BP 17: Membranes and Vesicles

Time: Wednesday 15:00–17:00 Location: H13

BP 17.1 Wed 15:00 H13

Lipid domain diffusion in confined geometry — •Claudia Steinem, Nikolas K. Teiwes, and Ole M. Schütte — Georg-August Universität, Göttingen, Germany

Pore-spanning membranes (PSMs) are well-suited to investigate lipid domain diffusion. Recent findings have highlighted the dynamic nature of such lipid domains in the plasma membrane of mammalian cells and the key role of the underlying cytoskeleton network in confining their diffusion. We established PSMs composed of DOPC, sphingomyelin, and cholesterol with co-existing liquid ordered (lo)/liquid disordered (ld) domains on silicon substrates with micrometer-sized pores to investigate the diffusion of lo-domains confined in the freestanding parts of the PSMs. We compared the lo-domains in the artificial PSMs with PSMs derived from spreading giant plasma membrane vesicles (GPMVs) obtained from HEK-293 cells. In both cases, mobile ordered domains are visualized by fluorescence microscopy. From the trajectories of the individual mobile domains, the MSD is determined, which provides the diffusion constants as a function of domain size. The analysis reveals that the domains' diffusion constants are slowed down by orders of magnitude due to the confinement in the PSM, where the drag force is governed by both the friction in the bilayer and the coupling to the aqueous phase compared to the unrestricted case. From the analysis, the membrane surface viscosity can be extracted, which is by a factor of four smaller in case of the naturally derived membranes compared to the artificial ones, which can be explained in terms of the large protein content in the GPMV-derived membranes.

BP 17.2 Wed 15:15 H13

SAXS measurements of photoswitching in azobenzene lipid vesicles — Martina Ober[1], Adrian Müller-Deku[2], Oliver Thorn-Seshold[2], and •Bert Nickel[1] — [1]Faculty of Physics and CeNS, Ludwig-Maximilians-Universiät München, Geschwister-Scholl-Platz 1, Munich 80539, Germany — [2]Department of Pharmacy, Ludwig-Maximilians-Universität München, Butenandtstraße 5-13, Munich 81377, Germany,

We study the switching of photoresponsive lipids that allow for precise and reversible manipulation of membrane shape, permeability, and fluidity. Though these macroscopic responses are clear, it is unclear how large the changes of trans/cis ratio are, and whether they can be improved. Here, we use small-angle X-ray scattering to measure the thickness of photoswitchable lipid membranes, and we correlate lipid bilayer thickness to trans/cis ratios [1]. This reveals an unexpected dependency of photoswitching ratio upon aqueous phase composition. In buffer with ionic strength, we observe thickness variations twice as large as previously observed. Furthermore, soft X-rays can quantitatively isomerise photolipid membranes to the all-trans state; enabling X-ray-based membrane control. High energy X-rays do not influence the state of the photoswitches, presumably because they deposit less dose in the sample.

[1] M. Ober et al, Nanophotonics 2022; 11(10): 2361, DOI https://doi.org/10.1515/nanoph-2022-0053

BP 17.3 Wed 15:30 H13

Buoyant adhered vesicles in finite-range membrane-substrate interactions — •Lucia Wesenberg and Marcus Müller — Georg-August University, Göttingen, Germany

Constructing switchable interlayers between soft, biological objects and hard solids is a major challenge to dynamically regulate interface interactions. Here, we focus on the adhesion of lipid vesicles on bio-inspired polymer substrates. Experiments on the adhesion of liquid droplets or vesicles on switchable surfaces often facilitate contact with the substrate by a density difference. But when compared to theoretical expectations, this key experimental characteristic as well as the finite range of the membrane-substrate interaction have mostly been neglected. Thus, we systematically studied the adhesion of axially symmetric vesicles for finite-range membrane-substrate interaction and buoyancy through simulations. We investigated the adhesion transition of vesicles in the absence of thermal fluctuations. For downward buoyancy, vesicles sediment onto the substrate and there is no mean-field adhesion transition. Whereas for upward buoyancy, adhered vesicles are metastable at best. A proper adhesion transition can only occur at zero buoyancy. Moreover, length scales such as the capillary length, extrapolation length, and curvature-decay scale exhibit a pronounced dependence on interaction range and buoyancy and should not be used uninformed. Whereas these characteristics significantly modified the adhesion diagram, the local transversality condition - relating contact curvature to adhesion strength and vesicle's bending rigidity - remains accurate in the presence of moderate buoyancy.

BP 17.4 Wed 15:45 H13

Seaweed and dendritic domains of erucic acid monolayers — •Florian Gellert, Heiko Ahrens, Harm Wulff, and Christiane A. Helm — Institute of Physics, University of Greifswald, Germany

Nucleation and growth of domains in the liquid expanded/liquid condensed phase transition in monolayers of erucic acid at the air/water interface is studied with a Brewster Angle Microscope. With increase of the compression speed of the monolayer, the growth mode of the domains changes from seaweed to dendritic. Seaweed domains have broad tips, and wide, variable side branch spacing. Dendritic domains have narrower tips, and small, well-defined side branch spacing and a larger fractal dimension. The domains have different growth mechanisms: seaweed domains grow by surface diffusion while dendrite domains grow by diffusion in the subphase (Marangoni effect). The hydrodynamic models of domain growth will be discussed.

15 min. break

BP 17.5 Wed 16:15 H13

Asymmetric membranes, chemical potentials and homeostasis — •Martin Girard — Max-Planck-Institut für Polymerforschung

The properties of membranes in cells are tightly regulated. For instance, Sineski clearly established that E. Coli cells maintain a viscosity of around 2 poise, which is achieved by modulating the chemical composition of the membrane. How cells choose to alter this composition is not obvious, and has been associated with various controversies over the years.

I have recently introduced usage of chemical potential in computer simulations as a proxy for membrane homeostasis in cells. In coarse-grained simulations, this results in surprisingly good agreement between trends measured in cells and simulation results. I have also shown that this model can be used as a proxy for flippase proteins, and thus enables simulations of asymmetric membranes. Using this model, I will show that imposing asymmetries in membranes can result in surprising behavior. For example, that cholesterol concentration can become correlated with the presence of unsaturated lipids, in accord with experimental measurements. I will discuss the biological implications of these results.

BP 17.6 Wed 16:30 H13

Coherent Diffractive Imaging of Synaptic Vesicles by Femtosecond FEL pulses — •Charlotte Neuhaus[1], Jette Alfken[1], Moritz Stammer[1], SPB Team[2], Marcelo Ganzella[3], Reinhard Jahn[3], and Tim Salditt[1] — [1]Georg-August-Universität, Institute for X-ray Physics, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]European XFEL, Holzkoppel 4, 22869, Schenefeld, Germany — [3]Department of Neurobiology, Max-Planck-Institut for Multidisciplinary Sciences, Am Faßberg 11, 37077, Göttingen, Germany

Synaptic Vesicles (SVs) are secretory organelles which store neurotransmitters in presynaptic nerve endings. Due to the small size of vesicles ($R \approx 20\,nm$), a high spatial resolution is needed to gain more insights into the structure and structural dynamics of SVs, including functional lipid and protein components. To this end, solution SAXS experiments were previously used, yielding information about the average electron density of SVs. However, many of the relevant structural properties and parameters are screened by ensemble averaging, given the substantial polydispersity of SVs and unavoidable contaminations in the preparations. To overcome these limitations, we have carried out serial diffraction experiments on single vesicles (including lipid vesicles, proteoliposomes and SVs) delivered by an aerosol jet into a nano-focused X-ray Free Electron Laser (XFEL) beam. By the *'diffraction before destroy'* principle, the individual vesicles can be probed without radiation damage. Thousands of diffraction patterns can now be analyzed and reconstructed. We report these experiments and preliminary results (data analysis still ongoing).

BP 17.7 Wed 16:45 H13

Dynamics of active vesicles — Priyanka Iyer, Masoud Hoore, Thorsten Auth, Gerhard Gompper, and •Dmitry Fedosov — Institute of Biological Information Processing and Institute for Advanced Simulation, Forschungszentrum Juelich, Juelich 52425, Germany

Biological cells are able to generate intricate structures and respond to external stimuli, sculpting their membrane from inside. Simplified biomimetic systems can aid in understanding the principles which govern these shape changes and elucidate the response of the cell membrane under strong deformations. We employ simulations of vesicles enclosing active self-propelled particles to investigate different non-equilibrium shapes with tether-like protrusions and highly branched, dendritic structures. Furthermore, adhesive interactions between active particles and the membrane result in highly branched tethers at low particle activity, where the system exhibits 'pseudo-equilibrium' shapes. The resulting membrane fluctuations present anomalous behaviour at high adhesive strengths, as they show an initial decrease with increasing activity. The active particles show ordering at the membrane surface which initially increases with activity and then decreases. The obtained state diagram characterizes shapes of active vesicles for various conditions applied.