CPP 17: Micro and Nano Fluidics I: Structured Substrates

Time: Wednesday 14:00–15:45 Location: H37

Invited Talk CPP 17.1 Wed 14:00 H37

Liquid distribution in a granular pile — Mario Scheel, Martin Brinkmann, •Stephan Herminghaus, and Ralf Seemann — MPI for Dynamics and Self-Organization

The addition of small amounts of liquid to a granulate dramatically chsnges the mechanical properties of the latter. This is due to capillary bridges forming between mutually adjacent grains in the pile, which exert an attractive force by virtue of the surface tension of the liquid. However, within a wide range of liquid content the mechanical properties of a wet granulate are surprisingly independent. This peculiar behavior is explored experimentally and theoretically by means of the liquid distribution within the granulate. The liquid distribution within a model granulate consisting of glass beads is analyzed experimentally by x-ray tomography as function of wettability and packing density. Liquid morphologies and the resulting capillary forces are calculated numerically by a minimization of the surface energy of the liquid. The constant mechanical properties of wet granulates for a large range of liquid contents is a result of one particular type of liquid morphology, which dominates over all other possible morphologies in case of a wetting liquid.

CPP 17.2 Wed 14:30 H37

Anisotropic self-diffusion in nanofluidic structures — •Martin Schoen[1], Keith Gubbins[2], and Henry Bock[3] — [1]Stranski-Laboratorium für Physikalische und Theoretische Chemie, Fakultät für Mathematik und Naturwissenschaften, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany — [2]Department of Chemical and Biomolecular Engineering, 911 Partners Way, North Carolina State University, Raleigh, NC 27695-7905, U.S.A. — [3]Department of Chemical Engineering, Heriot-Watt University, Edinburgh EH14 4AS, United Kingdom

By means of equilibrium molecular dynamics simulations we investigate self-diffusion in a "simple" fluid confined to nanoscopic slit-pores. The pore walls are decorated with wettable and nonwettable chemical "stripes" that alternate in the x-direction and are assumed infinitely long in the y-direction. We consider the impact of pore width as well as variations of the width of the wettable stripes. Depending on these model parameters and the thermodynamic conditions the confined fluid may exist as one of three morphologically distinct phases: a thin fluid film, a fluid bridge spanning the gap between the stripes, or a nanostructured liquid. By analyzing mean square displacements, velocity autocorrelation functions and in particular their power spectra a detailed picture of mass transport and its relation the dimensions of the chemical patterns on the substrates emerges. In particular, we find that the axial symmetry of the diffusion tensor preserved in the liquidlike phases is disrupted in both the film and the bridge phases.

CPP 17.3 Wed 14:45 H37

Manipulation of wetting morphologies in triangular grooves — •Krishnacharya Khare[1], Martin Brinkmann[1], Bruce M. Law[2], Stephan Herminghaus[1], and Ralf Seemann[1] — [1]Max Planck Institute for Dynamics and Self-Organization, D-37073 Göttingen — [2]Department of Physics, Kansas State University, USA

Wetting behavior of liquids in triangular grooves is studied experimentally and theoretically. For contact angles smaller than 90 degree minus half the opening angle of the groove, the liquid forms filaments with negative mean curvature extended along the entire length of the groove. For larger contact angles, liquid either forms elongated filaments of finite length and positive mean curvature or drop-like morphologies. Electrowetting is used to vary the contact angle and to switch between these morphologies. In this way, liquid filaments can be pulled out of a large feeding drop forming elongated filaments in prefabricated grooves. When being quenched from the filling to the non-filling regime the liquid filaments undergo dynamic instability and break up into isolated droplets with a preferred distance. This preferred droplet distance compares favorably with a straight forward theoretical model assuming the instability to be driven by the local variation of the Laplace pressure with filament width. This instability may be viewed as a generalization of the Rayleigh-Plateau instability and resembles the spinodal instability of thin films.

CPP 17.4 Wed 15:00 H37

Motion of nanodroplets near edges and wedges — A. Moosavi[1,2], •M. Rauscher[1,2], and S. Dietrich[1,2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

Nanodroplets residing near wedges or edges of solid substrates exhibit a disjoining pressure induced dynamics. Our nanoscale hydrodynamic calculations reveal that non-volatile droplets are attracted or repelled from edges or wedges depending on details of the corresponding laterally varying disjoining pressure generated, e.g., by a possible surface coating. [A. Moosavi et al.,Phys. Rev. Lett. 97, 236101 (2006)]

CPP 17.5 Wed 15:15 H37

Line tension effects for liquid droplets on circular surface domains — •Pedro Blecua, Jan Kierfeld, and Reinhard Lipowsky — Max Planck Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam, Germany

We study the morphologies of single liquid droplets wetting a substrate in the presence of a line tension of the three phase contact line. On a homogeneous substrate the line tension leads to a discontinuous unbinding of the droplet if its volume is decreased below a critical value. For a droplet wetting a structured surface with a circular domain, a *line tension contrast* gives rise to discontinuous depinning transitions of the contact line at the domain boundary as a function of the droplet volume, which can be studied analytically for axisymmetric droplet shapes. We calculate the corresponding free energy bifurcation diagram. Numerical minimization of the droplet free energy shows that line tension contrasts can stabilize non-axisymmetric droplet shapes thus modifying the bifurcation diagram.

CPP 17.6 Wed 15:30 H37

Nanobubbles in Solid-State Nanopores — •U. F. Keyser[1,2], R. M. M. Smeets[1], M. Y. Wu[1], N. H. Dekker[1], and C. Dekker[1] — [1]Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands — [2]Institut für Experimentelle Physik I, Universität Leipzig, Germany

From conductance and noise studies, we infer that nanometer-sized gaseous bubbles (nanobubbles) are the dominant noise source in solid-state nanopores[1]. We study the ionic conductance through solid-state nanopores as they are moved through the focus of an infrared laser beam. The resulting conductance profiles show strong variations in both the magnitude of the conductance and in the low-frequency noise when a single nanopore is measured multiple times. Differences up to 5 orders of magnitude are found in the current power spectral density. In addition, we measure an unexpected double-peak ionic conductance profile. A simple model of a cylindrical nanopore that contains a nanobubble explains the measured profile and accounts for the observed variations in the magnitude of the conductance.

[1] R. M. M. Smeets, U. F. Keyser et al., Phys. Rev. Lett. 97, 088101 (2006)