CPP 56: Membranes and vesicles II (joint session BP, CPP)

Time: Wednesday 15:00–18:30 Location: H 1028

Invited Talk CPP 56.1 Wed 15:00 H 1028

Caged Hyperpolarized Xenon in Phospholipid Membranes for NMR Sensing Applications — •Leif Schröder — Leibniz-Institut für Molekulare Pharmakologie (FMP), Berlin, Germany

Spin-hyperpolarized xenon comes with high sensitivity and specificity for NMR spectroscopy due to the large chemical shift range of the dissolved gas. Recent developments in indirect detection of temporarily caged atoms through chemical exchange saturation transfer with hyperpolarized nuclei (Hyper-CEST) allows to sense for the molecular environment of the NMR-active isotope Xe-129 despite being a noble gas. In fact, its tendency to participate in labile van der Waals interactions facilitates very sensitive NMR detection. The hydrophobicity of xenon causes easy partitioning into phospholipid membranes where it can be combined with hydrophobic molecular cages as their hosts that confer a specific chemical shift to the guest nuclei for easy Hyper-CEST detection. The CEST effect is sensitive to exchange dynamics and can therefore be used to characterize the conditions for the specific host-guest system in various environments. This talk will give an overview about applications such as sensing for membrane fluidity and integrity or NMR imaging studies of liposome tracking for targeted drug delivery.

CPP 56.2 Wed 15:30 H 1028

Lipid composition in fusion of model membrane systems studied by x-ray diffraction — •Sebastian Köhler[1], Yihui Xu[1], Ziad Khattari[2], and Tim Salditt[1] — [1]Institut für Röntgenphysik, Georg-August-Universität Göttingen — [2]Department of Physics, Hashemite University, Zarqa, Jordan

We have investigated the structure and interaction of solid-supported multilamellar phopholipid bilayers as model systems for membrane fusion in view of the formation of stalks (putative intermediate structures occurring during the fusion process). X-ray reflectivity and grazing incidence small angle x-ray scattering measurements have been performed on bilayer stacks of different ternary and quaternary lipid mixtures at varying osmotic pressure. Analysis of the obtained electron density profiles and pressure-distance curves reveals systematic changes in structure and hydration repulsion. The osmotic pressure needed to induce stalk formation at the transition from the fluid lamellar to the rhombohedral phase indicates how membrane fusion properties are modified by bilayer composition. We present phase diagrams for all studied lipid mixtures.

CPP 56.3 Wed 15:45 H 1028

VSG dynamics on the Trypanosome and on model membranes — Marius Glogger[1], Marie Spindler[1], Andreas Hartel[1,2], Nicola Jones[1], Markus Engstler[1], and •Susanne Fenz[1] — [1]Biocenter: Cell and Developmental Biology, University of Würzburg, Würzburg, Germany — [2]Department of Electrical Engineering, Columbia University, New York, New York 10027, United States

Trypanosomes are the pathogens of sleeping sickness in humans and Nagana in cattle. They exhibit a uniform surface coat of multiple copies of variable surface glycoproteins (VSGs). Trypanosomes use this extremely dense, albeit highly dynamic surface coat for protection against the host's innate immune response. The entire VSG surface coat can be exchanged by endocytosis of the old VSG and parallel exocytosis of a new VSG variant within 10 minutes. However, both processes are restricted to a small membrane invagination of the cell surface, the so-called flagellar pocket. The mobility of VSG is essential for the parasite's survival and the focus of our research interest. Trypanosomes are excellent model organisms because 95% of their surface coat consists of VSGs. Thus, comparable measurements in live cells and model membranes will allow us to separate active motion from passive diffusion. As VSGs are abundant they can be easily purified and subsequently integrated into supported lipid bilayers via their membrane anchor. We apply single-molecule fluorescence microscopy to study VSG dynamics in immobilized trypanosomes and model membranes with special emphasis on the modulating character of protein glycosylation.

CPP 56.4 Wed 16:00 H 1028

Al3+ binding effects on lipid membrane structure — Hannah Wayment-Steele[1], Sofia Svedhem[2], Lewis E. Johnson[3], Malkiat S. Johal[1], Björn Agnarsson[2], and •Angelika Kunze[4] — [1]Dept. of Chemistry, Pomona College, CA, USA — [2]Dept. of Applied Physics, Chalmers Univ. of Technology, Göteborg, Sweden — [3]Dept. of Chemistry, Univ. of Washington, Seattle, WA, USA — [4]Inst. of Physical Chemistry, Univ. of Göttingen, Göttingen, Germany

Aluminum is found in daily life as a contaminant in food-contact articles as well as in medical and cosmetic products. However, the aluminum ion has been identified as a neurotoxin; several studies have suggested that increased Al3+ concentrations are correlated with increased risks for Alzheimer's disease. The toxicity of the Al3+ derives from structural changes induced in membranes upon binding; it increases membrane rigidity, facilitates vesicle fusion and rupture. However, the mechanisms for these processes are still not fully understood.

Here, we elucidate the effect of Al3+ ions on neutral and charged mixed supported lipid membranes (SLMs) using a variety of surface sensitive experimental techniques in combination with molecular dynamic (MD) simulations.

Our results show that Al3+ affects lipid packing, bilayer thickness, diffusivity as well as it does induce irreversible domain formation in a mixed bilayer. The observed effects for neutral SLMs are mostly reversible whilst the effects observed for mixed SLMs are mostly irreversible. Notably does MD simulations reveal that Al3+ changes the order parameter of the fatty acid chains.

CPP 56.5 Wed 16:15 H 1028

Ultra-thin self-hydrated artificial membrane composed of DPPC and chitosan deposited without solvents — Maria J. Retamal[1,2], Marcelo A. Cisternas[1,2], Sebastian E. Gutierrez-Maldonado[3], Tomas Perez-Acle[3], Birger Seifert[1,2], Mark Busch[4], Patrick Huber[4], and •Ulrich G. Volkmann[1,2] — [1]SurfLab UC, Instituto de Fisica, Pontificia Universidad Catolica de Chile (UC), Santiago, Chile — [2]CIEN-UC, Santiago, Chile — [3]DLab, Fundación Ciencia y Vida, Santiago, Chile — [4]Institute of Materials Physics and Technology, Hamburg Univ. of Technology (TUHH), Hamburg-Harburg, Germany

We present the formation and characterization of a phospholipid bilayer (dipalmitoylphosphatidylcholine, DPPC) on a mattress of a polysaccharide (Chitosan) that keeps the membrane hydrated. The deposition of Chitosan (~25 Å) and DPPC (~60 Å) was performed from the gas phase in high vacuum onto a substrate of Si(100). The layer thickness was controlled in situ using Very High Resolution Ellipsometry (VHRE). Raman spectroscopy studies show that neither Chitosan nor DPPC molecules decompose during evaporation. With VHRE and AFM we have been able to detect phase transitions in the membrane. The presence of the Chitosan interlayer as a water reservoir is essential for both DPPC bilayer formation and stability. Our experiments at SurfLab UC show that the proposed sample preparation from the gas phase is reproducible and provides a natural environment for the DPPC bilayer. Reference: www.aip.org/publishing/journal-highlights/artificial-membranes-silicon

CPP 56.6 Wed 16:30 H 1028

Attraction between hydrated hydrophilic surfaces — •Matej Kanduc[1], Emanuel Schneck[2], and Roland Netz[1] — [1]Department of Physics, Free University Berlin — [2]Max Planck Institute of Colloids and Interfaces, Research Campus Golm

According to common knowledge, hydrophilic surfaces repel via hydration forces while hydrophobic surfaces attract, but mounting experimental evidence suggests that also hydrophilic surfaces can attract. Using all-atom molecular dynamics simulations at prescribed water chemical potential [1] we study the crossover from hydration repulsion to hydrophobic attraction between planar surfaces. We cover the complete spectrum from very hydrophobic surfaces (characterized by contact angles of 135°) to hydrophilic surfaces exhibiting complete wetting. Indeed, for a finite range of contact angles between 65° and 90°, we find a regime where hydrophilic surfaces attract at subnanometer separation and stably adhere without intervening water, in good agreement with experiments. Analysis of the total number of hydrogen bonds (HBs) formed by water and surface groups rationalizes this crossover between hydration repulsion and hydrophilic attraction in terms of a subtle balance [2]. Such solvent reorganization forces pre-

sumably underlie also other important phenomena, such as selective ion adsorption to interfaces as well as ion pair formation.

[1] M. Kanduc, A. Schlaich, E. Schneck, and R. Netz; Adv. Colloid Interface Sci. 208, 142 (2014).

[2] M. Kanduc, E. Schneck, and R. Netz; Chem. Phys. Lett. 610, 375-380 (2014)

15 min break

CPP 56.7 Wed 17:00 H 1028

Vesicles-on-a-chip: versatile fabrication of liposomes and polymersomes in microfluidic environment — •Julien Petit, Ingmar Polenz, Stephan Herminghaus, and Oliver Bäumchen — Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

Synthetic biology recently appeared as an emerging field of research for mimicking and understanding natural systems from a fundamental point of view. This "bottom-up" approach involves the investigation of the biological and physical properties and mechanisms of functional biological systems (from basic modules/parts of living cells to more complicated systems). One key challenge relies on the fabrication of compartments such as vesicles, that can be viewed as model membranes, as demonstrated by numerous studies during the past decades. Despite this fact, reliable methods for high-throughput production of vesicles (liposomes as well as polymersomes) in an easy and well-controlled manner are still in progress. In this scope, we propose a versatile method for producing monodisperse vesicles in a microfluidic environment from double-emulsions templates. The combination of the microfluidic chip design and the original channel treatment as well as the new fluid systems employed in the present study allows the production and manipulation of liposomes and polymersomes on demand. This new technique opens a playground for fundamental studies, e.g. on the collective behavior of vesicle clusters and their self-organization, as well as applications such as protein or drug encapsulation and mechanisms of targeted delivery.

CPP 56.8 Wed 17:15 H 1028

High resoultion mapping of the surface charge density of lipid bilayers under physiological conditions — •Thomas Fuhs, Lasse Hyldgaard Klausen, Flemming Besenbacher, and Mingdong Dong — Interdisciplinary Nanoscience Center (iNANO), Aarhus University, Aarhus, Denmark

The surface charge density of lipid bilayers governs the cellular uptake of charged particles and guides cell-cell and cell-surface interactions. Direct probing of the potential requires sub nanometer distances as the electrostatic potential is screened by high physiological salt concentrations. This prevented direct measurement of the SCD under physiological conditions. In this study we investigate supported bilayers of lipid mixtures that form domains of distinct surface charges, submerged in 150mM NaCl. We use a scanning ion-conductance microscope (SICM) setup to measure the ionic current through a nanopipette as the pipette is scanned several nm above the sample. The charged headgroups of the lipids attract counter ions leading to a charge dependent enhancement of the ion concentration near the surface. This creates a measurable change of conductivity in the vicinity of the surface. As the dependency of the current on the SCD and pipette potential is nontrivial we characterized it using numerical solutions to Poisson and Nernst-Planck equations. Based on the simulation results we propose an imaging method. We confirm feasibility of the proposed method by experimentally mapping the local surface charge density of phase separated lipid bilayers.

CPP 56.9 Wed 17:30 H 1028

From destruction to protection - following peptide interactions with membrane interfaces — •Johannes Franz[1], Denise Schach[1], Joe E. Baio[2], Dan Graham[3], David G. Castner[3], Mischa Bonn[1], and Tobias Weidner[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Oregon State University, Corvallis, OR, USA — [3]University of Washington, Seattle, WA, USA

The cell membrane is the most important biological surface as its interaction with peptides is an integral part of transport, communication, energy transduction and survivability. However, an intrinsic difficulty in monitoring peptide interaction with membranes is the required surface sensitivity. Sum frequency generation (SFG) vibrational spectroscopy is well suited to study protein monolayers at lipid surfaces because of its inherent surface specificity. In this study, two different peptides are shown to interact with model membranes in very different ways.

GALA, a peptide mimicking viral fusion proteins, can disrupt membranes and escape from endosomes when triggered at low pH. We follow GALA activity at the molecular level and probe peptide folding as well as the disturbance and hydration of individual leaflets within model bilayers. We show that the cell-penetrating peptide SAP(E) solely interacts with the lipid headgroup region proving the first step of its proposed uptake mechanism. Peptides can also help stabilize lipid membranes. We discuss preliminary results about the effects of specific antifreeze proteins on the temperature stability of lipid mono- and bilayers.

CPP 56.10 Wed 17:45 H 1028

Addressing Multivalent Interactions Using Single Particle Tracking — •Stephan Block, Srdjan Acimovic, Mikael Käll, and Fredrik Höök — Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden

Multivalent interactions are observed in a multitude of biological processes (e.g., association of viruses or bacteria to their host cells). The involved receptors are nano-sized objects, making it challenging to assess the exact number of attachment points under physiological conditions. Using TIRF microscopy of fluorescently labelled, small unilamellar vesicles, which serve as a model system for the interaction of viruses with cell membranes, we show that multivalent interactions can be assessed by single particles tracking (SPT). The vesicles are linked to a supported lipid bilayer (SLB) using DNA-tethers carrying cholesterol groups at their ends, which automatically insert into the membranes and which allow a 2D diffusion of the vesicle above the SLB. The number of attachment points can be manipulated by the concentration ratio of vesicles to DNA-tethers. SPT allows to extract the diffusion coefficients on the level of single vesicles and histograms of the observed diffusion coefficients exhibit a spectrum of distinct peaks, which are related to subpopulations of vesicles differing by their number of DNA-tethers. This enables to recalculate fluctuations of the diffusion constant of a certain vesicle into fluctuations of the number of attachment points linking the vesicle to the SLB. The extension of this analysis to virus particle tracking including a comparison between SPT with fluorescence correlation spectroscopy will be discussed.

CPP 56.11 Wed 18:00 H 1028

Fast tracking with nanometer precision of individual proteins on the cell membrane — •Richard Taylor and Vahid Sandoghdar — Max Planck Institute for the Science of Light, Erlangen, Germany

The diffusion dynamics of membrane-incorporated proteins in the live cell is of great biological significance, but its studies are complicated and nuanced due to the diversity and heterogeneity of the membrane landscape. While fluorescence microscopy is routinely employed to investigate membrane phenomena, a low fluorescence rate and photobleaching limit this technique both on the short and long time scales. Furthermore, fluorescence microscopy suffers from a poor axial resolution.

Here, we report on the use of interferometric scattering (iSCAT) imaging with high three-dimensional spatio-temporal resolution. By labelling the proteins with a small gold nanoparticle, we are able to track indefinitely the protein diffusion in and out of plane, to an unparalleled nm-level accuracy at many thousands of frames per second. We present recent work on tracking of EGFR proteins in the model HeLa cell. Furthermore, we discuss the use of iSCAT imaging for studying out-of-membrane movement, thus allowing investigation into endocytotic reactions.

CPP 56.12 Wed 18:15 H 1028

The interaction of patterned amphiphilic dendritic nanomaterial with a lipid-monolayer — •M.Alejandra Sanchez, Katharina Bücher, Klaus Müllen, Mischa Bonn, and Ellen H.G Backus — Max Planck Institute for Polymer Research, Mainz, Germany

Well-defined amphiphilic dendrimeric macromolecules are biomimetic nanomaterials that can be used for drug delivery into cells. By organic synthesis, functional groups can be positioned in an atomically defined way, resulting in alternating patches of polar and apolar nature. Here we study systematically the interaction of various dendrimers with a model membrane consisting of a self-assembled monolayer of the lipid DPPC (1,2-dipalmitoyl-sn-glycero-3-phosphocholine) on water. By using sum frequency generation spectroscopy we obtain molec-

ular specific information about the membrane molecules and the water molecules in the vicinity of the lipid. Although the dendrimers are not surface-active at the bare water-air interface, they do interact strongly with the lipid monolayer. The presence of dendrimers in the solution below the monolayer causes changes in the water orientation as well as the alignment of the lipid molecules. Remarkably, details of the interaction depend on the surface groups present on the dendrimer. Very small changes (e.g. n-propyl vs iso-propyl) result in a different behavior. We link the molecular level picture with the efficiency of penetrating into the cells.