CPP 7: Wetting, Fluidics and Liquids at Interfaces and Surfaces

Time: Monday 10:45–13:00 Location: H39

CPP 7.1 Mon 10:45 H39

Coupling of liquid-liquid phase separation and wetting dynamics — •Youchuang Chao, Olinka Ramírez-Soto, Christian Bahr, and Stefan Karpitschka — Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen, Germany

The interplay of phase separation and surface wetting is of great interest for various fields, ranging from industrial applications of oil recovery to the formation of membraneless organelles in living cells. Most of previous studies focus on understanding the interaction of phase separation with static wetting, i.e., pinned contact line conditions; nevertheless, how phase separation interacts with dynamical wetting, for instance, advancing contact lines is still unclear. Here, using highly mobile, Marangoni-contracted droplets of evaporating, binary liquid mixtures with a well-defined miscibility gap on fully wetting substrates, we explore the interplay of phase separation and wetting dynamics. Interestingly, we observe an abrupt wetting transition: from a contracted droplet state in the one-phase region to an actively driven spreading motion in the two-phase region; This is caused by the strong coupling of liquid-liquid phase separation and advancing contact lines, together with effects of evaporative enrichment and surface forces. Our finding may enable the development of novel surface processing strategies.

CPP 7.2 Mon 11:00 H39

Liquid phase separation during soft dynamic wetting — •Lukas Hauer[1], Zhuoyun Cai[2], Jonathan T. Pham[2], and Doris Vollmer[1] — [1]Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany — [2]Department of Chemical and Materials Engineering, University of Kentucky,Lexington, Kentucky, USA

Droplets sitting on soft substrates deform the material around the three-phase contact line, i.e., the formation of the wetting ridge. While on liquid films the ridge geometry is solely governed by capillarity, on (visco)elastic films elastic contributions add to the ridge geometry. Recently, on (visco)elastic materials a capillary induced phase-separated region of pure liquid was observed. Here, we investigate this phase separation on crosslinked PDMS films with differing amounts of free oligomer chains during dynamic wetting. We let droplets forcefully slide over PDMS films while monitoring the ridge zone with laser scanning confocal microscopy. Different dyes in the crosslinked network and in the free oligomers enable discrimination between the two phases. We find that phase-separation competes with the motion of the droplet: by tuning the droplets' speed, the phase-separated ridge height ranges from > 30 μm (at 5 μm/s) to no phase separation at all for fast speeds.

15 min. break

CPP 7.3 Mon 11:30 H39

Deep learning to analyze sliding drops — •Sajjad Shumaly, Fahimeh Darvish, Xiaomei Li, Alexander Saal, Chirag Hinduja, Werner Steffen, Oleksandra Kukharenko, Rüdiger Berger, and Hans-Jürgen Butt — Max Planck Institute for Polymer Research, Ackermannweg 10, D-55128, Mainz, Germany

Investigation of drop sliding forces requires knowledge of the shape of the drop close to the three-phase contact line. State-of-the-art contact angle measurement methods are designed for analyzing symmetric and high-resolution images of the drop. The analysis of videos of drops sliding down a tilted plane is hampered due to the low-resolution of the cutout area where the drop is visible. The drop is just a part of the whole image. In addition, drops sliding down a tilted plate are unsymmetrical in shape and the three-phase contact line may deform due to the sticky points.

In order to increase the accuracy of the measured contact angle, we trained a deep learning-based super-resolution model with an up-scale ratio of 3, i.e. the trained model is able to enlarge droplet images 9 times. In the second step, we performed an optimized polynomial fitting approach to measure the contact angle even for symmetric, asymmetric, or deformed droplets without the need for liquid parameters. To find the best parameters for polynomial fitting in our special problem, we conducted a systematic experiment using synthetic images.

CPP 7.4 Mon 11:45 H39

How often a Drops Sticks and Slips at a Wetting Transition — Chirag Hinduja[1], Alexandre Laroche[1,2], Sajjad Shumaly[1], Yujiao Wang[3,4], Doris Vollmer[1], Hans-Jürgen Butt[1], and •Rüdiger Berger[1] — [1]Max Planck Institute for Polymer Research, 55128 Mainz, Germany — [2]University of Zurich, 8057 Zurich, Switzerland — [3]Key Laboratory of Interfacial Physics and Technology, Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai 201800, China — [4]University of Chinese Academy of Sciences, Beijing 100049, China

We will discuss forces of sliding drops at a sharp wetting transitions featuring no topographic variation. Such surfaces with different wetting properties were made from chemical vapor deposition of trichlorooctylsilane (OTS) and tri-chloro(perfluoro) octylsilane (PFOCTS). We observed that drops sliding from an area of low to high contact angle hysteresis exhibit two force maxima. The drop motion is characterized by pinning of the advancing and receding contact lines, respectively. Accordingly, the motion of the drop follows two stick-slip processes. Drops sliding from an area of high to low contact angle hysteresis exhibit a single local force maximum, a single stick process, but two slip processes.

Sliding forces of drops were measured by a novel tool named scanning Drop Adhesion Force Instrument (sDAFI) which we use to image, locate and characterize wetting properties of cm-large areas with a resolution down to the micrometer-scale.

CPP 7.5 Mon 12:00 H39

Tunable lamellar topography driven by wetting dynamics — •Gissela Constante[1], Indra Apsite[1], Paul Auerbach[2], Sebastian Aland[2], Dennis Schönfeld[3], Thorsten Pretsch[3], Pavel Milkin[1], and Leonid Ionov[1,4] — [1]University of Bayreuth, Bayreuth, Germany — [2]Hochschule für Technik und Wirtschaft Dresden, Dresden, Germany — [3]Fraunhofer Institute for Applied Polymer Research IAP, Postdam, Germany — [4]Bavarian Polymer Institute, Bayreuth, Germany

The fabrication of switchable surfaces has been of interest in several fields such as biotechnology, industry, and others. The selection of materials and methods is crucial to provide proper control on the tunable surface. In this research, an exceptional high aspect ratio lamellar surface topography was fabricated by melt-electrowriting of microfibers of a shape-memory thermo-responsive polyurethane. Two different types of stimuli: temperature and light exposition were applied to modify the mechanical properties of shape memory polymer and thus program deformation and recovery of the surface. Wetting studies showed that the deformation of the high aspect ratio lamellar surface can be tunned not only manually, but as well by a liquid droplet. This behavior is controlled by temperature changes during direct heating/cooling or by exposure to light. The liquid in combination with thermo-responsive topography presents a new type of wetting behavior. This feature opens the possibility to apply such topographies for the design of smart elements for microfluidic devices, for example, smart valves.

CPP 7.6 Mon 12:15 H39

Gradient dynamics model for sessile drop evaporation in a gap: from simple to applied scenarios — •Simon Hartmann[1], Uwe Thiele[1], Christian Diddens[2], and Maziyar Jalaal[3] — [1]Institut für Theoretische Physik and Center for Nonlinear Science, Universität Münster — [2]Physics of Fluids group, Max Planck Center Twente for Complex Fluid Dynamics, and J. M. Burgers Center for Fluid Dynamics, University of Twente — [3]Van der Waals-Zeeman Institute, Institute of Physics, University of Amsterdam

We consider an evaporating drop of volatile partially wetting liquid on a rigid solid substrate. In addition, the setup is covered with a plate, forming a narrow gap with the substrate. First, we develop an efficient mesoscopic description of the liquid and vapor dynamics in a gradient dynamics form. It couples the diffusive dynamics of the vertically averaged vapour density in the narrow gap to an evolution equation for the drop profile. The dynamics is purely driven by a free energy functional that incorporates wetting, bulk and interface energies of the liquid as well as vapour entropy.

Subsequently, we employ numerical simulations to validate the model against both experiments and simulations based on Stokes equation. Finally, we show that the gradient dynamics approach allows for extensions of our model to cover more intricate scenarios, e.g., spreading drops of volatile liquid on polymer brushes or on porous media.

CPP 7.7 Mon 12:30 H39

Dewetting of thin lubricating films under aqueous drops on high and low surface energy surfaces — •Bidisha Bhatt, Shivam Gupta, Vasudevan Sumathi, Sivasurender Chandran, and Krishnacharya Khare — Indian Institute of Technology Kanpur, Kanpur, India

Understanding the stability of thin liquid films under different environments is important due to their potential applications, such as coatings, paints, and printing, to name a few. In this work, we investigate the stability of thin liquid films of a lubricating fluid under aqueous drops on slippery surfaces. Lubricating films under aqueous drops are found stable when the total excess free energy of the system is positive, which otherwise would dewet into droplets on hydrophilic surfaces. The dewetting dynamics and the apparent contact angle of the aqueous drop depend on the thickness of the lubricating film and the final morphology depends on interfacial boundary conditions between film and the substrate. However, the lubricating films on hydrophobic surfaces are stable under the aqueous drops, yet they can be destabilized using external perturbations like an electric field. Due to the electric field, surface capillary waves are generated at the film-drop interface, and the amplitude of the waves grows exponentially with time, similar to spinodal dewetting. Experimentally observed wavelength and growth rate of the surface capillary waves show good agreement with the theoretically predicted value using linear stability analysis. The dewetted droplets coalesce and form a uniform film again upon removing the applied voltage, making the dewetting process fully reversible.

CPP 7.8 Mon 12:45 H39

Cloaking Transition of Droplets on Lubricated Brushes — •Rodrique Badr[1], Friederike Schmid[1], Doris Vollmer[2], and Lukas Hauer[2] — [1]Johannes Gutenberg University, Mainz, Germany — [2]Max Plank Institute for Polymer Physics, Mainz, Germany

We study the equilibrium properties and wetting behavior of a simple liquid on a polymer brush, with and without the presence of lubricant. We investigate the behavior of the brush in terms of grafting density and the amount of lubricant present. As for the wetting behavior, we study a sessile droplet on top of the brush. Our model and choice of parameters results in the formation of a wetting ridge and in the cloaking of the droplet by the lubricant, a phenomenon that is observed experimentally and is of integral importance to the dynamics of sliding droplets. We quantify the cloaking in terms of its thickness, which increases with the amount of lubricant present, and provide thermodynamic theory to explain the behavior. In addition, we investigate the dependence of contact angles on the size of the droplet and the possible effect of line tension, as well as the dependence on the cloaking/lubrication of the brush.