DY 62: Complex Fluids and Soft Matter II (joint DY/CPP)

Time: Friday 9:30–12:30 Location: HÜL 186

Invited Talk DY 62.1 Fri 9:30 HÜL 186
Liquid Crystals in Microgravity — •Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg

Experiments under microgravity allow to study dynamic processes in thin freely suspended liquid films in air, as well as freely floating bubbles of smectic liquid crystals. These are representative for quasi-twodimensional liquids. Shape dynamics, film rupture, and mobility and interactions of inclusions in quasi-2D emulsions are topics of scientific interest in these unique fluid structures. Results from parabolic flights, a suborbital rocket flight, and an ISS experiment are presented.

DY 62.2 Fri 10:00 HÜL 186
Temporal evolution of free floating smectic bubbles — •Patricia Dähmlow, Torsten Trittel, Christoph Klopp, Kirsten Harth, and Ralf Stannarius — Otto-von-Guericke University Magdeburg, Germany

Freely floating smectic bubbles are investigated under microgravity conditions, which form a minimal surface, like soap bubbles, in equilibrium. A great advantage of freely floating bubbles is the absence of a meniscus, which acts as a reservoir of smectic material when the surface area of the film changes. In this work, the freely floating bubble must rearrange its internal layer structure without such a reservoir. Bubbles are produced by collapsing catenoids, resulting in an elongated shape after the rupture of the catenoids. With time the bubble shows complex oscillations, which includes the invagination of the film and thus, a temporary increase of the surface area until it relaxes to a sphere. Experiments are performed performed with optical highspeed imaging during parabolic flights.

DY 62.3 Fri 10:15 HÜL 186
Orientational order on surfaces - the coupling of topology, geometry and dynamics — •Axel Voigt, Michael Nestler, Ingo Nitschke, and Simon Praetorius — Institut für Wissenschaftliches Rechnen, TU Dresden, Germany

We consider the numerical investigation of surface bound orientational order using unit tangential vector fields by means of a gradient-flow equation of a weak surface Frank-Oseen energy. The energy is composed of intrinsic and extrinsic contributions, as well as a penalization term to enforce the unity of the vector field. Four different numerical discretizations, namely a discrete exterior calculus approach, a method based on vector spherical harmonics, a surface finite-element method, and an approach utilizing an implicit surface description, the diffuse interface method, are described and compared with each other for surfaces with Euler characteristic 2. We demonstrate the influence of geometric properties on realizations of the Poincare-Hopf theorem and show examples where the energy is decreased by introducing additional orientational defects.

DY 62.4 Fri 10:30 HÜL 186
Microrheology of rod-shaped particles in free standing liquid crystal films of the smectic phase — •Christoph Klopp, Alexey Eremin, and Ralf Stannarius — Institute of Experimental Physics, Otto-von-Guericke University Magdeburg, Germany

Flow phenomena in restricted geometries have been studied in a variety of different physical, chemical and biological systems in the last years. These studies investigate the motion of proteins in lipid membranes and the motion of submicrometer-sized inclusions on thin membranes. Organic liquid crystal materials are able to form very thin, stable free standing films of highly uniform structure and thickness, making them ideal systems for studies of hydrodynamics in two dimensions. We study the mobility of sphere and rod-shaped inclusions in freely-suspended liquid crystal films of the smectic A phase [1]. For the rod-shaped particles we analyze the rotational and translational mobility by measuring Brownian motion. We compare our results with the existing theory of Saffman and Delbrück [2] and analyze the effect of particle anisometry. Measurable effects appear when the length of the particles is comparable to or larger than the hydrodynamic size of the system (Saffman length) and we are able to confirm the theory of Levine et al. with our data [3].

[1] A. Eremin *et al.*, 2011. Pys. Rev. Lett. 107, 268301.
[2] Z. H. Nguyen *et al.*, 2010. Pys. Rev. Lett. 105, 268304.
[3] A. J. Levine *et al.*, 2004. Phys. Rev. Lett. 93, 038102.

DY 62.5 Fri 10:45 HÜL 186
Structure and rheology of suspensions controlled by capillary forces in thin liquid films — •Andrea Scagliarini[1] and Jens Harting[1,2] — [1]Forschungszentrum Jülich GmbH, Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (IEK-11), Nürnberg, Germany — [2]Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands

Commonly, the rheology of suspensions is primarily controlled by the volume fraction of solids, as it is the case, for instance, of colloidal gels. However, it has been recently shown that adding small amounts of a liquid, immiscible with the continuous phase of the suspension, affects strikingly the mechanical response of the system, even at low solid volume fraction, owing to the formation of particle aggregates and networks sustained by capillary forces. Such structures endow the material with elasto-plastic/gel-like properties which make these capillary suspensions particularly suitable for a number of applications. By means of lattice Boltzmann simulations I will address a number of open questions, concerning: i) the dependence of the network structure upon the particle shape and wettability, and, in turn, ii) the dependence of the rhelogical properties on such structure. In particular, I will show that by adding water to an oil-based suspension of strongly hydrophobic particles, the formation of a percolating cluster is observed. The percolation transition occurs at a critical value of the water volume fraction, for which we provide an explicit expression depending of the particle geometry, the solid volume fraction and the contact angle.

DY 62.6 Fri 11:00 HÜL 186
Transient dynamics in the accelerating region of collapsing freely suspended films — •Florian von Rüling and Alexey Eremin — Institute of Experimental Physics, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39016 Magdeburg, Germany

We report experimental studies on collapse dynamics of freely suspended smectic liquid crystal films. In contrast to soap films, whose collapse has been studied in detail, films of thermotropic liquid crystals have a well-defined layer structure and represent a quasi-two-dimensional fluid. The particular inner structure of smectics stabilizes freely suspended films with an extraordinary surface-to-volume-ratio. In our studies, we use tracer particles to visualise the flow in collapsing smectic films, thus enabling us to estimate the size of the dissipation region and to test the predictions of the theory. Using high-speed imaging we show that the advective flow involves the whole film, however, the flow velocity gradually reduces with the distance from the moving edge. The dissipation region is nearly independent of the film thickness.

15 min. break

DY 62.7 Fri 11:30 HÜL 186
A nearly incompressible mesoscopic method for simulating complex fluids and flows — •Davod Alizadehrad and Dmitry A. Fedosov — Institute of Complex Systems and Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

Numerical simulation and theoretical modeling of mesoscopic processes are constantly challenged by the large separation of time scales and length scales. We introduce a general mesoscopic framework for simulating complex liquids and flows using the smoothed dissipative particle dynamics [1]. Modifying the equation of state and the course-grained system, we show that the speed of sound can be controlled, while the radial distribution function (RDF), the mean-square displacement, and the Schmidt number correspond to liquid state, even for low temperatures. Performing reverse-Poiseuille flow simulations, measured viscosity shows only 1-2 percent changes over several orders variation of shear rates. The RDF in equilibrium and in shear flow remains same and independent of shear rates. This is an advantage in modeling of structures and boundaries either rigid or deformable. As a challenging test of incompressibility, we have considered the Poisson ratio, divergence of velocity field, and the number density in elongational flow. Density variation remains smaller than one percent and the velocity field satisfies well the divergence-free condition, indicating that the simulated fluid is nearly incompressible. Finally, we present the applicability and validity of the method in simulating cellular blood flow in irregular geometries as an example of complex mesoscopic fluids flow.

[1] K. Müller, et al., J. Comp. Phys. **281**, 301-315, (2015)

DY 62.8 Fri 11:45 HÜL 186

How to regulate the position of a droplet in a heterogeneous liquid environment? — •Samuel Krüger[1,2], Christoph A. Weber[4], Jens-Uwe Sommer[2,3], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Leibniz Institute of Polymer Research Dresden e.V. — [3]Technische Universität Dresden, Institute of Theoretical Physics, Dresden, Germany — [4]Harvard University, Division of Engineering and Applied Sciences, Cambridge, USA

Cells contain organelles that are not separated from the cytoplasm by a membrane. An example are liquid-like P granules in the *C. elegans* embryo. P Granules consist of RNA and proteins that are segregated from the cytoplasm. During asymmetric cell division, P granules are segregated to one side of the cell and distributed to only one daughter cell. This segregation is guided by the spatial concentration gradient of the protein Mex-5. Motivated by this system, we study the general question of how droplets are positioned in a concentration gradient of a regulator molecule that influences phase separation. We consider a ternary system and study the simplified case, where an external potential establishes the regulator gradient. A mean field Flory-Huggins model reveals a first order phase transition between the droplet position at high and low regulator concentration. We discuss this result in comparison to Monte Carlo simulations. Simulations reveal signatures of the mean field phase transition and give insight into the free energy landscape of the system in the presence of fluctuations.

DY 62.9 Fri 12:00 HÜL 186

Self-Assembly of Rings and Capsids in Hydrodynamic Flow — •Nikolas Schnellbächer[1,2], Fabian Fuchs[1,2], and Ulrich Schwarz[1,2] — [1]Institute for Theoretical Physics, Heidelberg University, Germany — [2]BioQuant, Heidelberg University, Germany

Patchy particle systems have emerged as useful model systems to investigate protein or colloidal self-assembly, but are usually studied under ideal conditions. We study self-assembly of patchy particles in hydrodynamic flow since this is a typical scenario for many applications and represents an important step towards more complex environments. Solute particles are propagated using Molecular Dynamics (MD) with solute-solute reactions being implemented through reactive patches. Solvent flow is simulated with Multi-Particle Collision Dynamics (MPCD). As paradigmatic examples, we study the assembly of pentagonal rings and icosahedral capsids with and without hydrodynamic flow. We find that there is a strong nonlinear relationship between shear rate and assembly yield and observe a multi-pitched interplay between shear rate and frequency of malformed complexes. This leads to optimal regimes both at low and intermediate shear rates, such that a balanced relation of bond association and dissociation prevents kinetic trapping and ensures constant monomer supply. At very high shear assemblies are disrupted by force. Our work highlights how both strong cooperative effects and non-equilibrium conditions are important to understand the intricate dynamics of self-assembly pathways.

DY 62.10 Fri 12:15 HÜL 186

Regulation of liquid phase separation of PGL-3 protein by RNA — •Omar Adame-Arana[1], Christoph A. Weber[1,2], Shambaditya Saha[3], Anthony A. Hyman[3], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA 02138, USA — [3]Max Planck Institute of Molecular Cell Biology and Genetics, 01307 Dresden, Germany

Liquid-liquid phase separation has been proposed as a key mechanism for the assembly and maintenance of membraneless compartments in cells. For example, in the *C. elegans* embryo, liquid-like droplets called P granules, condense and subsequently segregate to one side of the cell prior to cell division. P granules play a key role in the specification of germ cell fate. It has been shown that PGL-3, a key P granule component, is able to form RNA-rich liquid droplets in vitro. We investigate the role of RNA to facilitate phase separation using a Flory-Huggins model. We show that competition for RNA binding by PGL-3 and the regulatory protein Mex-5 can acount for the observed droplet segregation.