DY 11: Wetting, Fluidics and Liquids at Interfaces and Surfaces II (joint session CPP/DY)

Time: Monday 17:30–18:30 Location: H34

DY 11.1 Mon 17:30 H34

Vapor-mediated wetting and imbibition control on micropatterned surfaces — •Ze Xu and Stefan Karpitschka — Fachbereich Physik, Universität Konstanz, Konstanz, Germany

Wetting and evaporation of droplets on micropatterned surfaces are ubiquitous in nature and key to many technological applications, such as water/ice-proof coatings, spray cooling, inkjet printing, and semiconductor surface processing. The wettability of micropatterned surfaces is governed by surface chemistry and topography, and significant effort has been devoted to overcoming this intrinsic behavior, e.g. to dry or coat structures surfaces, by use of external stimuli like electromagnetic fields. However, these methods usually require specific materials, thus limiting their practical use. Here, we show that the spreading behavior of water droplets on hydrophilic surface patterns can be controlled and even temporarily inhibited by the presence of the vapor of a low surface tension liquid. We show that this delayed wicking arises from Marangoni forces due to vapor condensation at the droplet periphery that compete with the capillary wicking force of the surface topography. We further demonstrate how modulating the vapor concentration in space and time can be used to guide droplets across patterns and even extract liquid from fully imbibed films, devising new strategies for coating, cleaning and drying of functional surface designs.

DY 11.2 Mon 17:45 H34

Gradient dynamics model for volatile binary mixtures including Marangoni flows — •Jan Diekmann und Uwe Thiele — Universität Münster, Wilhelm-Klemm-Straße 9, 48149 Münster

We present a mesoscopic thin-film model in gradient dynamics form for binary liquid mixtures on solid substrates incorporating interface tension-induced flow, and volatility in a narrow gap. Thereby, we use and expand models established in [1-4] by accounting for the two substances in each of two bulk phases - liquid and gas - and for the enrichment of one component at the liquid-gas interface. We discuss the different contributions to the free energy, thereby employing Flory-Huggins theory of mixing for the condensed phase and assuming ideal gases for the vapor phase. The resulting five-field model is then analyzed with numerical time simulations focusing on the interplay of the drop dynamics with the developing lateral concentration gradients, and the resulting Marangoni flows. The results are compared to experimental findings [5].

[1] Thiele et al. Physical Review Fluids, 2016. doi: 10.1103/physrevfluids.1.083903.

[2] Xu et al. Journal of Physics: Condensed Matter, 2015. doi:10.1088/0953-8984/27/8/085005.

[3] Hartmann et al. Langmuir, 2024. doi: 10.1021/acs.langmuir.3c03313.

[4] Thiele et al. Physical Review Letters, 2013. doi: 10.1103/physrevlett.111.117801.

[5] Chao et al. Proceedings of the National Academy of Sciences, 2022. doi: 10.1073/pnas.2203510119.

DY 11.3 Mon 18:00 H34

Fast dynamics of PNIPAM microgels at fluid interfaces: insights from droplet bouncing and jetting — Atieh Razavi, Suvendu Mandal, Benno Liebchen, Regine von Klitzing, and •Amin Rahimzadeh — Technische Universität Darmstadt, Hochschulstrasse 8, 64289 Darmstadt, Germany

PNIPAM microgels, as cross-linked polymer networks, are known to adsorb at the air-water interface, reducing surface tension. The kinetics of their adsorption, and thus the dynamic surface tension, depend on their cross-linking density, which determines the stiffness of individual microgels. Under interfacial perturbations such as dilation, softer microgels restore surface tension more rapidly, creating interfaces with higher surface elastic moduli, as shown by interfacial rheology studies using profile analysis tensiometry (1-10 s timescales). However, the behavior of microgels under very rapid interfacial deformations (milliseconds) remains unclear. We address this question through experiments involving droplet bouncing and jetting, processes relevant to applications such as inkjet printing and needle-free drug delivery. Our results demonstrate that microgels rapidly respond to fast interfacial deformations, with softer microgels restoring surface tension more efficiently. This quicker response allows greater interfacial extension in the presence of softer microgels. Molecular dynamics simulations corroborate our experimental findings, providing further insight into the mechanisms at play. This study highlights the critical role of microgel stiffness in determining their interfacial dynamics across a wide range of timescales and deformation rates.

DY 11.4 Mon 18:15 H34

Soft dynamic wetting transition — •Christopher Henkel[1], Vincent Bertin[2], Jacco Snoeijer[2], and Uwe Thiele[1,3] — [1]Institut für Theoretische Physik, Universität Münster, Germany — [2]Physics of Fluids Group, Faculty of Science and Technology, Mesa+ Institute, University of Twente, The Netherlands — [3]Center for Nonlinear Science (CeNoS), Universität Münster, Germany

We investigate the forced receding and advancing dynamics of a three-phase contact line on a viscoelastic substrate, i.e., the wetting transition of a substrate from macroscopically dry to wet or vice versa. Thereby, we use the Landau-Levich (or dip-coating) geometry, where a solid viscoelastic plate is dragged out of or pushed into a liquid bath. We employ a mesoscopic hydrodynamic model in long-wave approximation, i.e. valid at small contact angle and plate inclination. The elastic response of the substrate follows the Winkler foundation with a Kelvin-Voigt relaxation. In particular, we investigate how the shape and stability of the meniscus changes with the plate velocity and the substrate softness. In this we compare numeric results with asymptotic analytic calculations. Finally, we explore whether the occurrence of stick-slip motion in the advancing case can be predicted, using simple scaling arguments.