CPP 38: POSTERS Micro- and Nanofluidics

Time: Thursday 17:00–19:30 Location: P3

CPP 38.1 Thu 17:00 P3

Colloids dragged through a polymer solution: Experiment, theory, and simulation — •Christof Gutsche[1], Friedrich Kremer[1], Matthias Krüger[2], Markus Rauscher[2], Rudolf Weeber[3], and Jens Harting[3] — [1]Institut für Experimentalphysik I, Universität Leipzig, 04103 Leipzig, Germany — [2]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany and Institut für Theoretische und Angewandte Physik, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]Institut für Computerphysik, Universität Stuttgart, Pfaffenwaldring 27, 70569 Stuttgart, Germany

Complex fluids in general and colloid-polymer mixtures in particular are an ideal model system for studying the structure and phase behavior of multicomponent systems. We present optical tweezer based microrheological measurements of the drag force on colloids pulled through a solution of lambda-DNA used here as a monodisperse model polymer. The experiments show a drag force that is larger than expected from the Stokes formula and the independently measured viscosity of the DNA solution. We attribute this to the accumulation of DNA in front of the colloid and the reduced DNA density behind the colloid.

C.Gutsche, F. Kremer, M. Krüger, M. Rauscher, R. Weeber, J. Harting. J. Chem. Phys. 129, 084902 (2008)

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Reversible single bacterial cell localization in microfluidic PDMS devices — •Lukas Galla, Dominik Greif, Jan Regtmeier, and Dario Anselmetti — Bielefeld University, Experimental Biophysics & Applied Nanoscience, Universitätsstr. 25, 33615 Bielefeld, Germany

For successful optical investigations of bacteria cells it is beneficial to use a method that allows a reversible and defined positioning of single cells at physiological conditions.

Here, we present two approaches for single cell and particle localization in a microfluidic poly(dimethylsiloxane) (PDMS) device. Firstly, in structured microchannels with obstacles at defined positions we used electrokinetic driving forces and electrodeless dielectrophoresis for particle trapping. Secondly, branched channel systems with 1μm-intersection points in combination with hydrostatic flux control also allow an exact positioning of particles. In order to prevent unspecific particle adsorption, the channel surface of both types of PDMS chips was coated with a triblock-copolymer (F108).

The functionality of these two approaches was confirmed in experiments with $1{,}9\mu$m fluorescent beads followed by successful localizations of bacterial cells (*S.meliloti* 1021, $0{,}5\mu$m x 3μm) suspended in culture medium. No reduction of the cell viability was observed. Both approaches demonstrate the efficiency of the single bacterial cell trapping methods and open the way for new designs of single cell experiments.

CPP 38.3 Thu 17:00 P3

Motion of an elastic capsule in time dependent shear flow — •Steffen Kessler, Reimar Finken, and Udo Seifert — II. Institute of Theoretical Physics, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

The motion of an elastic 3d capsule in a linear shear flow with time-dependent shear rate is studied both numerically and analytically using an extended Keller-Skalak model. Since the ellipsoidal shape of the capsule is fixed here, only two degrees of freedom remain: the orientation of the capsule with respect to the shear flow, and the internal motion of the membrane with respect to the fixed shape.

For a given shape, the capsule dynamics in time-constant shear flow depends on the applied shear rate and the viscosity contrast between inner and outer fluid. In the corresponding phase diagram tumbling and tank-treading regimes are separated by an "intermittent" regime where the capsule is simultaneously tank-treading and tumbling.

In the case of a time-oscillating shear rate, numerical examples show that tumbling motions can be induced from the tank-treading regime if the shear rate enters the tank-treading regime during its oscillation. Furthermore, numerical results for the mean tumbling rate show an interesting resonance dependence on the applied oscillation frequency, superimposed onto a smooth background vanishing at a cut-off frequency. These findings can be understood analytically for quasispherical capsules and parameters close to the critical point of the phase diagram. A mapping of the system onto a discrete model for low frequencies explains the resonance pattern of the tumbling-rate.

CPP 38.4 Thu 17:00 P3

Hydrodynamically induced attraction and repulsion of rotated dumbbells — •Steffen Schreiber and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany

Two asymmetric and hydrodynamically interacting dumbbells are rotated in a solvent. We show that different shapes of the two dumbbells break the symmetry with respect to a time translation by half a rotational period which causes either a hydrodynamically induced attraction or repulsion between them, depending on the specific shapes. We present phase diagrams of this novel dynamical effect and a reduced model for a qualitative explanation.

CPP 38.5 Thu 17:00 P3

Experimentierkiste "Den Geheimnissen der Flüssigkeiten auf der Spur" — •Frank Müller, Atanaska Kasabova, Matthias Lienard, Christian Zeitz, Peter Loskill, Samuel Grandthyll und Karin Jacobs — Institut für Experimentalphysik, Universität des Saarlandes, 66041 Saarbrücken

Obwohl Technologie von Jugendlichen akzeptiert wird, sei es in Form von Laptops oder Mobiltelefonen, beschränkt sich das Interesse meist auf die passive Nutzung. Dabei steht eher die Tatsache im Vordergrund, dass "das neue Handy" diese oder jene zusätzliche Spielart aufweist, die Frage nach dem "Warum" oder "Wie" ist aber eher von untergeordneter Bedeutung. Eine Möglichkeit, das Interesse and Technik und Wissenschaft zu fördern, besteht darin, die Vermittlung von wissenschaftlichen Inhalten über die Wandtafel hinaus zu präsentieren und Schülern die Möglichkeit zu geben, selbst aktiv tätig zu sein. Die hier präsentierte "Experimentierkiste" ist für den Einsatz an Schulen im Rahmen des Schwerpunktprogramms SPP 1164 "Nano & Microfluidics" konzipiert worden und beinhaltet 12 Experimente, die von einer Schulklasse im Rahmen einer 1-2 stündigen Veranstaltung bearbeitet werden können. Bei den in Auszügen gezeigten Experimenten wurde besonders Wert auf die einfache Gestaltung gelegt, deren "Zutaten" in jedem Supermarktregal zu finden sind. So steht jedem, dessen Interesse an der einen oder anderen Fragestellung im Rahmen der schulischen Präsentation einmal geweckt worden ist, die Möglichkeit offen, seine "Forschung" zu Hause zu vertiefen.

www.softmatter.de -> Lab-in-a-box

CPP 38.6 Thu 17:00 P3

Roughness affects slippage and slippage affects hydrodynamic instabilities — •Ludovic Marquant, Matthias Lessel, Oliver Bäumchen, Julia Mainka, Frank Müller, and Karin Jacobs — Saarland University, Experimental Physics, D-66041 Saarbrücken

Dewetting experiments have proven to be ideally suited to probe the flow dynamics of liquids on solids. Here we focus on the boundary condition at the solid/liquid interface. Under certain conditions, the details of which we will present, the liquid can slip over the solid, leading to higher flow velocities and less drag. In our study we prepare polystyrene films below the entanglement length on top of hydrophobized substrates. The surface functionalization is done by preparing self-assembled monolayers of dodecyl- (DTS) or octadecyl-trichlorosilane (OTS) or by spin casting a thin AF1600 film.

We show that i) roughness affects slippage and that ii) hydrodynamic instabilities similar to the Rayleigh-Plateau instability, are influenced by slippage.

CPP 38.7 Thu 17:00 P3

Near-Surface Structure and Dynamics Explored by Grazing Incidence Neutron Scattering — •Marco Walz[1], Max Wolff[2,3], Nicole Voss[1], Philipp Gutfreund[2,3], Hartmut Zabel[1], and Andreas Magerl[1] — [1]Crystallography and Structural Physics, Univ. Erlangen-Nürnberg — [2]Solid State Physics, Ruhr-Univ. Bochum, Germany — [3]Institut Laue-Langevin, Grenoble, France

Even in simple fluids the conventional non-slip boundary condition becomes microscopically void. Surface slip characterized by the slip length may become macroscopic, and a large slip length implies a pronounced anomaly in the shear flow adjacent to a solid surface, where the anomaly itself is only present in a thin layer next to the solid interface within the order of nanometers. For an understanding of boundary slip, the anomalies in the structural and dynamical properties in the interface layer need to be understood. To highlight the properties of the boundary layer we carried out Grazing Incidence Small Angle Neutron Scattering (GISANS) and, for the first time, a Neutron Spin-Echo experiment under condition of Grazing Incidence (GINSE). Our investigation of a concentrated tri-block copolymer solution shows that the local structure depends on the distance to the interface and the chemical termination of the solid boundary. However, the key for the understanding of slip may also be related to a change in the local dynamics of a liquid at an interface and under flow. We have verified that the investigation of the dynamics of the sample with the GINSE technique is feasible, and we present data taken near the critical angle of total reflection.

CPP 38.8 Thu 17:00 P3

Dewetting of thin liquid films on viscoelastic substrates — •Konstantina Kostourou[1], Dirk Peschka[3], Andreas Münch[2], Barbara Wagner[3], Stephan Herminghaus[1], and Ralf Seemann[1,4] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]School of Mathematical Sciences, University of Nottingham, UK — [3]Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany — [4]Experimental Physics, Saarland University, Germany

We study the dewetting of thin polymer films on viscoelastic (PDMS and molten PMMA) substrates. Experimentally we observe that the dewetting rates increase as we increase the substrate elasticity, whereas they show a two-phase behavior as we tune the substrate viscosity. Furthermore, we find that characteristic rim shapes and substrate deformations depend on the viscoelasticity of the underlying substrate. In our theoretical approach we couple the Navier-Stokes equations to a Kelvin-Voigt model to describe the liquid and solid phase respectively. We derive a set of one-dimensional thin-film equations for the liquid film and the solid substrate, where the depth averaged velocity of the liquid and the deformation of the solid substrate is largely tangential to the liquid-solid interface. Finally, we compare the experimental results with the predictions of our model. Whereas we observe a deviation in the case of the PDMS substrates, we find them to be in good agreement in the case of the PMMA substrates. Specifically, our model is able to define both the dewetting dynamics of our system and the deformation of the substrate close to the three phase contact line.

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Polystyrene nanodroplets on rubber elastic substrates — •Konstantina Kostourou[1], Stephan Herminghaus[1], and Ralf Seemann[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, D-37073 Göttingen, Germany — [2]Experimental Physics, Saarland University, D-66041 Saarbrücken, Germany

We study the shape of polystyrene (PS) nanodroplets on substrates of cross-linked Polydimethylsiloxane (PDMS). These drops deform the rubber elastic substrate onto which they are seated. The three phase contact line is lifted upwards by the interfacial energies, whereas the interface between the drop and the substrate is pushed downwards due to the Laplace pressure of the droplet. The upward deformation of the PDMS is measured by imaging the sessile droplets by atomic force microscopy (AFM) and its exact position is determined by overlapping the topography and the phase signal ("top side"). To measure the downward deformation of the PDMS we lift off the PS droplet from the substrate and image the deformation that is frozen into the "bottom side"of the droplet. By analyzing the profiles of the bottom side of the droplet and assuming that our system can be defined by the Hertzian model for a rigid sphere in contact with a soft elastic plane, we can calculate quantitatively the Elastic Modulus of the substrate, that is in very good agreement with values extracted by other independent techniques (rheology, nanoindentation). Furthermore, the lift-off technique allows us to image the upward displacement of the three phase contact line and to compare it to the results of the deformation in the vicinity of the three phase contact line from the "top side".

CPP 38.10 Thu 17:00 P3

Static and Dynamics of Wet Granular Materials — •Somnath Karmakar[1,2], Michael Sipahi[1], Mario Scheel[1], Marc Schaber[2], Martin Brinkmann[1], Marco Di Michiel[3], Stephan Herminghaus[1], and Ralf Seemann[1,2] — [1]Max Planck Institute for Dynamices and Self-Organization, Göttingen, Germany — [2]Universität des Saarlandes, Saarbrücken, Germany — [3]ESRF, Grenoble, France

When a small amount of liquid is added to dry granular matter, a network of capillary bridges is formed exerting an attractive force between granules and the granular pile turns into a moldable material. The resulting network of liquid morphologies changes dramatically with liquid content and wettability of the granules. We study the mechanical properties, i.e. tensile strength, yield stress and critical fluidization acceleration of wet granular materials with different wettability and grain shape like sand, glass, and basalt beads for various liquid contents. Our experimental observations show, that in case of a liquid with small contact angle, the mechanical properties of a granular pile are largely independent of the amount of added-liquid over a wide range. In case of a large contact angle, however, the mechanical properties are strongly dependent on the liquid content. We resolve this experimental finding by imaging the liquid distribution inside the granular piles, using X-ray microtomography.

CPP 38.11 Thu 17:00 P3

Contact angle determination in multicomponent lattice Boltzmann models — •Sebastian Schmieschek and Jens Harting — Institut für Computerphysik, Pfaffenwaldring 27, 70569 Stuttgart

Droplets on hydrophobic surfaces are common in microfluidic applications and there exists a number of commonly used multicomponent and multiphase lattice Boltzmann schemes to study such systems. In this contribution we focus on a popular implementation of a multicomponent model as introduced by Shan and Chen. Here, interactions between different components are implemented as repulsive forces whose strength is determined by phenomenological parameters. In this contribution we present simulations of a droplet on a hydrophobic surface. We investigate the dependence of the contact angle on the simulation parameters and quantitatively compare different approaches to measure it.

CPP 38.12 Thu 17:00 P3

Wetting of hydrophilic periodic nanotemplates on Si surfaces — Stefan Heindl[1], •Alfred Plettl[1], Sabine Hild[2], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, D-89069 Ulm, Germany — [2]Institut für Polymerwissenschaften, Universität Linz, A-4040 Linz, Austria

To influence the wetting behavior of a Si surface, periodically ordered nanomasks were prepared by either a micellar [1] or a miniemulsion technique [2] and used to fabricate extended arrays of nanopillars on a Si wafer by RIE etching [3]. These methods allow a systematic variation of the height and density of such structures. The degree of hydrophobicity of the samples was additionally modified by coating with hexamethyldisilane (HMDS) or octadecyltrisilane (OTS). Wetting of water was studied by measuring contact angles as well as spreading-receding hysteresis behavior. The specific effect of the nanostructures is to increase the contact angles and enhance hysteresis.

By combining the above nanopatterning techniques with conventional electron beam lithography and a cryogenic Si deep etching, two different roughness scales can be superimposed. The resulting effect on wetting may contribute to an understanding of the well-known Lotus effect.

[1] G. Kästle et al., Adv. Funct.Mat. 13, 853 (2003).
[2] A. Manzke et al., Adv. Mater. 19, 1337 (2007).
[3] F. Weigl et al., Diamond and rel. Mat.15, 1689 (2006).

CPP 38.13 Thu 17:00 P3

Stability of droplets: A free energy based lattice Boltzmann study — •Markus Gross[1,2], Fathollah Varnik[1,2], and Dierk Raabe[1] — [1]Max-Planck Institut für Eisenforschung, Düsseldorf, Germany — [2]Interdisciplinary Center for Advanced Materials Simulation, Ruhr-Universität Bochum, Germany

Liquid droplets are very important in many scientific research branches and their study has attracted much interest for a long time. In this work we investigate the behavior of droplets via a mesoscale computer simulation approach, the Lattice Boltzmann method.

In the first part, we consider the stability of a droplet and its saturated vapor inside a finite volume, an issue of considerable importance in nanotechnology. Results obtained within our simulations show the same system size dependence as obtained via analytic approximations to the underlying free energy functional as well as independent numerical solutions of the problem. In particular, we find a certain critical radius below which a liquid droplet becomes unstable and evaporates.

A second topic of fundamental interest is the behavior of droplets on superhydrophobic substrates for the case where the droplet is of comparable size to the roughness scale. A simple analytical free energy model is presented that can explain all the essential results of our simulations. Most interestingly, we are able to observe a new generic metastable state of partial impalement that is different from the known Cassie/Baxter or Wenzel states. Furthermore, we study the stability of the Cassie/Baxter state and its dependence on the substrate geometry, contact angle and droplet size.

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Small droplets on superhydrophobic substrates — •Markus Gross[1,2], Fathollah Varnik[1,2], and Dierk Raabe[1] — [1]Max-Planck Institut für Eisenforschung, Düsseldorf, Germany — [2]Interdisciplinary Center for Advanced Materials Simulation, Ruhr-Universität Bochum, Germany

We investigate the stability of liquid droplets on a regular superhydrophobic substrate for the case of droplets that are of comparable size to the surface asperities.

A simple analytic three-dimensional free energy model is proposed and compared to the results obtained from lattice Boltzmann computer simulations. Both approaches are found to be in good agreement. The stability of the fakir state is shown to depend on the substrate geometry, contact angle and droplet size. Remarkably, we are able to observe a new metastable state of partial impalement that is different from the fakir or Wenzel state. We find that, due to this new state, an evaporating droplet can be saved from going over to the Wenzel state and instead remains close to the top of the surface texture.

CPP 38.15 Thu 17:00 P3

Mesoscopic dynamics of active media — •Arthur V. Straube and Philipp Thomas — Department of Theoretical Physics, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We present a mesoscopic model describing nonequilibrium active media. We follow the ideas of the method of *stochastic rotation dynamics* and introduce a coarse-grained active field, which is modeled by discrete chemical particles coupled to the solvent. To validate our approach, we first look at the concentration dependence of the diffusion coefficient of passive chemical particles. Next we introduce birth and death rules and focus on population dynamics. Finally, we address the full problem of nonuniform active states produced by a source of the chemical field. The results are compared with the exact solution obtained within the continuum theory. We outline possible chemical and biological applications of the proposed approach.