

CPP 39: Wetting, Micro and nanofluidics II

Time: Friday 9:30–12:00

Location: C 243

CPP 39.1 Fri 9:30 C 243

Capillary Levelling in Thin Polymer Films as a Nano-Rheological Tool to Probe Interface Dynamics — •OLIVER BÄUMCHEN, JOSHUA D. MCGRAW, MELISSA FERRARI, PAUL D. FOWLER, and KARI DALNOKI-VERESS — Department of Physics & Astronomy and the Brockhouse Institute for Materials Research, McMaster University, Hamilton, ON, Canada, L8S 4M1

Entanglement of polymer chains in confinement is modified as a result of altered chain conformations. According to Silberberg's principle, chain segments are reflected at an interface causing a reduction of the inter-chain entanglement density. If the interface is transient, local polymer conformation changes can be inferred from a temporal change in flow properties: over time polymer chains become more entangled, thus there is more resistance to flow. Here, we measure the gradual disappearance of an entropic interface between two melts of identical polymer chains during the flow of stepped bilayer polymer films. Samples are prepared in the glassy state and, when in the melt, flow to relieve the Laplace pressure gradient induced by a step in the topography (McGraw et al., *Soft Matter*, 2011). Our results reveal the dynamics of re-entanglement across the transient entropic interface.

CPP 39.2 Fri 9:45 C 243

Impact of polystyrene chain length on the instability of a dewetting liquid front — •SABRINA HAEFNER¹, MATTHIAS LESSEL¹, LUDOVIC MARQUANT¹, OLIVER BÄUMCHEN², and KARIN JACOBS¹ — ¹Saarland University, Experimental Physics, D-66041 Saarbrücken, Germany — ²McMasters University, Dept. of Physics & Astronomy, Hamilton, ON, Canada

A water cylinder in air is breaking up in droplets, seeking to minimize its surface energy. This phenomenon is known as Rayleigh-Plateau-instability. A liquid front of a dewetting liquid film is a similar geometry and hence also subject to the Rayleigh-Plateau-instability. For polymer melts Marquant et al. have shown the influence on the instability by the type of solid/liquid boundary condition ('slip' or 'no slip'). Bäumchen et al. have shown in a recent study, that in thin polystyrene (PS) films slippage can be induced by only exceeding a certain chain length of the polymer. Combining both things, we are interested in the impact of chain-length-induced slippage on the Rayleigh-Plateau-instability of a dewetting front. As substrates an amorphous fluoropolymer (AF1600) layer was prepared on smooth Si wafers entailing nearly no-slip conditions for PS chain length under 35 kg/mol. With increasing slip length the instability sets in at lower dewetted distances. At a certain molecular weight (higher slippage) this is reversed and the instability then develops only after larger dewetted distances. This effect can be explained by the rim profile of the liquid front, which is strongly influenced by the type of boundary condition.

CPP 39.3 Fri 10:00 C 243

Orientalional prewetting of planar solid substrates by a model liquid crystal — •MANUEL GRESCHKE and MARTIN SCHOEN — Stranski-Laboratorium für Physikalische und Theoretische Chemie, Fakultät für Mathematik und Naturwissenschaften, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany

We present grand canonical ensemble Monte Carlo simulations of prewetting transitions in a model liquid crystal at structureless solid substrates. Molecules of the liquid crystal interact via anisometric Lennard-Jones potentials and can be anchored planar or homeotropically at the substrates. Fluid-substrate attraction is modeled by a Yukawa potential of variable range. By monitoring the grand-potential density and the nematic order parameter as functions of the chemical potential several discontinuous prewetting, wetting, and isotropic-nematic phase transitions are observed. These transitions depend on both the range of the fluid-substrate attraction and the specific anchoring at the substrate. Our results show that at substrates characterized by degenerate anchoring prewetting occurs at lower chemical potentials compared with cases in which the anchoring is monostable. This indicates that prewetting transitions are driven by orientational entropy because degenerate anchoring allows for more orientationally distinct configurations of molecules compared with monostable anchoring. By analyzing in addition local density and various local order parameters a detailed picture of the structure of various phases emerges from our simulations.

Topical Talk

CPP 39.4 Fri 10:15 C 243

Guided and spatio-selective transport via anisotropic fluid flows — •ANUPAM SENGUPTA and CHRISTIAN BAHR — Max-Planck-Institute for Dynamics and Self-Organization, Göttingen, Germany

Microscale flow of anisotropic fluids [1,2] (nematic liquid crystals) offers a novel approach in the realm of transport phenomena. We study the transport of colloidal particles, either isolated or self-assembled chains, flowing in a nematic matrix through microfluidic channels. We demonstrate the influence of the nematic director field on the spatial orientation of the particles and the guidance of the particles by flow-induced topological defect structures of the nematic matrix. The transport of colloidal entities can be additionally tuned using an external field or by means of smart microfluidic architecture. In addition to flow parameters and channel dimensions and geometry, significant influence of the equilibrium molecular orientation of the liquid crystal on the channel walls (surface anchoring) has been observed. Surface anchoring of the molecules affects the evolution and sustenance of flow-induced phenomena in liquid crystals. This plays a pivotal role in the transport process, effectively providing us the route to guided and/or stereo-selective transport of colloidal particles over large length scales. Such phenomena are in contrast to isotropic fluids. The transport phenomena are characterized using a combination of polarising optical microscopy and fluorescence confocal polarizing microscopy.

[1] A. Sengupta, S. Herminghaus and Ch. Bahr, *Mol. Cryst. Liq. Cryst.* **547**, 203 (2011).

[2] A. Sengupta, U. Tkalec and Ch. Bahr, *Soft Matter* **7**, 6542 (2011).

CPP 39.5 Fri 10:45 C 243

Inertial Lift Forces and Probability Distributions in InertialMicrofluidics — •CHRISTOPHER PROHM, MICHAEL GIERLAK, and HOLGER STARK — Institut für Theoretische Physik, Technische Universität Berlin, D-10623 Berlin, Germany

At intermediate Reynolds numbers, particles in a microfluidic channel organize themselves at a fixed distance from the channel axis and its walls[1]. This effect can be described in terms of an effective lift force acting on the particles. Devices utilizing this inertial focusing for particle separation have recently been demonstrated[2,3].

Here, we study a spherical particle in a pressure driven flow through a microchannel at intermediate Reynolds numbers. We employ multi-particle collision dynamics[4] (MPCD) to simulate the particle motion coupled to a viscous fluid which is described by the full Navier-Stokes equation. MPCD is a mesoscale simulation technique and has successfully been applied to colloidal dynamics in previous studies.

We determine lift forces and resulting single particle probability distributions in steady state and analyze their dependence on particle radius and Reynolds number. To connect lift forces and distributions, we propose a Smoluchowski equation, where the point particle exhibits a drift motion due to the lift force. We show that this effective picture and the simulations are in good agreement.

[1] Segré and Silberberg, *Nature*, **189**, 209 – 210 (1961).

[2] Hur et al., *Lab Chip*, **10**, 274 – 280 (2009).

[3] Di Carlo et al., *PNAS*, **104**, 18892 – 18897 (2007).

[4] Kapral et al., *Adv. Chem. Phys.*, **140**, 89 – 146 (2008).

CPP 39.6 Fri 11:00 C 243

Sorting of chiral particles in microfluidic devices with helical flows — •MARIA ZVYAGOLSKAYA¹, RALF EICHHORN², and CLEMENS BECHINGER¹ — ¹Universität Stuttgart, 2. Physikalisches Institut, Pfaffenwaldring 57, 70569 Stuttgart — ²NORDITA, Roslagstullsbacken 23, 106 91 Stockholm, Sweden

Different enantiomers of chiral compounds often show huge differences in their biochemical activity. Therefore, the separation of such molecules which are typically produced in equal amounts during synthesis, is important for many processes e.g. in pharmaceutical or food industry. Current separation techniques are frequently based on differences in the migration behaviour in chiral host media. However, such materials are expensive and have to be optimized for different chiral compounds. Here, we demonstrate with experiments and simulations a novel method which is based on hydrodynamic coupling of chiral compounds in a helical fluid flow. Three-dimensional chiral particles on the micron-scale are created by a photolithography and are labeled with different fluorescent dyes to distinguish their chiral-

ity. In the presence of a helical flow, we observe marked differences in the behavior of particles with opposite chirality regarding their spatial distribution perpendicular to the flow which leads to an effective separation mechanism.

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Rotating magnetic field assisted microfluidics — •FRANK WITTBRACHT¹, BERNHARD EICKENBERG¹, ALEXANDER WEDDEMANN², and ANDREAS HÜTTEN¹ — ¹Thin Films and Physics of Nanostructures, Bielefeld University, Bielefeld, Germany — ²Research Laboratory of Electronics/LEES, MIT, Cambridge, United States

Superparamagnetic beads suspended in a liquid show characteristic behavior when immersed in a homogenous external magnetic field. Due to the inhomogeneous character of the stray field of the beads, magnetic agglomerates are formed. The dimensionality of these magnetic superstructures can be adjusted by rotating the external magnetic field. This allows especially for the formation of highly ordered two-dimensional clusters consisting of magnetic beads [1]. Time scales for the cluster formation are studied with respect to a dependence on the rotation frequency of the magnetic field [2]. We present a microfluidic device, which utilizes the interaction between magnetic agglomerates and channel walls in order to perform colloidal separation. The magnetic agglomerates may also act as dynamic free-flowing microstirrers which enhance the effective diffusion at the interface of a two fluid streams. At the chosen system parameters an increase in the diffusivity of 32 was obtained and a separation efficiency of about 80% at flow rates up to 0.4 mm/s was achieved.

[1] A. Weddemann, F. Wittbracht, B. Eickenberg, A. Hütten, Langmuir, 26, 19225 (2010)

[2] F. Wittbracht, B. Eickenberg, A. Weddemann, A. Hütten, J. Appl. Phys., 109, 114503 (2011)

CPP 39.8 Fri 11:30 C 243

Hydration of small hydrophobic objects: The effects of an electric field — •ZORAN MILIČEVIĆ¹, DAVID M. SMITH², and ANA-SUNČANA SMITH¹ — ¹Institut für Theoretische Physik und Cluster of Excellence: Engineering of Advanced Materials, Universität Erlangen-Nürnberg, Erlangen, Germany — ²Computer Chemie Centrum, Universität Erlangen-Nürnberg, Erlangen, Germany

It is well established that the hydrophobicity of an interface, droplet or a particle can be modulated by an external electric field. However, the field effects on water structure around a hydrophobic object are not understood to a satisfactory level. We study the organization of water around a Lennard-Jones particle and an oil droplet in the presence and absence of a static electric field. We perform extensive MD simulations using the GROMACS software package and the SPC/E model of water. The structure of water is analyzed by means of the total solute-solvent correlation function, which includes the orientational degrees of freedom of the solvent. We find that a structure of water arises from the competition between optimal orientation of water with respect to the field and with respect to the solute, yielding an asymmetric distribution of solvent charges around the particle. The particle thus appears to be a small dipole. Another consequence of the field are very long range solvent-solute effective interactions. We furthermore evaluate the force correlations as a function of time and find them sensitive to the treatment of van der Waals interactions in simulations, which may explain some discrepancies in the observed mobilities of small droplets in simulations reported previously in the literature.

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Theory of water and charged liquid bridges — •KLAUS MORAWETZ — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP) Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

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.

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