DY 64: Wetting and Liquids at Interfaces and Surfaces II (joint session CPP/DY/O)

Time: Friday 9:30–12:15 Location: ZEU 260

Invited Talk DY 64.1 Fri 9:30 ZEU 260
Slide electrification: charging of surfaces by moving water drops — •Hans-Jürgen Butt — Max Planck Institute for Polymer Research, Mainz, Germany

Water drops sliding over insulating surfaces can lead to surface charging. In contrast to charging caused by friction between two solids, drop slide electrification is largely unexplored. Slide electrification has been consistently reported, but results are difficult to reproduce. One reason for the lack of quantitative understanding is that the deposition of charge is a non-equilibrium effect and depends essentially on microscopic processes at the contact line. We address both the experimental and theoretical sides of this problem. We reproducibly measure the charge gained by water drops sliding down hydrophobic surfaces. To explain these results, we theorize that some fraction of the charge in the Debye layer is transferred to the surface rather than being neutralized as the drop passes. Given that nearly every surface in our lives comes in contact with water, this water-dependent surface charging may be a ubiquitous process that we are only beginning to understand.

DY 64.2 Fri 10:00 ZEU 260
Spreading on viscoelastic solids: Are contact angles selected by Neumann's law? — Mathijs van Gorcum[1], •Stefan Karpitschka[2], Bruno Andreotti[3], and Jacco H. Snoeijer[1] — [1]Physics of Fluid Group, University of Twente, Enschede, Netherlands — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [3]Laboratoire de Physique Statistique, Univ. Paris-Diderot, Paris, France

The spreading of liquid drops on soft substrates is extremely slow, owing to strong viscoelastic dissipation inside the solid. A detailed understanding of the spreading dynamics has remained elusive, partly owing to the difficulty in quantifying the strong viscoelastic deformations below the contact line that determine the shape of moving wetting ridges. Here we present direct experimental visualizations of the dynamic wetting ridge, complemented with measurements of the liquid contact angle. It is observed that the wetting ridge exhibits a rotation that follows exactly the liquid angle, as was previously hypothesized [Karpitschka et al., Nat. Commun. (2015)]. This experimentally proves that, despite the contact line motion, the wetting ridge is still governed by Neumann's law. Furthermore, our experiments suggest that moving contact lines lead to a variable surface tension of the substrate. We set up a new theory that incorporates the influence of surface strain, the so-called Shuttleworth effect, for soft wetting. It includes a detailed analysis of the boundary conditions at the contact line, complemented by a dissipation analysis, which shows, again, the validity of Neumann's balance.

DY 64.3 Fri 10:15 ZEU 260
Formation of a thin film during drop merging leads to fingering instability — •Peyman Rostami[1,2] and Günter Auernhammer[1,2] — [1]Max Planck Institute for Polymer Research, 55128, Mainz, Germany — [2]Leibniz Institute of Polymer Research, 01069, Dresden, Germany

The coalescence and interaction between two drops have been the subject of intensive studies in recent years [1], due to its wide range of application and the presence in the nature.

Here, we study the merging of partially miscible drop. We deposit drops of different liquids on a substrate. Under appropriate conditions, the merging process generates an instability which resembles the Rayleigh-Plateau instability. If the liquid with higher surface activity is deposited as a second droplet. Its vapor can diffuse through the air and induce a Marangoni flow inside the already deposited droplet. This induced flow can pull a thin liquid layer over the surface , which decays into drops by a Rayleigh-Plateau instability.

We present a detailed study of this instability analyzing the onset of the instability and its characteristic length scales. Finally, a model is presented to explain the Marangoni flow induced by the gas phase. This model is validated by particle tracking.

References [1] S. Karpitschka, C. Hanske, A. Fery, and H. Riegler, Langmuir, vol. 30, no. 23, pp. 6826*6830, 2014.

DY 64.4 Fri 10:30 ZEU 260
Condensation frosting on lubricant impregnated surfaces — •Lukas Hauer[1], Lou Kondic[2], and Doris Vollmer[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Department of Mathematical Sciences, NJIT, Newark, USA

In many technical applications the formation of frost and ice displays a hazard to the steady functionality of devices. This motivates the development of new materials to tackle the reduction of icing on surfaces. Understanding the nature of frosting and icing is indispensable to this effort. While icing on surfaces is commonly studied by localized nucleation mechanisms, the formation of frost is comparable more complicated. Condensation frost is characterized by multi-step and multi-physical phenomenon. The formation of condensate droplets, percolation, and frost front propagation is an inherently stochastic process. Despite its ubiquitous nature, a quantitative model for frost growth on surfaces remains elusive. Lubricant impregnated surfaces are known for improved anti-icing properties. They experience lower ice drop adhesion and allegedly delayed surface frosting. We show that frost formation can induce immensely strong capillary forces that could result in surface damage, lubricant depletion and the loss of anti-icing properties. Laser scanning confocal microscopy enabled us to monitor the dynamic lubricant migration during condensation frosting on micro-structured surfaces. We present a model of the lubricant migration, utilizing lubrication theory. This work serves to improve understanding of lubricant dynamic during condensation frosting, providing future roadmaps towards the future design of anti-icing surfaces.

DY 64.5 Fri 10:45 ZEU 260
Dynamics of liquid droplets on switchable prestructured substrates — •Moritz Stieneker[1] and Svetlana Gurevich[1,2] — [1]Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Str. 9, D-48149 Münster, Germany — [2]Center for Nonlinear Science (CeNoS), University of Münster, Corrensstrasse 2, D-48149 Münster, Germany

A mesoscopic continuum model is employed to model a thin, liquid film on a substrate with a spatio-temporal wettability. In particular, the effect of a switchable wettability pattern on the structure formation is analyzed for a one-dimensional case with the help of path-continuation techniques and direct numerical time simulations. It is found that if the periodic switching is introduced, the system reaction depends on the ratio between the time scale given by switching and the reaction time of the liquid. The behaviour of the contact angle during the slow and fast switching is investigated in details. Furthermore it is demonstrated that in the case of the slow switching the droplet solutions corresponding to the local minima of the free energy can be stabilized.

DY 64.6 Fri 11:00 ZEU 260
Liquid-liquid phase separation in contact with deformable surfaces — •Hansol Jeon[1,2] and Stefan Karpitschka[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Georg-August-Universität Göttingen

The capillary forces of droplets on top of soft solids deform the solid surface into sharp wetting ridges. The amplitude of the wetting ridge is governed by elasto-capillary length, the ratio of liquid surface tension to the solid's shear modulus. Previous experiments on soft wetting used large liquid-vapour surface tensions and thus were in a highly non-linear regime regarding the response of the solid. This led to debates in the literature regarding the effects of strain dependent solid surface tensions or the dynamics of soft wetting. Liquid interfaces with small surface tensions could instead probe the linear regime of soft wetting and shed new light onto the static and dynamic behaviours of solid surface tension. Thus we investigate the liquid-immersed case of soft wetting, aiming for a control of the liquid and solid surface tensions. We tested various liquid combinations and explored a wide range of surface tensions and substrate shear moduli, finding valid Neumann constructions in all cases.

15 min. break

DY 64.7 Fri 11:30 ZEU 260
Droplets fighting contamination — •Abhinav Naga, William Wong, Anke Kaltbeitzel, Maria D'Acunzi, Hans-Jürgen Butt, and Doris Vollmer — Max Planck Institute for Polymer Research,

Mainz, Germany

Lubricated surfaces are prone to accumulating contaminants due to their sticky yet slippery nature. The presence of contaminants, such as dust and dirt particles, alters their performance. An understanding of the effect of contaminated particles on the friction of surfaces is important not only from a fundamental perspective whereby further insight can be gained of the underlying mechanisms, but also from an applied perspective to predict the effectiveness of lubricated surfaces in the presence of contaminants.

In this study, we systematically contaminate lubricated silicone surfaces (Sylgard 184) and non-lubricated surfaces with spherical glass microparticles. We place a droplet on each surface and measure the force needed to push the droplet at different speeds towards an individual microparticle. We visualise this process with laser scanning confocal microscopy, focusing on the deformation inflicted by the microparticle on the droplet and its lubricant ridge. We combine these visualisations with our force measurements to suggest a mechanism for the removal of contaminated particles from surfaces using droplets, and we outline the differences between the outcomes on the lubricated and the non-lubricated surfaces. This work will help to understand droplet dynamics on imperfect or dirty lubricated surfaces.

DY 64.8 Fri 11:45 ZEU 260

Memory effects in polymer brushes showing co-nonsolvency effects — •Simon Schubotz[1,2], Petra Uhlmann[1], Andreas Fery[1,2], Jens-Uwe Sommer[1,2], and Günter K. Auernhammer[1,3] — [1]Leibniz-Institut für Polymerforschung Dresden e.V., 01069 Dresden, Germany — [2]Technische Universität Dresden, 01069 Dresden, Germany — [3]Max-Planck-Institut für Polymerforschung, 55128 Mainz, Germany

Some polymer brushes show a co-nonsolvency effect: They collapse in a mixture of two good solvents at some specific mixing ratio. Previous studies focused on the response of brushes which are entirely covered by a liquid. Here, we concentrate on partial wetting of co-nonsolvent polymer brushes, i.e., on the dynamics of a three-phase contact line moving over such brushes. We demonstrate that the wetting behavior depends on the wetting history of the polymer brush.

We use Poly(N-isopropylacrylamide) (PNiPAAm) brushes and water and ethanol as good solvents. In water/ethanol mixtures, the brush thickness is a non-monotonous function of the ethanol concentration. The memory of brushes is tested by consecutively depositing drops of increasing size at the same position. Previously deposited drops induce changes in the brush that modifies the wetting behavior (advancing contact angle) of subsequent drops.

We believe that the change in the contact angels is induced by adaptation like swelling of or liquid exchange in the brush due to the drop on top.

DY 64.9 Fri 12:00 ZEU 260

Gradient dynamics model for drops spreading on polymer brushes — •Simon Hartmann and Uwe Thiele — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Deutschland

When a liquid drop spreads on an adaptive substrate the latter changes its properties what may result in an intricate coupled dynamics of drop and substrate. We present a generic mesoscale hydrodynamic model for such processes that is written as a gradient dynamics on an underlying energy functional. We specify the model details for the example of a drop spreading on a dry polymer brush. There, liquid absorption into the brush results in swelling of the brush causing changes in the brush topography and wettability. The liquid may also advance within the brush via diffusion (or wicking) resulting in coupled drop and brush dynamics. The specific model accounts for coupled spreading, absorption and wicking dynamics when the underlying energy functional incorporates capillarity, wettability and brush energy. We employ a simple version of such a model to numerically simulate a droplet spreading on a swelling brush and provide an in-depth analysis of the simulation results and some interesting quantities.