DY 41: Droplets and Wetting (joint session DY/CPP)

Time: Wednesday 15:00–16:45 Location: ZEU 147

DY 41.1 Wed 15:00 ZEU 147

Coalescence of liquid droplets in a quasi 2D liquid films — •Christoph Klopp, Ralf Stannarius, and Alexey Eremin — Otto von Guericke University, Institute for Physics, 39106 Magdeburg, Germany

Coalescence of droplets plays a crucial role in nature and modern technology. Various experimental and theoretical studies explored droplet dynamics in 3D and on 2D solid or liquid substrates [1-3]. Here, we demonstrate coalescence of isotropic droplets in thin quasi 2D liquids, an overheated smectic A films. We investigated their dynamics experimentally and measured the shape deformation during the whole merging process using high-speed imaging. This system is a unique example, where the lubrication approximation can be directly applied, and the smectic membrane plays the role of the precursor film. Our studies reveal the scaling laws of the coalescence time depending on the droplet size and the material parameters. We also compared our results with existing models for liquid lens coalescence on liquid and solid surfaces.

[1] Paulsen et al., Coalescence of bubbles and drops in an outer fluid, Nat. Commun. 5, 3182 (2014)
[2] Aarts et al., Hydrodynamics of Droplet Coalescence, Phys. Rev. Lett. 95, 164503 (2005)
[3] Shuravin et al., Coalescence of viscous two-dimensional smectic islands, Phys. Rev. E 99, 062702 (2019)

DY 41.2 Wed 15:15 ZEU 147

Surface wettability-induced magnitude change and sign inversion of the apparent line tension — •Binyu Zhao[1,4], Shuang Luo[2], Elmar Bonaccurso[3], Günter Auernhammer[4], Zhigang Li[2], and Longquan Chen[1] — [1]University of Electronic Science and Technology of China, Chengdu 610054, China — [2]The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong — [3]Airbus Central R & T, Materials X, Munich 81663, Germany — [4]Leibniz Institute of Polymer Research Dresden, Dresden 01069, Germany

Line tension is defined, thermodynamically, as the excess free energy per unit length of the contact line as postulated by Gibbs in 1878. Despite strenuous research efforts thence, the magnitude and sign of line tension remain in a hot debate. In this study, we determined the apparent line tension from the size-dependent contact angle of sessile nanodroplets on surfaces with different wettabilities via atomic force microscopy measurements. We showed that the apparent line tension changed its magnitude with the surface wettability and its sign changed from positive to negative for droplets on surfaces with an apparent contact angle higher than a critical value. Furthermore, using molecular dynamics simulations, we analysed the potential energy of liquid molecules within the nanodroplet and in the vicinity of the three-phase contact line. This allowed us to explain the surface wettability-induced magnitude change and sign inversion of the apparent line tension form the perspective of surface thermodynamics.

DY 41.3 Wed 15:30 ZEU 147

Characterizing the speed, size and shape of droplets during their flight from an ultrasonic spray coater — •Pieter Verding[1,2], Wim Deferme[1,2], and Werner Steffen[3] — [1]Hasselt University, Institute for Materials Research, Diepenbeek, Belgium — [2]IMEC, Diepenbeek, Belgium — [3]Max-Planck-Institut for Polymer research, Mainz, Germany

Ultrasonic spray coating - USSC is a technology offering numerous possibilities, such as depositing ultrathin homogeneous layers up to 20 nm on large scale. However, its application is limited due to the many process parameters which have a large impact on the quality of the coating. For this reason, measuring the droplet size, speed and concentration during the flight from the ultrasonically generated droplet to the substrate, gives insight in how to tune these parameters. Because thousands of droplets are created at the same time, measuring the properties of the droplets during flight is a complicated task.

Three different measurement techniques have been developed in and around an USSC setup. Dynamic Light Scattering (DLS) shows, after Fourier transformation, shifted peaks, representing the speed of the droplets. By applying Turbidimetry, it is possible to determine the size of the droplets. Droplets size and speed could be measured and gave comparable results as measured with a High Speed Camera (HSC). Furthermore, it was shown that the size and velocity of the droplets depend on the process parameters. It is therefore concluded from this work that a combination of DLS and Turbidimetry is a valuable alternative to measure droplets during their flight from an USSC.

DY 41.4 Wed 15:45 ZEU 147

Simulating the hydrodynamics of droplets on photo-switchable substrates — •Josua Grawitter and Holger Stark — Technische Universität Berlin, Institute of Theoretical Physics, Hardenbergstr. 36, 10623 Berlin, Germany

Interfaces between fluids and photo-switchable substrates provide a unique mechanism to precisely manipulate liquid droplets by creating and adapting a heterogeneous wettability landscape. Because droplets respond to changes in wettability, such interfaces provide a means to keep the droplets in non-equilibrium and thereby induce new states of dynamic wetting.

We present a boundary element method to determine the Stokes flow inside a droplet with its curved free surface and its flat interface at the substrate, where we apply the Navier boundary condition to permit motion of the contact line. In our approach we use the Cox-Voinov law [1] and introduce the velocity of the contact-line as a side condition. We also implement an iterative domain-splitting integration scheme capable of treating singular integrands, which are typical for the boundary element method. Using the implemented method, we study how droplets respond to specific spatiotemporal wettability patterns that either move or deform the droplet. Here, we present first studies of the spatio-temporal deformation dynamics induced by oscillating wettability along the contact line and of directed motion initiated by traveling wettability patterns. We specifically investigate how to design the patterns in order to maximize droplet speed.

[1] O. V. Voinov, Fluid Dyn. **11**, 714 (1976).

DY 41.5 Wed 16:00 ZEU 147

A bite of cotton candy physics — •Stephane Dorbolo[3], Floriane Weyer[1], Nicolas Vandewalle[1], and Alexandre Delory[2] — [1]GRASP, UR-CESAM, Departement de Physique, Universite de Liege, Belgium — [2]ESPCI, Paris, France — [3]FNRS, GRASP, UR-CESAM, Departement de Physique, Universite de Liege, Belgium

A cotton candy is made of kilometers of sugar fibers. These thin fibers are easily and quickly soluble into water. The system is generic and found applications in soldering and networks of nano-fibers. First, the wettability of the sugar is measured. The problem is complex since the sessile droplet modifies the substrate made of sugar. Second, the interactions of a sugar fiber with the humidity present in the air and with a single droplet are discussed through experimental investigations. Finally, a model is presented to describe the motion of a droplet along one single fiber.

DY 41.6 Wed 16:15 ZEU 147

Breakup Dynamics of Capillary Bridges on Hydrophobic Stripes — Maximilian Hartmann[1], •Mathis Fricke[2], Lukas Weimar[1], Dirk Gründing[2], Tomislav Maric[2], Dieter Bothe[2], and Steffen Hardt[1] — [1]Nano- and Microfluidics Group, TU Darmstadt, Alarich-Weiss-Straße 10, 64287 Darmstadt, Germany — [2]Mathematical Modeling and Analysis Group, TU Darmstadt, Alarich-Weiss-Straße 10, 64287 Darmstadt, Germany

The breakup dynamics of a capillary bridge on a hydrophobic stripe between two hydrophilic stripes is studied both experimentally and numerically. The capillary bridge is formed from an evaporating water droplet wetting three neighboring stripes of a chemically patterned surface. The simulations are based on the Volume-of-Fluid (VOF) method implemented in Free Surface 3D (FS3D). By considering the breakup process in phase space, the breakup dynamics can be evaluated without the uncertainty in determining the precise breakup time. It is found that within an intermediate inviscid regime, the breakup dynamics follows a $t^{2/3}$-scaling, indicating that the breakup process is dominated by the balance of inertial and capillary forces. For smaller bridge widths, the breakup velocity reaches a plateau, which is due to viscous forces becoming more important. In the final stage of breakup, the capillary bridge forms a liquid thread that breaks up consistent with the Rayleigh-Plateau instability. The existence of satellite droplets in a

regular pattern indicates that the primary breakup process is followed by self-similar secondary breakups.

DY 41.7 Wed 16:30 ZEU 147

Flow structure of marangoni-contracted sessile droplets — O. Ramirez[1], M.A. Hack[2], W. Kwiecinski[3], E.S. Kooij[3], T.J. Seegers[2], J.H. Snoeijer[2], and •S. Karpitschka[1] — [1]MPI for Dynamics and Self-Organization, Göttingen, Germany — [2]Physics of Fluids Group, University of Twente, Enschede, Netherlands — [3]Physics of Interfaces Group, University of Twente, Enschede, Netherlands

A droplet of two miscible liquids should spread over a high-energy surface until complete wetting. However, if one component is more volatile and has a higher surface tension, a quasi-stationary non-vanishing apparent contact angle can be observed. This is caused by the enrichment of the residual component near the contact line and the associated surface tension gradient. A hydrodynamic-evaporative model, using a long-wave approximation for the droplet coupled to diffusion limited evaporation predicts a balance between Marangoni and capillary flows and a power law between the apparent contact angle and the ambient humidity [Karpitschka et al., Langmuir (2017)]. This explanation differs from a recent model, where the low surface tension of a precursor around the droplet is held responsible [Benusiglio et al., Soft Matter (2018)]. A discrimination between possible mechanisms requires experimental resolution of the flow in the drop. We present uPIV measurements and relate them to the apparent shape of the drop, for aqueous solutions of various short chain carbon diols. Depending on the surface activity of the diol, its concentration, and the ambient humidity, we observe different regimes, indicating that multiple mechanisms lead to the observed angles.