DY 26: Focus Session: Water – from Atmosphere to Space III (joint session CPP/DY)

Time: Tuesday 14:00–15:30 Location: ZEU/LICH

Topical Talk DY 26.1 Tue 14:00 ZEU/LICH

Why water in plants survives negative pressure — Marin Šako[1,2], Emanuel Schneck[3], Roland Netz[4], and •Matej Kanduč[1] — [1]Jožef Stefan Institute, Ljubljana, Slovenia — [2]University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia — [3]Physics Department, Technische Universität Darmstadt, Darmstadt, Germany — [4]Fachbereich Physik, Freie Universität Berlin, Berlin, Germany

It may seem surprising that we can lower the pressure in a liquid to negative values, far below the saturated vapor pressure at which a vapor phase should form. In water, such deeply metastable states are possible only when it is exceptionally pure and free of nucleation sites. It is therefore even more striking that plants transport water at negative pressures down to -100 atm without cavitation, even though xylem sap is anything but pure: it contains dissolved ions, sugars, lipids, and other organic molecules. How is this possible?

In this talk, I will show how molecular simulations and theory can explain this surprising behavior. We find that amphiphilic molecules such as lipids can adsorb onto hydrophobic surface crevices — places that would normally trap nanobubbles. Once coated, these surface defects can no longer stabilize bubbles, which allows water to stay intact even under strong tension. This mechanism offers a molecular-level explanation for how trees transport water to heights of over 100 meters without cavitation. More broadly, it illustrates how soft-matter physics and interfacial molecular organization can control the mechanical stability of liquids under extreme conditions.

DY 26.2 Tue 14:30 ZEU/LICH

Cholesterol Controlled Photo-Switching Activity of Azobenzene Glycoconjugates in Lipid Membranes — •Prashant Hitaishi[1,2], Svenja C. Hövelmann[1,2], Michael Röhrl[3], Nicolas Hayen[1], Ella Diebell[1], Ali Ashtiani[1], Carlotta Mager[1], Thisbe Lindhorst[3], and Bridget M. Murphy[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Leibnizstraße 19, Kiel, 24118, Germany — [2]Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, Hamburg, 22607, Germany — [3]Otto Diels-Institut für Organische Chemie, University of Kiel, Germany

Reversible photo-switchable molecules enable precise optical control of soft interfaces and are attractive for smart surfaces and light-triggered drug delivery. Azobenzene glycoconjugates (Azo) undergo reversible trans-cis isomerization under alternating UV and visible illumination, thereby modulating their conformation and interactions with lipid membranes. Here, Azo is incorporated into DPPC monolayers containing 0, 15, or 30 mol% cholesterol to mimic biologically relevant membrane compositions. Langmuir monolayer isotherm studies combined with time-resolved illumination cycles and X-ray measurements are used to quantify Azo-induced changes in membrane structure and relaxation kinetics. Increasing cholesterol slows Azo photo-switching, indicating a more constrained, rigid nanoenvironment, and shows that membrane composition can be used to tune light responsiveness in lipid interfaces for designing azobenzene-based responsive biomaterials.

DY 26.3 Tue 14:45 ZEU/LICH

Photoelectron Angular Distributions of Ions Influenced by Surfactants at the Solution-Vapor Interface — •Shirin Gholami[1], Tillmann Buttersack[1], Clemens Richter[2], Rémi Dupuy[3], Daniela Torres-Díaz[1], Christophe Nicolas[4], Uwe Hergenhahn[1], and Hendrik Bluhm[1] — [1]Fritz Haber Institute of the Max Planck Society, Berlin, Germany — [2]SPECS Surface Nano Analysis GmbH, Berlin, Germany — [3]Sorbonne Université, CNRS, Paris, France — [4]Synchrotron SOLEIL, Paris, France

Aqueous liquid-vapor interfaces play key roles in atmospheric and oceanic processes. The ocean-air boundary forms the largest aqueous-vapor interface, covering over 70 % of Earth's surface. In addition to Na^+ and Cl^-, Mg^{2+} and SO_4^{2-} are the most abundant ions in ocean water.

Here, we investigate how Mg^{2+} and SO_4^{2-} ions behave at the aqueous solution-vapor interface in the presence of charged surfactants. Using sub-monolayer coverages of octylamine $-\mathrm{CNH}_3^+$ and octanoate $-\mathrm{COO}^-$, we examine how these surfactants modify the distance of the ions from the interface. Liquid-jet X-ray photoelectron spectroscopy in combination with photoelectron angular distributions provides Å-scale depth sensitivity, enabling us to quantify ion-surfactant interactions.

Our results show that differently charged surfactants shift the interfacial positioning of Mg^{2+} and SO_4^{2-}, and that specific ion-ion interactions influence their interfacial propensity.These findings reveal how surfactants govern the depth distribution of ions, providing insight into oceanic and atmospheric processes.

DY 26.4 Tue 15:00 ZEU/LICH

Contact line dynamics on moving fibers measured by X-ray holography — •Louisa E. Kraft[1,2], Jens Lucht[3], Fiona Berner[1,2], Hannes P. Hoeppe[3], Tobias Eklund[1,2], Yizhi Liu[1], Markus Osterhoff[3], Tim Salditt[3], Hans-Jürgen Butt[1], and Katrin Amann-Winkel[1,2] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Johannes Gutenberg University, Institute for Physics, Mainz, Germany — [3]Georg-August-University, Institute of X-ray Physics, Göttingen, Germany

The wetting properties of solid surfaces are important for many natural and industrial processes, especially with respect to dynamic wetting. The wetting dynamic of solid surfaces, in particular the quantitative description of the dynamic contact angles, is still under debate. Dynamic contact angle variations connect macroscopically measured quantities with microscopic processes. Most studies rely on optical or confocal microscopy which limits the experimental access to the sub-microscopic region where these processes take place. We present data from X-ray holography experiments, imaging the three-phase contact line on moving glass fibers with an improved spatial resolution of about 450 nm combined with a temporal resolution of 10 Hz. We used the GINIX nanofocusing setup at the P10 beamline at PETRA III (DESY, Hamburg). The used glass fibers were pulled out of a liquid bath filled with varying aqueous solutions while changing the lateral velocity. We could clearly observe a decrease of the receding dynamic contact angle with increasing fiber velocity confirming the predictions of dynamic wetting theory.

DY 26.5 Tue 15:15 ZEU/LICH

Properties of micrometre-sized supercooled water droplets — Claudia Goy[1], •Frédéric Caupin[2], Felix Lehmkühler[1], and Robert E. Grisenti[3,4] — [1]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany — [2]Université Claude Bernard Lyon 1, Villeurbanne, France — [3]GSI, Darmstadt, Germany — [4]J. W. Goethe-Universität, Frankfurt am Main, Germany

Water displays a wide range of anomalous behaviors, many of which become particularly pronounced in the supercooled state, where its properties deviate strongly from those of other liquids. A prevailing hypothesis suggests that, at low temperatures, water may locally adopt two distinct structural motifs. This presentation will discuss results from temperature-dependent experiments that probe the physical and chemical properties of liquid water. The studies employ evaporatively cooled liquid jets in vacuum, investigated with techniques such as Raman spectroscopy and X-ray spectroscopy. These approaches enable a detailed examination of inter- and intramolecular vibrational modes, providing insight into the molecular dynamics of cooling water and optical properties, including the refractive index. Together, these experimental methods offer a comprehensive view of the temperature-dependent behavior of water, shedding light on the complex interactions that drive its anomalies. Through these studies, we aim to elucidate the mechanisms governing water's unique behavior in the supercooled regime and contribute to a deeper understanding of its structural transformations and physical properties.