BP 9: Posters: Membranes

Time: Monday 17:30–19:30 Location: Poster B2

BP 9.1 Mon 17:30 Poster B2

Simulation of supported lipid bilayer formation — •Marc Fuhrmans and Marcus Müller — Theoretische Physik, Universität Göttingen, Göttingen, Deutschland

Exposition of unilamellar vesicles to attractive surfaces is a frequently used way to create supported lipid bilayers. Although this approach is known to produce continuous supported bilayers, the mechanism of their formation and its dependence on factors like surface roughness or membrane tension as well as the interplay between neighboring vesicles or the involvement of pre-adsorbed bilayer patches are not understood very well.

We have used dissipative particle dynamics simulations to assess different mechanisms of vesicle spreading on attractive surfaces, placing special emphasis on the orientation of the resulting bilayer. Making use of the universality of lipid-associated phenomena, we employed a solvent-free coarse-grained model, enabling us to cover the relatively large system sizes and time scales required. Our results indicate that, depending on the strength and range of the interactions with the substrate as well as the surface's roughness, different mechanisms of vesicle spreading occur, resulting in a switch from a predominant inside-up to an outside-up orientation of the created supported bilayer.

BP 9.2 Mon 17:30 Poster B2

Lattice-based Monte Carlo simulations of lipid membranes: Correspondence between triangular and square lattices — •Anastasiia B. Artemieva, Eugene P. Petrov, and Petra Schwille — Max Planck Institute of Biochemistry, Department of Cellular and Molecular Biophysics, 82152 Martinsried, Germany

We have recently demonstrated [1, 2] that lattice-based Monte Carlo (MC) allows one to study the structure and dynamics of membranes on experimentally relevant spatial scales and time intervals with moderate computational expenses. To date, most of lattice-based MC simulations of lipid membranes have been carried out on triangular lattices. Previously we have argued [1, 2] that the particular lattice geometry in MC simulations should not matter for reproducing the properties of the membrane at scales larger than the lattice unit, provided that the lipid–lipid interaction parameters are properly rescaled. Still, it remained an open question whether there exists a single conversion factor for all lipid–lipid interaction parameters to achieve identical results on triangular and square lattices, or the different interaction parameters have to be adjusted individually. Here, based on the properties of the Ising model, we demonstrate that one can indeed choose a single numerical coefficient to rescale all lipid–lipid interaction parameters depending on the lattice type, which provides one-to-one correspondence of thermodynamics properties of lipid membranes in lattice-based MC simulations on triangular and square lattices.

[1] J. Ehrig, E. P. Petrov, P. Schwille, *Biophys. J.* **100** (2011) 80

[2] J. Ehrig, E. P. Petrov, P. Schwille, *New J. Phys.* **13** (2011) 045019

BP 9.3 Mon 17:30 Poster B2

Cytoskeletal pinning prevents large-scale phase separation in model membranes — •Eugene P. Petrov[1,2], Senthil Arumugam[1], Jens Ehrig[1], and Petra Schwille[1,2] — [1]Biophysics, BIOTEC, Technische Universität Dresden, 01307 Dresden, Germany — [2]Max Planck Institute of Biochemistry, Department of Cellular and Molecular Biophysics, 82152 Martinsried, Germany

One important feature of cell membranes, which has been difficult to recapitulate in the artificial bilayer systems, is the membrane-associated cytoskeleton, which is considered to be one of the reasons for the sub-resolution size of membrane domains. Here we describe a minimal model cytoskeletal network formed by the prokaryotic tubulin homologue, FtsZ. Using giant unilamellar vesicles formed from a quaternary lipid mixture, we demonstrate that, on the one hand, the artificial membrane-associated cytoskeleton suppresses large-scale phase separation below the phase transition temperature, and, on the other hand, preserves phase separation above transition temperature. Our experimental observations support the ideas put forward in our previous simulation study [1]: In particular, the picket-fence effect on phase separation explains why micrometer-scale membrane domains are observed in isolated, cytoskeleton-free giant plasma membrane vesicles, but not in intact cell membranes. The experimentally observed suppression of large-scale phase separation much below the transition temperatures also serves as an argument in favor of the cryoprotective role of the cytoskeleton.

[1] J. Ehrig, E. P. Petrov, P. Schwille, *Biophys. J.* **100** (2011) 80.

BP 9.4 Mon 17:30 Poster B2

A physical description of actin-driven filopodia growth — •Denis Johann and Karsten Kruse — Uni Saarland, Postfach 151150, 66041 Saarbrücken, Germany

Filopodia are cytoskeleton-driven fingerlike protrusions of eukaryotic cells that are filled with actin filaments. Motivated by these structures, we investigate the length distribution of membrane protrusions driven by treadmilling filaments growing at the tip and disassembling at the base. To this end we use a continuum mean-field equation for the treadmilling filaments and their constituting subunits as well as for the membrane that is characterized by its surface tension and its bending rigidity. The coupling between the membrane and the cytoskeleton is mediated by an effective potential. Using a GPU-based parallelized algorithm, we find that this system can create stationary filopodia lengths. This length increases linearly with the concentration of free monomers at the bottom of the filopodia, but also depends on the kinetic parameters governing filament assembly and disassembly as well as the mechanical properties of the membrane. Finally, we characterize the filament length distribution in steady state.

BP 9.5 Mon 17:30 Poster B2

Single lipid molecule tracking on suspended lipid membranes — •Jens Ehrig[1], Susann Spindler[1], Cornelia Becker[1], Chia-Lung Hsieh[2], and Vahid Sandoghdar[1] — [1]MPI for the science of light, Erlangen, Germany — [2]Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan

We study the diffusion of single lipid molecules in free-standing lipid membranes by means of interferometric scattering microscopy (iSCAT)[1]. Free-standing aperture-spanning membranes are obtained by bursting giant unilamellar vesicles on a holey Si_3N_4 support[2]. The diffusion of lipids is studied by recording the scattering signal from gold nanoparticles (AuNP) bound to various molecules in the membrane including the ganglioside GM1 as well as phospholipids with a biotinylated headgroup. The AuNP are bound to GM1 via cholera toxin subunit B (CTxB) or antibodies. In case of the biotinylated phospholipids the biotin directly binds to the streptavidin-covered AuNP. Using the iSCAT technique we are able to resolve the motion of single lipid molecules at a high spatial and temporal resolution of below $\sim$2 nm and $\sim$1 μs, respectively. The results from measurements on free-standing membranes are compared to the ones obtained on supported lipid bilayers.

[1] K. Lindfors et al. *Phys Rev Lett* **93** 2004; P. Kukura et al. *Nat Methods* **6** 2009; [2] F. Heinemann and P. Schwille *ChemPhysChem* **12** 2011

BP 9.6 Mon 17:30 Poster B2

Optical force induced phagocytic particle binding and uptake by Giant Unilamellar Vesicles — •Andreas Meinel and Alexander Rohrbach — Lab for Bio- and Nano-Photonics, University of Freiburg, Germany

Phagocytosis is a central cellular mechanism in order to engulf particles into the cell membrane. Due to the complex interplay between active and passive cellular components, this mechanism is still not fully understood. A better investigation of the uptake process can be reached by reducing the system's complexity through using biomimetic systems. We utilize a Giant Unilamellar Vesicle (GUV) as a model for the cell membrane and a photonic force microscope (PFM) to induce and characterize the phagocytic particle uptake.

The PFM allows the trapping and tracking of a micron sized bead in all three dimensions with a high temporal resolution and a spatial precision in the nanometer range. In this study we focus on the acting forces between the particle and the cell membrane during the uptake process. Furthermore, the GUV-bead interaction is described by a theoretical model and compared with experimental results. The proposed methodology initiates a way to get access to the underlying energetical and mechanical concepts of the phagocytic particle uptake process.

BP 9.7 Mon 17:30 Poster B2

The interaction between polyproline containg cell-penetrating peptides and a lipid bilayer — •Johannes Franz, Kalina Peneva, Mischa Bonn, and Tobias Weidner — Max Planck Institute for Polymer Research, 55118 Mainz, Germany

Cell-penetrating peptides (CPPs) are membrane-permeable, short amino acid sequences that can be used to deliver covalently and non-covalently bound cargoes, i.e. drugs, into cells without damaging the cell membrane. However, the mechanism for CPP internalization is still subject of ongoing research. CPPs are divided into different subfamilies, depending on their chemical properties. They differ not only in their primary structure and overall charge, but also in their local folding. We used a modified form of SAP (sweet arrow peptide), an anionic CPP containing repetitive polyproline motifs, as a model peptide. The secondary structure of SAP(E), polyproline II (PPII), allows aggregation and could contribute to the peptides membrane permeability. Membrane models omit the complexity of the natural cell membrane while ensuring the full functionality of embedded peptides. We built up a polymer-assisted lipid bilayer to enable an unimpeded translocation of CPPs across the model membrane. Sum frequency generation (SFG) vibrational spectroscopy was used to investigate molecular interactions between SAP(E) and the tethered lipid bilayer during membrane translocation.

BP 9.8 Mon 17:30 Poster B2

Evaluation of methods for membrane preparations. — •Patrick Paul[1], Ulla Nolte[1], Reinhard Fässler[2], and Kay E. Gottschalk[1] — [1]Institute of Experimental Physics, Ulm University, Ulm, Germany — [2]Max Planck Institute of Biochemistry, Department of Molecular Medicine, Martinsried, Germany

The interaction of proteins with the intracellular side of cell membranes is important for a variety of cellular functions. To study these interactions, we try to prepare cell membranes of adherent cells such that the intracellular side is exposed. We characterize different membrane preparation methods with light microscopy and high resolution atomic force microscopy.

BP 9.9 Mon 17:30 Poster B2

Laser-spectroscopic Characterization of the Interaction between fluorescent Molecules and nano-sized Lipid Vesicles — •Alice Wilking, Idir Yahiatène, and Thomas Huser — Universität Bielefeld, Abteilung für Experimentalphysik, 33605 Bielefeld, Germany

Nanolipoproteins (NLPs) play an important role in the transport of bioactive compounds (e.g. cholesterol) through the blood. This work addresses the synthesis of NLPs and the investigation of their diffusion characteristics by Fluorescence Correlation Spectroscopy (FCS) to determine their size and shape in solution. We show the fabrication of 100 nm lipid vesicles using a mini-extruder. To make them visible the lipid vesicles were labeled with the lipid-intercalating fluorophore Di-I.

Di-I changes its photophysical character with its chemical environment. We also characterized Di-I by FCS, absorption and emission spectra in different solvents (changes in central wavelengths, dimer formation) and used dSTORM (direct Stochastical Optical Reconstruction Microscopy) to directly image and quantify the photophysical character of the dye; in its free and intercalated state. We found that Di-I is more photostable while it is intercalated. We also synthesized NLPs by mixing lipid vesicles with the protein ApoA-1. These NLPs are synthetic lipoproteins and as already demonstrated they portray a mean diameter of 7 nm - 15 nm. We have been able to confirm these values by FCS measurements.

BP 9.10 Mon 17:30 Poster B2

Pore-spanning lipid bilayers on microchips — •Theresa Kaufeld and Christoph F. Schmidt — Drittes Physikalisches Institut, Biophysik Universität Göttingen

Several methods exist for artificial membrane formation, e.g. membranes on a solid hydrophilic support, or the classical BLM, a free-standing lipid bilayer formed across hydrophobic apertures. We have here focused on the reconstitution of lipid bilayers on porous substrates, combining the stability of solid supports and the accessibility of both sides of the bilayer of the classical BLM which is necessary for electrical recordings of membrane channels. We have designed microsubstrates with individually addressable arrays of micrometer-sized apertures for electrical experiments and fluorescence microscopy, which are also suitable for other techniques such as mechanical manipulation of lipid bilayers. The substrates were characterized in terms of surface roughness and pore geometry by SEM and AFM. Impedance spectroscopy was used to characterize the substrate electrically and showed a resistance in the kilo-Ohm range, which is clearly distinguishable from the Giga-Ohm seal. Solvent-free lipid bilayers were formed by GUV-spreading and imaged with fluorescence microscopy. Electric experiments using Gramicidin D as a test ion channel showed suitability for single channel resolution.