

CPP 30: Friction and Rheology

Time: Tuesday 11:45–13:00

Location: C 264

Invited Talk

CPP 30.1 Tue 11:45 C 264

Novel hyphenated rheology techniques for the study of quiescent and flow-induced polymer crystallization — VOLKER RÄNTZSCH, MÜRÜVVEY BEGÜM ÖZEN, KARL-FRIEDRICH RATZSCH, GISELA GUTHAUSEN, and MANFRED WILHELM — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Combining rheology with *in-situ* characterization techniques has received great attention in the past 30 years because such combinations lead to correlated information on flow properties, molecular dynamics and microstructure of soft matter such as polymers, liquid crystals or colloids. Additionally, flow profiles both in the linear and non-linear regime can be applied to monitor and also to modify the state of a sample and measure its implications on molecular dynamics and microstructure. Here we present novel hyphenated set-ups including RheoNMR and RheoSAXS. These unique combinations can be employed to simultaneously conduct a full rheological characterization (G' , G'' , $|\eta^*|$, etc.) while monitoring molecular dynamics via ^1H TD-NMR and nanoscale structure via 2D-SAXS for temperatures up to $+210^\circ\text{C}$. Possible applications for hyphenated rheology techniques include the measurement of crystallizing soft matter (fats, polymers, etc.) and multiphase systems during the application of shear protocols. To display the possibilities of these new techniques, studies on the quiescent and flow-induced crystallization of polyolefins are presented.

CPP 30.2 Tue 12:15 C 264

Measuring lateral force on soft and stiff materials with Intermodulation AFM — PER-ANDERS THORÉN, RICCARDO BORGANI, DANIEL FORCHHEIMER, and DAVID B. HAVILAND — Department of Applied Physics, KTH Royal Institute of Technology Stockholm SE-106 91, Sweden

We present a technique [1] for measuring the velocity-dependence of frictional forces on a single asperity (an AFM tip) reaching velocities up to several cm/s. The method is based on the measurement and analysis of intermodulation products, or frequency mixing of multiple drive tones near a high Q torsional resonance, which arise from the nonlinear frictional force. The method gives the oscillation amplitude dependence of both conservative and dissipative dynamic force quadratures, revealing the transition between static and dynamic friction at the nanometer scale. We show measurements on a stiff mica sample and for a few different soft polymer surfaces such as PDMS and a PS-LDPE-blend. Using a modified Prantl-Tomlinson model [1], we simulate the interaction of the cantilever and its tip with the mica-surface. The softer polymer surfaces are discussed in terms of a moving surface model [2], where the finite relaxation time of the lateral deformation of the viscoelastic surface gives rise to the hysteresis seen in the force quadrature curves.

[1]: P-A. Thorén et al., Nat. Commun. 7, doi:10.1038/ncomms13836 (2016)

[2]: P-A. Thorén et al., arXiv <http://arxiv.org/abs/1711.09024> (2017)

CPP 30.3 Tue 12:30 C 264

The transition from hydrodynamic via interfacial to dry friction for sheared surfaces in water — ALEXANDER SCHLAICH^{1,2}, JULIAN KAPPLER¹, and ROLAND R. NETZ¹ — ¹Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — ²Laboratoire Interdisciplinaire de Physique (LIPhy), CNRS and Université Grenoble Alpes, F-38000 Grenoble, France

The friction force between hydrated surfaces under shear is important in various fields ranging from biolubrication to flocculation and jamming. For large surface separation friction is well described by hydrodynamics and dominated by the water viscosity. As the normal pressure increases the surface separation goes down, leading to water properties that differ drastically from bulk and where the interfacial viscous properties dominate, thus modifying the friction force. When the normal pressure is so high that all water is squeezed out, dry friction is obtained.

We establish the general framework that describes the separation-dependent crossover between these three regimes. We concentrate on neutral yet polar membrane-like surfaces which exhibit stable water films and are governed by strong hydration repulsion and report extensive atomistic non-equilibrium molecular dynamics simulations. In that case it is important to correctly account for the constant water chemical potential as the water number changes according to the applied normal pressure.

CPP 30.4 Tue 12:45 C 264

Microliter viscometry using a bright-field microscope: η -DDM — MANUEL A. ESCOBEDO-SANCHEZ¹, JUAN-PABLO SEGOVIA-GUTIERREZ¹, ANGEL B. ZUCCOLOTTO-BERNEZ², JAN HANSEN¹, CAROLINE-C. MARCINIAK¹, KATRIN SACHOWSKY¹, FLORIAN PLATTEN¹, and STEFAN U. EGELHAAF¹ — ¹Condensed Matter Physics Laboratory, Heinrich Heine University, Düsseldorf, Germany — ²Departamento de Física, CINVESTAV-IPN, México D.F, Mexico

Passive microrheology can be considered as the counterpart of bulk small amplitude oscillatory shear measurements at the microscale. Microrheology exploits the Brownian motion of colloidal tracer particles. The mean-squared displacement (MSD) of the tracers is related to the rheological and viscometric properties of the suspension. It is commonly determined by particle tracking, which requires a careful selection of tracer trajectories. In contrast, Differential Dynamic Microscopy (DDM) avoids particle tracking and hence its limitations while still allowing for microliter-sized samples. DDM exploits the spatial Fourier transform of image differences which provides access to the MSD via the intermediate scattering function that is commonly acquired in dynamic light scattering experiments. We propose to combine DDM with the empirical Cox-Merz rule to estimate the steady shear viscosity of biological and soft matter systems. This technique even is applicable when reliable steady shear measurements are hard to achieve due to the torque resolution limit. Hence, an optical microscope can be used as a convenient and reliable microliter viscometer.