

CPP 35: Microfluidics II: Boundary conditions

Time: Thursday 14:00–15:30

Location: ZEU 160

Topical Talk CPP 35.1 Thu 14:00 ZEU 160

Simulations of lubrication force experiments — ●JENS HARTING¹, CHRISTIAN KUNERT¹, and OLGA I. VINOGRADOVA² — ¹Institut für Computerphysik, Pfaffenwaldring 27, 70569 Stuttgart, Germany — ²A.N. Frumkin Institute of Physical Chemistry and Electrochemistry, Russian Academy of Sciences, 31 Leninsky Prospect, 119991 Moscow, Russia

When an object that is submerged in a liquid is approached towards a surface, the lubrication force raises. The measurement of the lubrication force gives an insight in the flow profile near objects and thus one can deduce the flow boundary condition. In particular, such a measurement can be used to study the effect of boundary slippage. Therefore many groups perform experiments, where a colloidal sphere is attached to the cantilever of an atomic force microscope (AFM) to measure the lubrication force. For the ideal situation of a perfect sphere being approached with a small, constant velocity towards a perfectly smooth wall a theoretical description is well known and a correction for boundary slip can be applied. In the case of rough boundaries and non-constant approaching velocity a theoretical description is missing. In this contribution we present lattice Boltzmann simulations of such non ideal cases and show that the known theory holds even for very rough surfaces if one applies an effective boundary.

CPP 35.2 Thu 14:30 ZEU 160

The microscopic origin of surface slip: Looking at the boundary layer of sheared liquids on solid surfaces — ●PHILIPP GUTFREUND^{1,2}, MAXIMILIAN WOLFF^{1,2}, STEFAN GERTH³, ANDREAS MAGERL³, and HARTMUT ZABEL² — ¹Institut Laue-Langevin — ²Ruhr-Universität Bochum — ³Universität Erlangen-Nürnberg

According to text-book physics the contacting layer of a flowing liquid is sticking to the solid boundary and from this a smooth velocity profile develops into the bulk of the liquid, which is in agreement with many macroscopic experimental observations. However, recently, both experiments and theory have shown that on a microscopic scale simple liquids may undergo significant slip at a solid wall. Different mechanisms can be evoked to address slip like the formation of a thin depletion layer or a molecular ordering in the liquid near the interface. For most liquids, the short length scales important for slip effects are difficult to probe directly and non destructively. Grazing incident neutron scattering techniques have proved to be a very sensitive tool for the detection of depletion effects and structural arrangements close to solid-liquid walls. We will present recent results obtained by Neutron Reflectivity (NR) and Grazing Incidence Neutron Diffraction (GIND) studies on the depth profile and structure of the boundary layer of sheared hexadecane, that is known to show surface slip, on differently coated solid surfaces. The NR results for deuterated hexadecane show a depletion layer of about 2 nm and the GIND patterns show that the liquid structure factor seems to be influenced by shear.

CPP 35.3 Thu 14:45 ZEU 160

Altering the boundary conditions to influence flow dynamics of a liquid film — ●MATTHIAS LESSEL, OLIVER BÄUMCHEN, and KARIN JACOBS — Saarland University, Experimental Physics, D-66041 Saarbrücken

In the course of the miniaturization of fluidic devices, the typical diameter of flow channels becomes smaller and smaller. Typically, the velocity of the liquid at the boundary to a channel wall is zero, a parabolic velocity profile is measured and high pressure is needed to move the liquid.

We study the impact of surface modifications on the slip length on a model system: polymer films on tailored Si wafers. To induce flow we use the dewetting process, which is driven by an internal force governed by the effective interface potential. In our case, hydrophobic

substrates (Si wafers covered by octadecyltrichlorosilane (OTS), dodecyltrichlorosilane (DTS), or Teflon (AF1600)) are only partial wetted by the polystyrene melt. They are ideal smooth substrates. So, roughness effects could be neglected.

Using optical microscopy we found at constant temperature an increase of the dewetting velocity on substrates which show slippage. The slip lengths could be calculated by observing the growth of dewetting holes in the film. The slip lengths lay in the range from several nanometers for AF 1600 to several micrometers for DTS. These results could be approved by analyzing the rim shapes around the holes using AFM. The shapes were found to be influenced by slippage too.

CPP 35.4 Thu 15:00 ZEU 160

In-situ investigation of the solid/liquid interface of a block copolymer solution under shear stress with μ -focus GISAXS — ●ANDREAS TIMMANN¹, STEPHAN VOLKHER ROTH¹, STEFFEN FISCHER², and STEPHAN FÖRSTER² — ¹HASYLAB at DESY, Notkestr. 85, D-22603 Hamburg, Germany — ²Inst. f. Phys. Chem., Uni HH, Grindelallee 117, D-20145 Hamburg, Germany

Block-copolymers are interesting for their ability to self organize in various structures. In dilute solution they form micelles, cylindrical micelles and vesicles. The length scales of these structures ranges from about 5 nm up to several hundred nanometres. Hence such structures are well suited for investigations using small-angle X-ray scattering.

The experiments were performed the beamline BW4 at HASYLAB, Hamburg [1] using the microfocus set-up. We present the results of the investigation of a 13 wt.% solution of a poly-(isoprene-block-ethylene oxide) in water. The block degrees of polymerization of the isoprene and the polyethylene oxide were 55 and 170, respectively. The shear stress was applied by a stress-controlled Bohlin CVO rheometer in a plate-plate-geometry with a diameter of 20 mm and a gap of 1 mm. We investigated the interface layer of the solution with the rotor of the shear geometry at different temperatures. Under shear a desorption of the micelles from the rotor plate was observed, which is independent of the actual shear rate. [2]

References:

- [1] Roth et al., Rev. Sci. Instrum., 2006, 77, 085106
- [2] Timmann et al., App. Phys. Lett., 2007, 91, 213102

CPP 35.5 Thu 15:15 ZEU 160

Shear induced relaxation of polymer micelles at the solid-liquid interface — ●MAX WOLFF^{1,2,3}, ROLAND STEITZ⁴, PHILIPP GUTFREUND^{1,2}, NICOLE VOSS⁵, STEFAN GERTH⁵, MARCO WALZ⁵, ANDREAS MAGERL⁵, and HARTMUT ZABEL¹ — ¹Institute for Solid State Physics/EP IV, Ruhr-University Bochum, Germany. — ²Institute Laue-Langevin, Grenoble, France. — ³Materials Physics, Uppsala University, Sweden. — ⁴Helmholtz Centre Berlin for Materials and Energy, Berlin, Germany. — ⁵Crystallography and Structural Physics, University of Erlangen-Nürnberg, Erlangen, Germany.

Mixtures of amphiphilic block copolymers with a selective solvent are known to form various structures. Applying external fields such as shear can dramatically change the overall structure of the sample. In most cases, crystallites become aligned.

A 20 % aqueous solution of F127 was investigated by combining rheology in a cone/plate-geometry and surface-sensitive grazing incident neutron scattering. The crystalline structure formed by the polymer micelles becomes less pronounced for low shear rates, but correlations increase for higher shear rates. After stopping shear a slow relaxation of the micelles is found in the vicinity of a hydrophilic silicon wall, while a fast relaxation is observed in the boundary layer against the hydrophobic silicon wall (weak micelle-wall interaction). The results show that in the vicinity of the interface wall-particle interactions compete heavily with the shear force acting on the liquid [1].

- [1] M. Wolff et al., Langmuir (Letter) 24, 11331 (2008).