication layer. Conversely, friction forces on hydrophilic substrates are large. A general friction law is presented and describes the dynamics of hydrogen-bonded matter in the viscous limit.
Jan Martin Nordbotten	Multiscale simulation of flows in porous media	Flows in porous media express complex structures emerging from the interaction between non-linear constitutive laws and the strong underlying heterogeneous parameters characterizing the medium. In this talk we focus on the simulation of these flow fields, and the systematic exploitation of coupling between detailed simulations and coarse-level mean-field simulations.
Alex Oron	Stability of a Liquid Film on a Forced Fiber	
Stéphane Perrard	Walking in central force field	A drop bouncing on a oil bath can live for few hours. It has been shown that such droplet can walk, propelled by the waves that has been emmitted in the past. It exhibits a form of wave particle duality, and surprising phenomenon as single particle diffaction, quantification of level or tunneling effect has been observed. We have now developped a new technic to exert force on that drops. We will present our new results on this configuration. We are able to obtain both statistical behaviour for one trajectory, with some property of quantification. A link with the Shrödinger equation will be also done.
Marc Pradas	Additive noise effects in active non-linear spatially extended systems	External or internal random fluctuations are ubiquitous in many physical systems and can play a key role in their dynamics often inducing a wide variety of complex spatio-temporal phenomena, including noise-induced spatial patterns and noise-induced phase transitions. Examples can be found in several fields: from biology, climate modelling and technological applications to fluid dynamics and granular media. Many of these phenomena and applications can be modelled by noisy spatially extended systems (SES), i.e. infinite dimensional dynamical systems described through stochastic partial differential equations. Clearly, characterising the influence of noise on SES is crucial for the understanding of both the inception and long-time complex behaviour of physical systems, as well as for the control and optimisation of technological processes. Here we study the effects of pure additive noise on SES with quadratic non-linearities that are close to the primary bifurcation ("instability onset"). We consider a degenerate noise, in the sense that noise is acting on the subspace of stable modes only. By means of a multiple scale analysis for general noisy SES, which also requires the use of a singular perturbation methodology, we obtain an amplitude equation for the dominant mode from which we analytically investigate the noise effects on the dominant dynamics of the system. We observe that several non-trivial scenarios are possible depending on the stable modes the noise is acting on, including noise-induced critical transitions, intermittency and stabilisation when the noise is acting on the first stable mode only; or a noise filtering process, i.e. the dominant mode is not affected at all by the stochastic forcing when it is acting on the second stable mode. Our analytical findings are exemplified with a model SES, the noisy Kuramoto-Sivashinsky equation which describes, amongst many other different physical settings, the dynamics of a thin-liquid film flowing over a topographical substrate. In all cases, very good agreement between the theoretical predictions and numerical experiments is observed.
Suzie Protiere	drops on flexible rails	Fibrous media are ubiquitous functional materials, which often consist of flexible high aspect ratio fibers that can easily deform under capillary forces with many industrial and ecological consequences. We study the influence of a mist of droplets on an elastic array of fibers by considering a finite volume drop on a pair of two flexible fibers, clamped at one end and free to deflect at the other. The elastocapillary deformation of the fibers leads to the spontaneous motion of the drop toward the free ends. The drop either remains compact with minimal spreading or spreads into a long liquid column that coalesces the fibers. We find that there is a critical volume of liquid, hence a critical drop size, above which this coalescence does not occur, and we identify another drop size which maximizes spreading, thus liquid capture. Experimental results and mathematical models will be presented and compared. These ideas are applicable to a wide range of fibrous materials, as we illustrate with quantitative examples for feathers, beetle tarsi, sprays and microfabricated systems. work in collaboration with C. Duprat, A. Y. Beebe and H. A. Stone (Princeton University, USA)
Markus Rauscher	Nanofluidics: Dynamics of thin films and nano-droplets	Fluids on the nanoscale behave qualitatively different from macroscopic systems. This becomes particularly evident if a free liquid-liquid or liquid-vapor interface is close to a solid surface such as in the case of nanodrops or ultrathin films. Hydrodynamic slip, thermal fluctuations, the molecular structure of the fluid, and the range of the intermolecular interactions are important for the structure and the dynamics of such open nanofluidic systems. Here we focus on a top-down approache to the theoretical description of fluids on the nanoscale: mesoscopically augmented hydrodynamic equations. We discuss their application to the dynamics of dewetting on homogeneous substrates as well as on the dynamics of nanpdroplets and rivulets on topographically or chemically structured substrates.
Hans Riegler	Non-coalescence of sessile drops from different but miscible liquids: Experimental results and hydrodynamic analysis	Capillarity always favors drop fusion. Nevertheless sessile drops from different but completely miscible liquids often do not fuse instantaneously upon contact. Rather, intermediate non-coalescence is observed. Two separate drop bodies, connected by a thin liquid neck move over the substrate. Supported by experimental data a thin film hydrodynamic analysis of this state is presented. Presumably advective and diffusive volume fluxes in the neck region establish a localized and temporarily stable surface tension gradient. This induces a local surface (Marangoni) flow that stabilizes a traveling wave i.e., the observed moving twin drop configuration. The theoretical predictions are in excellent agreement with the experimental findings. H. Riegler and P. Lazar, Langmuir 2008, 24, 6395-6398 S.Karpitschka and H. Riegler, Langmuir 2010, 26, 11823-11829 S.Karpitschka and H. Riegler, Phys. Rev. Lett. 2012, in print
Ramon Rubio	Dynamics of particles trapped at fluid interfaces	Particle laden fluid interfaces are important for many technological processes: emulsion and foam stabilization, flotation, etc. In these cases both the structure, i.e. the phase diagram, and the dynamics of the particles (shear and dilational elastic moduli) are important. The dynamics of particles trapped at interfaces has received less attention than the study of their interactions and the phase diagram. It is well known that microparticles are frequently trapped at fluid interfaces almost irreversibly, thus we will focus only on the dynamics in the plane of the interface. The interaction potential between charged microparticles at water/oil interfaces is remarkably long-ranged, therefore, even for relatively low particle densities, the dynamics shows a clear sub-diffusive behavior. We will discuss the time dependence of the mean square displacement, MSD, of latex microparticles measured with different experimental techniques, and the behavior of the diffusion coefficients calculated from the MSDs. We will also discuss the use of microparticles as probes for microrheological measurements on polymer and surfactant monolayers, with emphasis on the discrepancies found between the results obtained using microrheology and standard interfacial shear rheometers.
Nikos Savva	Contact line dynamics on heterogeneous substrates	We present a theoretical investigation of the three-dimensional contact line dynamics resulting from the motion of a viscous, partially wetting droplet over a horizontal and chemically heterogeneous substrate. The chemical nature of the substrate is incorporated through local variations in the microscopic contact angle, which appear as boundary conditions in

the governing equations. Assuming small contact angles and the presence of slip, we derive a long-wave model for the evolution of the droplet thickness, whereby inertial and gravitational effects are neglected. Analytical progress is made by considering perturbations from a circular contact line and asymptotically matching the flow in the two-dimensional boundary layer around the contact line with the flow in the bulk of the droplet. This matching procedure eventually leads to a set of differential equations for the Fourier coefficients of the contact line. Noteworthy is also that our analysis resolves the free-boundary problem without the a priori introduction of some Cox-Voinov-type relation between the apparent contact angle and the local contact line speed. The derived equations are solved for a number of representative substrate configurations.

Benoit Scheid

Role of surface rheology in antibubble dynamics

An antibubble is a spherical thin air shell that is immersed in a surfactant mixture and drains under the action of hydrostatic pressure. A lubrication model is proposed that accounts for dilatational and shear surface viscosities. It is demonstrated that for surfactants whose adsorption rate is much larger than convection rate, the interface is incompressible and only surface shear viscosity matters, while otherwise, i.e. for compressible interface, it is mainly the surface dilatational viscosity that plays a role, at least in a regime where elasticity (Marangoni) effects are negligible. Either way, numerical solutions show that the antibubble lifetime increases with the appropriate surface viscosity component in agreement with experimental observations.

Markus Schmuck

Physics, mathematics, and numerics of particle adsorption on fluid interfaces}

We study two arbitrary immiscible fluids where one phase contains small particles of the size of the interface and smaller. We primarily focus on charge-free particles with wetting characteristics described by the contact angle formed at the interface between the two phases and the particles. Based on the experimental observation that particles are adsorbed on the interface in order to reduce the interfacial energy and hence the surface tension as well, we formulate a free energy functional that accounts for these physical effects. Based on calculus of variations and formal gradient flow theory, we derive partial differential equations describing the location of the interface and the density of the particles in the fluid phases. Our numerical experiments analyze the time evolution of the surface tension, the particle concentration, and the free energy and reflect basic experimentally observed phenomena.

Ralf Seemann

Liquid morphologies and their manipulation in elastic grooved substrates

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If linear surface grooves are made from a rubber elastic material (poly-dimethylsiloxane (PDMS)) a plethora of various wetting morphologies can be found depending on groove geometry, wettability, and elasticity. The deformation of grooves is the more pronounced the softer the substrates and might even result in a lateral ordering of the appearing wetting morphologies across the groove provided the substrate contains several parallel grooves separated by thin elastic ridges. By changing the groove geometry by stretching and relaxing the elastic sample one can switch between different liquid morphologies. The thus induced flow of liquid along rubber elastic grooves is much slower than the flow in solid grooves of equal geometry and wettability. A study of dewetting fronts on planar visco-elastic and viscous surfaces reveals a characteristic deformation of the liquid/rubber and liquid/liquid interfaces and a flow field that penetrates deep into the liquid substrate.

David Sibley

Slip or not slip? An examination of the moving contact line.

The moving contact line problem occurs when one fluid replaces another as it moves along a solid surface, a situation arising in a vast range of applications. The apparent paradox of motion of the fluid-fluid interface yet static fluid velocity at the solid satisfying the no-slip boundary condition has been known for a number of decades, with a wealth of publications suggesting methods to resolve it since.

We consider a number of models proposed to alleviate the moving contact line problem through investigating their behaviour analytically as the contact line is approached. Of specific interest are the pressure and stress behaviours alongside the velocity field found, and whether a rolling-like behaviour is thus supported.

Jacco Snoeijer

Spreading and coalescence of drops on a substrate

We address two elementary features of wetting dynamics: spreading and drop coalescence. First we consider the very fast spreading that occurs immediately after a drop is brought into contact with a substrate. Our recent high-speed imaging experiments reveal the surprising effect of surface wettability and liquid viscosity on the initial spreading dynamics. Second, we address the coalescence of two drops on a substrate, just after they are brought into contact. We present similarity solutions for the first stage of coalescence, which are verified quantitatively by experiments. In particular we find that drops of unequal contact angles induces a horizontal coalescing motion, during which the drops move sideways over the substrate.

Desislava Todorova

Influence of solute--dependent wettability on films of mixtures and suspensions

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We discuss the behaviour of thin films of non-volatile liquid mixtures, colloidal suspensions and polymer solutions on a solid substrate. We use a gradient dynamics formulation based on an underlying free energy functional that allows us to establish coupled long-wave time evolution equations for the film height and mean solute concentration that reduce for a 'passive' solute to equations, well known in the literature [1, 2]. This form naturally incorporates additional effects [3]. In particular, we focus on a concentration-dependent wettability, derived with the help of homogenisation techniques to obtain effective optical characteristics [4]. Combining this with the classical theory of effective molecular interactions between the film surface and the substrate, we arrive at a Derjaguin (or disjoining) pressure that depends on film height and concentration.

We use the derived model to study the linear stability of flat homogeneous films. In particular, we investigate how the stability thresholds are influenced by the incorporation of the additional degree of freedom related to the concentration field. We also analyse nonlinear thickness and concentration profiles for steady droplets and relate them to the resulting binodal curves for the case of two coupled fields. Finally, we look at the time evolution of flat homogeneous films with solute and further discuss the dynamical effects of the coupled height and composition fluctuations.

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Yannis Tsoumpas

Pinning of a perfectly wetting volatile liquid at a sharp edge - experiment and theory

Axel Voigt

Surface viscosity - an often neglected but important property for interfacial phenomena

Multiphase flow systems are strongly influenced by transport processes along the lower dimensional fluidic interface. These processes include e.g. adsorption effects from the bulk phases and transport of species on the interface. Variable surface properties, such as surface tension, which can depend on these species, can strongly influence the bulk flow. However, one crucial aspect is neglected in most of these models: The interface by it's own can also have fluid like properties and the surface viscosity might even has a stronger influence on multiphase flow system in these cases. Examples can be found in cell membranes, particle-laden fluid interfaces and liquid crystal films. An other everyday example of such ‚lower dimensional' interfacial fluids will be familiar to those who can remember playing with soap bubbles and seeing the eye-catching movement on the surface, which clearly indicates fluid-like properties of the soap film. Theoretical investigations of these phenomena are very limited and date back to Scriven. The equations of motion are formulated intrinsically in a two-dimensional manifold with time-varying metric and make extensive use of the covariant derivative, and calculations in local coordinates, which involve the coefficients of the Riemannian connection and its derivatives. The complexity of the equations may explain why they are often written but never solved in the general case. Within a step by step approach we will consider various numerical aspects. We start with a Navier-Stokes equation on a curved surface. The equation differs from the planar case. Using a stream function formulation allows to rewrite it as a scalar partial differential equation on a surface for which we will derive a phase-field representation. We will analyse the interplay of surface flow, surface morphology and surface evolution in this case.

Stephen Wilson	Three-dimensional coating and rimming flow: a ring of fluid on a rotating horizontal cylinder	The steady three-dimensional flow of a thin, slowly varying ring of Newtonian fluid on either the outside or the inside of a uniformly rotating large horizontal cylinder is investigated. Specifically, we study "full-ring" solutions, corresponding to a ring of continuous, finite and non-zero thickness that extends all the way around the cylinder. In particular, it is found that, as for the analogous two-dimensional full-film flow described by Moffatt (1977), there is a critical solution corresponding to either a critical load above which no full-ring solution exists (if the rotation speed is prescribed) or a critical rotation speed below which no full-ring solution exists (if the load is prescribed). We describe the behaviour of the critical solution and, in particular, show that the critical flux, the critical load, the critical semi-width and the critical ring profile are all increasing functions of the rotation speed. We also show that the profile of the critical full-ring solution has a corner analogous to the corner in the critical two-dimensional full-film solution, but (unlike in the the two-dimensional case) that both its position and shape depend on the rotation speed. In the limit of small rotation speed, the critical flux is small and the critical ring is narrow and thin, leading to a small critical load. In the limit of large rotation speed, the critical flux is large and the critical ring is wide on the upper half of the cylinder and thick on the lower half of the cylinder, leading to a large critical load. We also describe the behaviour of the non-critical full-ring solution, and, in particular, show that the semi-width and the ring profile are increasing functions of the load but, in general, non-monotonic functions of the rotation speed. In the limit of large rotation speed, the ring approaches a limiting non-uniform shape, whereas in the limit of small load, the ring is narrow and thin with a uniform parabolic profile. Finally, we show that, while for most values of the rotation speed and the load the azimuthal velocity is in the same direction as the rotation of the cylinder, there is a region of parameter space close to the critical solution for sufficiently small rotation speed in which backflow occurs in a small region on the right-hand side of the cylinder.