BP 48: Membranes and Vesicles II

Time: Thursday 9:30–13:00 Location: HÜL 386

Invited Talk BP 48.1 Thu 9:30 HÜL 386

Shaping membranes: ENTH activity as a function of membrane tension — •Claudia Steinem[1], Martin Gleisner[1], Benjamin Kroppen[2], Nelli Teske[1], Andreas Janshoff[3], and Michael Meinecke[2] — [1]Institute of Organic and Biomolecular Chemistry, University of Göttingen, Germany, — [2]Department of Cellular Biochemistry, University of Göttingen, Germany — [3]Institute of Physical Chemistry, University of Göttingen, Germany

One of the early players of the process of clathrin-mediated endocytosis is the protein epsin. The epsin N-terminal homology domain (ENTH) binds to PtdIns(4,5)P2 resulting in tubulation as a result of membrane bending. This process is highly sensitive to the lateral membrane tension σ. By means of protruded pore-spanning membranes (PSMs, σ = 2 mN/m) and adhered giant unilamellar vesicles (GUVs, σ = 0.1-1 mN/m), we analyzed how ENTH binding alters membrane tension and whether membrane tubules are formed. Binding of ENTH to PtdIns(4,5)P2-doped protruded PSMs resulted in a growth of the protrusions, which indicates a reduction of the membrane tension. Tubulation was not observed. At low membrane tension of adhered GUV, ENTH binding induced tubular structures, while at higher membrane tension, ENTH interaction only led to a flattening of the GUVs. GUV flattening was attributed to an increased surface area caused by the insertion of the ENTH helix-0 into the membrane. Our results demonstrate that ENTH is capable of reducing the lateral membrane tension, which makes membrane bending energetically less costly.

BP 48.2 Thu 10:00 HÜL 386

Optical control of membrane permeability and fluidity with synthetic photoswitchable phospholipid molecules — •Stefanie Pritzl[1], Patrick Urban[1], James Frank[2], Carla Pernpeintner[1], Dirk Trauner[2], and Theobald Lohmüller[1] — [1]Chair for Photonics and Optoelectronics, Physics Department and CeNS, LMU Munich — [2]Department of Chemistry and CiPSM, LMU Munich

Phospholipid bilayer membranes are almost impermeable for ions or small substances while individual lipids and other membrane components within the bilayer sheet display a high level of lateral mobility. In our work, we devised a strategy to control both membrane permeability and fluidity with light by using photoswitchable phospholipid molecules embedded in an artificial bilayer membrane. These photolipids contain an azobenzene group in one of the hydrocarbon chains that undergoes photoisomerization upon irradiation with blue and UV light. The effect of photoswitching on membrane properties was tested by patch-clamp measurements on free-standing lipid membranes and by fluorescence methods. We observed a fast and reversible switching of membrane currents upon light activation, while membrane fluidity and lipid diffusion could be altered by a factor of two. These results highlight a new principle for controlling membrane properties on fast time scales, which are important for applications in cell signaling and drug delivery.

BP 48.3 Thu 10:15 HÜL 386

Controlling Membrane Rigidity and Deformability of Giant Lipid Vesicles with Photoswitchable Lipid Molecules — •Christian Röske[1], Carla Pernpeintner[1], James Frank[2], Patrick Urban[1], Dirk Trauner[2], and Theobald Lohmüller[1] — [1]Chair for Photonics and Optoelectronics, Physics Department, LMU Munich — [2]Department of Chemistry and CiPSM, LMU Munich

The shape and deformability of lipid vesicles is strongly depending on the mechanical properties of its bilayer membrane. Manipulating the membrane rigidity to induce membrane fluctuations or even shape transformations is usually achieved by changing the temperature, ion concentration, or molecular composition of the membrane itself. Such drastic changes of experimental parameters, however, are often non-reversible or difficult to control. Here, we demonstrate an alternative approach to manipulate membrane properties by incorporating photoswitchable lipid molecules into giant unilamellar vesicles (GUVs). The photolipids used in this study contain an azobenze moiety that undergoes reversible photoisomerization upon illumination with UV and visible light. The immediate effect of photoswitching on membrane stiffness and deformability was characterized by using optical tweezers and micropipette aspiration. We observe that membrane rigidity of GUVs can be switched fast and reversibly by almost two orders of magnitude depending on the photolipid concentration and the illumination intensity. Based on these findings, we devised a mechanism to utilize photolipid membranes for storing energy and to releasing it as locally usable work, which is only controlled by light.

BP 48.4 Thu 10:30 HÜL 386

Influence of Mono- and Divalent Ions on Cardiolipin Monolayers — •Renko Kensbock, Heiko Ahrens, and Christiane A. Helm — Inst. of Physics, Greifswald University, Germany

We investigate electrostatic interactions within negatively charged cardiolipin monolayers at the air-water interface with isotherms and real-time Brewster angle microscopy (BAM). A non-monotonic dependence for the LE/LC transition surface pressure on monovalent salt concentration (NaCl, KCl, CsCl) is observed with a maximum at around 0.1 M. No specificity for monovalent cations is detectable, which points to the prevalence of electrostatics. For subphases of 0.15 M NaCl with different divalent cations, the transition surface pressure decreases upon increase of their concentration. This indicates binding of divalent cations to the monolayer and an increase in electrostatic screening. The mono- and divalent salt effects are in accordance with electrostatic model calculations accounting for the head-group interactions: an electrostatic contribution (Grahame's equation) and counter-ion binding (law of mass action) are considered. The divalent binding constant assumes a 1:1 divalent cation to cardiolipin binding and is specific for the divalent cations used.

BP 48.5 Thu 10:45 HÜL 386

Receptor distribution in supported lipid bilayer upon binding of norovirus like particle — •Nagma Parveen[1], Daniel Midtvedt[1], Vladimir Zhdanov[1], Gustaf Rydell[2], Vesa Hytonen[3], and Fredrik Höök[1] — [1]Department of Physics, Chalmers University of Technology, Gothenburg, Sweden — [2]Department of Infectious Diseases, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden — [3]BioMediTech, University of Tampere, Biokatu 6, FI-33520 Tampere, Finland

Prior to internalization and infection, virions first bind to specific receptors present on the external lipid membrane of their host cells. This process is typically dynamic and multivalent, and known to influence the receptor distribution on the cell membrane and the shape of membranes, factors that are believed to be also crucial during the internalization process. To explore this, we have used fluorescently labeled histidine-tagged virus like particles (VLP) of norovirus and followed their binding to histo-blood group antigens (HBGAs) embedded in cell-membrane mimic, i.e. supported lipid bilayer (SLB). These HBGAs, e.g. Btype1 and Htype1 are known to be natural receptors of norovirus. Interestingly, we found that in case of Btype1 the VLPs bind in small clusters (1-2 μm) whereas the binding is homogeneous to Htype1 indicating that Btype1 forms clusters in SLB upon VLP binding. The kinetics of VLP binding and cluster growth is detected using time-lapse total internal fluorescence microscopy. The cluster formation is further supported by a competitive binding assay using inhibitious lectin.

30 min break

BP 48.6 Thu 11:30 HÜL 386

Minimum-free-energy paths in membrane fusion: Coarse-grained molecular dynamics simulations — •Yuliya Smirnova and Marcus Müller — Georg August University, Institute for Theoretical Physics, Göttingen, Germany

Collective phenomena in membranes such as fusion and fission involve reorganization of many molecules. Such transformations do not occur spontaneously but require the crossing of large (compared to k_BT) free energy barriers. Recent advances in free-energy calculation techniques, in particular, implementation of the so-called string method in MD simulations, allow us to study membrane transformations and calculate free energies along the transformation paths without a priori knowledge of the reaction coordinate. We focus on two initial stages of fusion: (1) bringing two membranes into close apposition and (2) forming an initial lipid connection (stalk) between the two apposed

bilayers. With help of the string method, we calculated the minimum free-energy paths of stalk formation between two apposed membranes as a function of membrane separation, lipid composition, and tension. Within the range of membrane separation distances, which allow formation of at least a metastable stalk structure, the free energy-barrier is not sensitive to the separation distance, however, the excess free-energy of the stalk decreases substantially with decreasing distance. Changing lipids to more fusiogenic species or introducing tension does not change the free-energy barrier significantly. On the other hand, the free-energy contribution of bringing two membranes from large to small separation distance significantly decreases for more fusiogenic lipids.

BP 48.7 Thu 11:45 HÜL 386

Lipid vesicle and SNARE-mediated membrane fusion studied by small-angle X-ray scattering — •Karlo Komorowski[1,2], Annalena Salditt[1], Yihui Xu[1], Halenur Yavuz[2], Reinhard Jahn[2], and Tim Salditt[1] — [1]University of Göttingen, Institute for X-Ray Physics, Göttingen, Germany — [2]Max-Planck-Institute for Biophysical Chemistry, Department of Neurobiology, Göttingen

Membrane fusion takes place in numerous physiological processes on the cellular and subcellular level as in the case of synaptic transmission. In order to release neurotransmitters into the synaptic cleft, fusion of synaptic vesicles with the presynaptic plasma membrane is mediated by the SNAREs synaptobrevin 2, syntaxin 1a and SNAP-25, initiating the merger by a zippering process of a four-helix bundle. Using mutants of synaptobrevin, a stable docking state between SNARE-liposomes can be arrested due to partial zippering of the SNARE complex. That way it is possible to overcome the short timescales in which the intermediates naturally occur. The biochemically well controlled systems are then suitable for steady state small-angle X-ray scattering (SAXS) experiments. Here we aim at the structure of the intermediates of the SNARE-mediated liposome fusion pathway, which can be partly arrested. In addition, we have performed protein-free vesicle fusion studies, aiming at an understanding of the role of inter-membrane potentials in docking and in fusion. Finally, we propose to enhance SAXS studies of vesicles by microfluidic sample environments, which allow the monitoring of different steps along the fusion pathway. In order to obtain structural parameters from the SAXS data, we make use of form and structure factor models of lipid bilayers.

BP 48.8 Thu 12:00 HÜL 386

Scattering Study on Small Unilamellar DMPC-Vesicles Incorporating the Saponin Escin — •Carina Dargel[1], Ramsia Sreij[1], Aurel Radulescu[2], and Thomas Hellweg[1] — [1]Physical and Biophysical Chemistry, Bielefeld University, Germany — [2]Jülich Center for Neutron Science, outstation at FRM II, Garching, Germany

1,2-Dimyristoyl-sn-glycero-3-phosphocholine (DMPC) belongs to the class of phospholipids and acts i.a. as a major membrane component. Therefore, model membranes consisting of DMPC mimic biological membranes quite well and allow to study effects of additives under different conditions, e.g. composition and temperature. Saponins are plant derived surfactants which occur among others in nuts and garlic and exhibit an amphiphilic structure built of a hydrophobic steroidic or triterpenic backbone with a varying number of hydrophilic sugar chains. The interaction of saponins with biological membranes is not yet scrutinized. Therefore in this study the effect of the pure saponin escin on small unilamellar vesicles of DMPC, prepared by extrusion, is investigated mainly by different scattering methods in dependence on the escin-amount and the temperature. An incorporation of escin above a critical amount can be deduced from the investigated parameters, namely the thermal phase transition temperature and vesicle size parameters like the radius, membrane thickness and lipid head-to-head distance within one monolayer.

BP 48.9 Thu 12:15 HÜL 386

Hydrodynamic interactions nearby elastic cell membranes — •Abdallah Daddi-Moussa-Ider, Achim Guckenberger, and Stephan Gekle — Biofluid Simulation and Modeling, Universität Bayreuth, Universitätsstraße 30, Bayreuth 95440, Germany

We present an analytical calculation of the hydrodynamic interaction between two spherical particles moving nearby an elastic cell whose membrane is endowed with a resistance towards shearing and bending. The theory predicts the frequency-dependent self- and pair-mobility functions up to the fifth order of the ratio between particle radius and membrane distance as well as between radius and interparticle distance. We find that the steady motion of two particles towards a planar elastic membrane possessing only shearing resistance leads to attractive interaction in contrast to the hard-wall case where the interaction is known to be repulsive. We further compute the mobility function of a particle moving perpendicular to the surface of a spherical capsule, finding that membrane curvature leads to the appearance of a prominent additional peak in the mobility caused by shear resistance. In the vanishing frequency limit, the particle mobility near a no-slip hard-sphere is recovered only when the membrane possesses a non-vanishing resistance towards shearing. Our analytical predictions are compared with boundary-integral simulations where an excellent agreement is obtained.

Reference

Daddi-Moussa-Ider, A. and Gekle, S., J. Chem. Phys., 145, 014905 (2016)

BP 48.10 Thu 12:30 HÜL 386

Optically active, self-assembled solid-state nanopores for single particle detection — •Andreas Schlegel, Paul V. Gwozdz, Christian Heyn, Wolfgang Hansen, and Robert H. Blick — Institute of Nanostructure and Solid State Physics and Center for Hybrid Nanostructures (CHyN), University of Hamburg, Germany

Nanopores (NPs) are crucial components for single molecule detection setups. So far, NPs are used in DC i.e. for ionic blockage current measurements. Typically those DC measurements lack parallelity for high throughput. To address this, attempts using optically active NPs have been made.

In contrast to existing solid-state NP (SNP) experiments, we present an approach to use an SNP system which is inherently self-assembled and provides scalable pore diameters. These MBE-grown III-V SNPs are contained in a GaAs membrane. Furthermore, the SNPs in our system show photoluminescence and are potentially optically active due to the quantum confined Stark effect. This will be used for DNA sequencing in the future [1].

We introduce a procedure to transfer the membranes from its wafer substrate onto a transparent polymer. The membranes shall be suspended to use the embedded SNPs in a setup which combines DC with optical read-out.

[1] P. V. Gwozdz et. al., Appl. Phys. Lett. **109**, 223103 (2016)

BP 48.11 Thu 12:45 HÜL 386

Adhesion ability of angiotensin II with model membranes — Julia Preu[1], Louis Tiefenauer[2], and •Thomas Gutberlet[3] — [1]Department of Molecular Membrane Biology, Max-Planck-Institute of Biophysics, Frankfurt, Germany — [2]Laboratory of Biomolecular Research, Paul Scherrer Institut, Villigen PSI, Switzerland — [3]Jülich Centre for Neutron Science at Heinz Maier-Leibnitz Zentrum, Forschungszentrum Jülich GmbH, Garching, Germany

The octa-peptide angiotensin II (Ang II, (H2N-Asp*Arg*Val*Tyr*Ile*His*Pro*Phe*COOH)) is one of the key player on blood pressure regulation in mammals. Predominantly binding to the Angiotensin type 1 and 2 receptors, the hormone is one of several peptide ligands binding to G protein coupled receptors (GPCR). The chemical nature of the amino acid sequence has an impact on the behavior in the proximity of membranes, demonstrated using different membrane model systems and biophysical methods. Applying electrochemical impedance spectroscopy and small angle x-ray scattering a detailed view on the adhesion of the peptide with model membrane surfaces was performed. The role of specific amino acids involved in the interaction with the phospholipid head group were investigated and, studying a truncated version of Ang II, Ang (1-7), the key role of the C-terminal phenylalanine was proven.