BP 9: Membranes and Interfaces

Time: Tuesday 10:30–13:00 Location: PC 203

BP 9.1 Tue 10:30 PC 203

Size distribution and radial density profile of synaptic vesicles by SAXS and light scattering — •Simon Castorph[1], Matthew Holt[2], Michael Sztucki[3], Reinhard Jahn[2], and Tim Salditt[1] — [1]Institute for X-ray Physics, Göttingen, Germany — [2]Max Plank Institute for Biophysical Chemistry, Göttingen, Germany — [3]European Synchrotron Radiation Facility, Grenoble, France

Synaptic vesicles are small membraneous organelles within the nerve terminal, encapsulating neurotransmitters by a lipid bilayer. The transport of the neurotransmitter, the fusion at the plasma membrane, and the release of the stored neurotransmitters into the synaptic cleft are since long know as essential step in nerve conduction of the chemical synapse. A detailed structural view of these molecular mechanisms is still lacking, not withstanding the enormous progress in the field during recent years [1, 2].

From measurements and quantitative fitting of small angle x-ray scattering curves and dynamic light scattering the averaged structural properties of synaptic vesicles can be determined.

We present SAXS measurements and fits revealing the width of the size distribution function and details of the radial scattering length profile of synaptic vesicles from rat brain. Representative values for the inner and outer radius and the size polydispersity as well as the density and width of the outer protein layer are obtained.

References: [1] Südhof, T. (2004) *Annu. Rev. Neurosci.* **27**, 509 - 547 [2] Takamori, S., et al. (2006) *Cell* **127**, 831 - 846

BP 9.2 Tue 10:45 PC 203

Local Heating of Phospholipid Bilayers with Gold Nanoparticles — •Alexander S. Urban[1], Margaret R. Horton[2], Srujan K. Dondapati[1], Tapan K. Sau[1], Thomas A. Klar[1], Joachim O. Rädler[2], and Jochen Feldmann[1] — [1]Photonics and Optoelectronics Group, Ludwig-Maximilians-Universität München — [2]Soft Condensed Matter Group , Ludwig-Maximilians-Universität München

We examine the possibility of increasing the membrane permeability for drugs and large bio-molecules by exploiting light-induced local heating of phospholipid bilayers containing gold nanoparticles. Giant unilamellar vesicles (GUVs) provide model systems for cellular membranes. They were prepared from 1,2-Dioleoyl-sn-Glycero-3-Phosphocholine via the electroformation method. Nanoparticles were made in various shapes (rods, spheres, cubes), sizes (20-100 nm) and with different surfactants, the latter playing an important role in the vesicle adhesion efficiency. Cetyl trimethylammonium bromide forms bilayers around the gold and was readily incorporated into GUV membranes. Too high a concentration of gold nanoparticles resulted in vesicle rupture due to osmotic stress. Furthermore, we investigated the heating of the GUV-gold complexes by illumination with laser light near the plasmon resonance. Increasing the laser intensity led to rupturing of the bilayers. The intensity required for rupture was highly dependent on nanoparticle size and the number of gold nanoparticles in close proximity. This model system is also being used to quantitatively study the transport of biologically active molecules across the lipid membrane through specific and local cell heating.

BP 9.3 Tue 11:00 PC 203

Transport at nanoscale revealed by the temperature dependence of ion conductance — •Catalin Chimerel[1], Liviu Movileanu[2], Ulrich Kleinekathöfer[1], and Mathias Winterhalter[1] — [1]Jacobs University Bremen, Bremen, Germany — [2]Syracuse University, Syracuse, New York, USA

Temperature dependent ion conductance in nanopores is measured in a wide range of electrolyte concentration and compared with molecular modeling. Single outer membrane protein F (OmpF) channels from E. coli are reconstituted into planar lipid bilayers. In a qualitative agreement with the experimental data, applied field molecular dynamics revealed atomistic details of the charge transport in the studied nanopore. Comparing the temperature dependence of the channel conductance with that of the bulk electrolyte conductivity in the range from 0°C to 72°C revealed that at low salt concentration the charge transport is mainly driven along the pore surface. Increasing the salt concentration saturates the surface charge transport and induces charge transport in the center of the nanopore. Opposite to the surface transport, the transport in the nanopore center favors the formation of ion pairs. Increasing the salt concentration increases the ion pair formation in the nanopore faster than in the bulk, therefore an increase in salt concentration leads to a slower increase in the nanopore conductance compared to the bulk conductivity. Increasing the temperature reduces the life time of the ion pairs and leads to a faster increase in channel conductance compared to the bulk conductivity.

BP 9.4 Tue 11:15 PC 203

Specular and Off-Specular Neutron Scattering from Solid-Supported Glycolipid Membrane Multilayers — •Emanuel Schneck[1], Florian Rehfeldt[2], Bruno Demé[3], Christian Gege[4], Richard Schmidt[4], and Motomu Tanaka[1] — [1]Physikalisch-Chemisches Institut, Universität Heidelberg, INF 253, 69120 Heidelberg, Germany — [2]Lehrstuhl für Biophysik E22, Technische Universität München, D-85748 Garching, Germany — [3]Institut Laue-Langevin, B.P. 156, F-38042 Grenoble Cedex 9, France — [4]Fachbereich Chemie, Universität Konstanz, Fach M 725, D-78457 Konstanz, Germany

Solid-supported glycolipid membrane multilayers, acting as well-defined model systems for the study of saccharide-mediated intermembrane interactions, were studied by specular and off-specular neutron scattering. Experiments were carried out at controlled temperatures and humidities, as well as under bulk water using a self-developed liquid cell. Force-distance relationships were recorded by measuring at various osmotic pressures. Mechanical properties of the studied membranes (i.e. bending moduli and inter-membrane compression moduli) were extracted by comparing scattering signals to reciprocal space maps simulated in the framework of smectic crystal theory. The results demonstrate that distinct variations in the oligosaccharide headgroup structures of the glycolipid molecules can result in significant changes in bending modulus and inter-membrane interactions.

15 min. break

BP 9.5 Tue 11:45 PC 203

Diffusion of nano-particles bound to model membranes — •Florian Rückerl, Lydia Woiterski, Josef Käs, and Carsten Selle — Universität Leipzig, Linnéstr. 5, 04103 Leipzig

The diffusive transport in membranes is an important process in cells, especially for signaling at the cell surface. In our investigations we compare the diffusive motion of different nano-particles (latex beads, quantum dots and quantum dots bound to lipids) in a variety of model membranes (monolayers, tethered bilayers and giant unilamellar vesicles). The model membranes,composed of ternary mixtures of lipids (DOPC, cholesterol and DPPC or Sphingomyelin), form liquid membranes and exhibit an ordered-disordered phase coexistence. Our aim is to elucidate the interactions of the membrane with the particles close to the border of such phase coexistence regions. The comparison of the systems enables to differentiate between the mechanisms that influence the diffusion, mainly electrostatic and hydrodynamic interactions. In monolayers the dipolar interaction is dominant leading to a confinement of the partially charged particle at the border of the domain. This transition from two- to one-dimensional diffusion is also dependent on the domain size, being most effective for small domains ($R < 1\mu m$). A similar change can be observed for latex beads adsorbed to lipid vesicle, where dipolar interactions are considered only weak and short-ranged.

Thus, domain associated dimensional reduction might play a significant role in more physiological bilayer systems. This might be utilized by cellular systems in order to control membrane protein diffusion.

BP 9.6 Tue 12:00 PC 203

Fluorescence correlation spectroscopy measurement of anomalous diffusion and crowding of lipid-bound proteins — •Margaret Horton[1], Felix Höfling[1,2], Joachim Rädler[1], and Thomas Franosch[1,2] — [1]Center for Nanoscience, Ludwigs-Maximilians-Universität, München, Germany — [2]Arnold Sommerfeld Center for Theoretical Physics, Ludwigs-Maximilians-Universität, München, Germany

In cell membranes, proteins and lipids diffuse in a highly heterogeneous landscape. Aggregates and dense domains of proteins or lipids can modify the path of diffusing molecules, giving rise to anomalous

transport. We study two-dimensional diffusion in membranes that are heterogeneous due to protein crowding. Using fluorescence correlation spectroscopy (FCS), we measure the diffusion of the protein avidin bound to biotinylated lipids in a supported bilayer. The density of avidin is controlled by varying the concentration of the lipid anchors. A clear distinction between anomalous and normal diffusion can be achieved with long measurement times (200s) and analysis of the mean squared displacement (MSD). This approach offers an alternative to standard methods of fitting autocorrelated FCS data to probe the dynamic arrangement of molecules in heterogeneous membranes. At low protein surface coverage, normal diffusion is observed. As more protein covers the membrane, there is a transition to anomalous diffusion that becomes more anomalous as the membrane becomes more crowded. These results suggest mechanisms by which cell membrane-associated molecules remain mobile in crowded environments.

BP 9.7 Tue 12:15 PC 203

A simulation approach to membrane protein aggregation via hydrophobic mismatch — •Gernot Guigas, Ulrich Schmidt, and Matthias Weiss — Cellular Biophysics Group, Deutsches Krebsforschungszentrum, Bioquant Center, Im Neuenheimer Feld 267, 69120 Heidelberg

The oligomerization of membrane proteins is a vital and ubiquitous phenomenon in living cells, e.g. when receptor proteins at the cell's plasma membrane oligomerize after ligand binding to trigger downstream signaling cascades. While a pairwise attractive interaction may account for many oligomerization phenomena, several lines of evidence also implicate membrane-mediated forces as important driving forces for membrane protein aggregation. Using dissipative particle dynamics (DPD), we have studied the aggregation of membrane proteins in a simple yet generic setup. Depending on the strength of the hydrophobic mismatch of the transmembrane domain and the surrounding lipid bilayer we observed a strong aggregation of membrane proteins. Moreover, the diffusive properties of the membrane proteins were strongly altered when the hydrophobic mismatch was varied.

BP 9.8 Tue 12:30 PC 203

Adhesion of Fluid Vesicles at Chemically Structured Substrates — Gunnar Linke, Reinhard Lipowsky, and •Thomas Gruhn — Max Planck Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam, Germany

Spatial immobilization of vesicles is important for many vesicle applications like the usage as chemical reactor in nano laboratories or as modules in membrane sensors. A controlled fixation of a vesicle can be achieved by adhering it to a finite adhesive domain on an otherwise repulsive substrate surface. We have studied this scenario with the help of mesoscopic Monte Carlo simulations. If the vesicle is larger than the attractive domain, the spreading of the vesicle onto the substrate is restricted by the size of this surface domain. Once the contact line of the adhering vesicle has reached the boundaries of the domain, further deflation of the vesicle leads to a regime of low membrane tension with pronounced shape fluctuations, which are now governed by the bending rigidity. For a circular domain and a small bending rigidity, the membrane oscillates strongly around an average spherical cap shape. If such a vesicle is deflated, the contact area increases or decreases with increasing osmotic pressure, depending on the relative size of the vesicle and the circular domain. The lateral localization of the vesicle's center-of-mass by such a domain is optimal for a certain domain radius, which is found to be rather independent of adhesion strength and bending rigidity. For vesicles adhering to stripe-shaped surface domains, the width of the contact area perpendicular to the stripe varies non-monotonically with the adhesion strength.

BP 9.9 Tue 12:45 PC 203

Effective potential for a fluctuating membrane between two walls — •Ana-Suncana Smith — II. Institut für Theoretische Physik, Universiät Stuttgart

Lipid membranes, due to their weak curvature elasticity, typically exhibit large out of plane fluctuations. In the vicinity of the substrate, it is the balancing of the attractive van der Waals potential against the bending deformations of the membrane and the steric repulsion arising from fluctuations, which determines the effective potential between the substrate and the membrane. The difficulty is that the effective potential is coupled to the fluctuation amplitude, which thus must be determined self-consistently. Exact solution of this problem has so far been found only in the vicinity of the unbinding transition (Lipowsky, R.; Leibler, S. Phys. Rev. Lett. 1986, 56, 2541). However, the shape of this potential away from the transition has not been calculated yet. We here present an approximate analytic model for the effective potential. We concentrate particularly on the case when the membrane is placed between two walls, and explore the shape of effective potential for a variety of direct interaction potentials.