BP 13: Posters: Biological Membranes

Time: Monday 17:15–20:00 Location: P3

BP 13.1 Mon 17:15 P3

Physical description of endosome dynamics — •Jonathan Edward Dawson[1], Lionel Foret[2], Roberto Villasen[3], Yannis Kalaidzidis[3], Lutz Brusch[4], Andreas Deutsch[4], Marino Zerial[3], and Frank Jülicher[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Ecole Normale Superieure, LPS, Paris, France — [3]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany — [4]ZIH-TUD, Dresden , Germany

We present a theoretical study describing the collective dynamics of a endosomal population in a cell. Endosomes are vesicular structures that sort and transport cargo molecules internalized into the cell by endocytosis. Dynamics of endosomal trafficking and sorting involves large number of individual endosomes which exchange material by fusion and fission thereby establish a network. In particular, using fluorescence microscopy with image analysis we quantify cargo distributions in a specific endosomal network and present a general theory that presents a quantitative understanding of experimental data. The steady state distribution of total fluorescence intensity of cargo molecules in endosomes strikingly display a broad power law, which is robust. Our theory can quantitatively reproduce the shape of steady distribution and their time dependence. We determine the kinetic parameters of early endosomal network in HeLa cells. Our theory predicts various scaling properties which have been observed in the experimental data.

BP 13.2 Mon 17:15 P3

Physical description of endosome dynamics — •Jonathan Edward Dawson[1], Lionel Foret[2], Claudio Collinet[3], Roberto Villasen[3], Yannis Kalaidzidis[3], Lutz Brusch[4], Andreas Deutsch[4], Marino Zerial[3], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Ecole Normale Superieure, LPS, Paris, France — [3]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany — [4]ZIH-TUD, Dresden , Germany

We present a theoretical study describing the collective dynamics of a endosomal population in a cell. Endosomes are vesicular structures that sort and transport cargo molecules that are internalized into the cell by endocytosis. Dynamics of endosomal trafficking and sorting involves a large number of individual endosomes which exchange material by fusion and fission thereby establish a dynamic network. Using fluorescence microscopy and automated image analysis we quantify cargo distributions in a specific endosomal network and present a general theory that provide a quantitative description of cargo trafficking in the network. The steady state distribution of total fluorescence intensity of cargo molecules in endosomes display a power law. Our theory can quantitatively reproduce the shape of steady distribution and their time dependence. We determine the kinetic parameters of early endosomal network in HeLa cells. Our theory predicts various scaling properties which have been observed in the experimental data.

BP 13.3 Mon 17:15 P3

Shape and fluctuations of a membrane pinned to a patterned substrate — •Daniel Schmidt[1], Udo Seifert[1], and Ana-Sunčana Smith[2] — [1]II. Institut für Theoretische Physik, Universität Stuttgart — [2]Institut für Theoretische Physik and Excellence Cluster: Engineering of Advanced Materials, Universität Erlangen-Nürnberg

We study the interplay between tension and nonspecific adhesion of a fluctuating phospholipid bilayer by pinning the membrane on a square-patterned substrate. The membrane itself is described by the Helfrich Hamiltonian. The membrane-substrate nonspecific interaction, which is in our model approximated by a harmonic potential, has a minimum at a finite distances from the substrate and thus induces membrane deformations. By minimizing the total free energy and using the equipartition theorem, we determine the shape and the roughness of the membrane, and follow the behavior of the membrane over the whole range of tensions.

By applying the theoretical results to the data acquired in experiments on an analogous in-vitro system, we can unambiguously determine the strength of the potential and the tension in the measurements.

BP 13.4 Mon 17:15 P3

Dynamics of specific adhesion — •Timo Bihr[1], Ana-Sunčana Smith[2], and Udo Seifert[1] — [1]II. Institut für Theoretische Physik, Uni Stuttgart — [2]Institut für Theoretische Physik and Excellence Cluster: Engineering of Advanced Materials, Universität Erlangen-Nürnberg

We perform dynamic Langevin simulations of a membrane specifically adhering to the substrate. The membrane is modeled by a Hamiltonian that apart from the Helfrich term contains a harmonic contribution accounting for the nonspecific membrane-substrate potential and a term associated with the formation of ligand-receptor bonds. During the simulation the receptors are immobilized on the substrate, whereas the ligands diffuse freely through the membrane. Ligand-receptor binding and unbinding is modeled by time-dependent rate constants that satisfy detailed balance.

We find that when the correlations between the bonds are weak, sparse arrangement of bonds are observed and the increase of the number of bonds in time is associated with a squeezed exponential. When the correlations between the bonds are strong, a domain grows radially out of a nucleation center. In the reaction limited regime, this behavior is analytically modeled and the results compare well to those arising from several experimental studies.

BP 13.5 Mon 17:15 P3

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

Pore-spanning lipid bilayers (nano- or micro-black-lipid membranes (BLM)) are useful for reconstituting and studying ion channels. These bilayers combine the stability of solid-supported membranes and the accessibility to both sides of the bilayer of classical BLMs. Due to defects in the bilayers it is, however, difficult to create fully electrically isolating membranes. In order to make experiments more effective it is desirable to construct several small arrays of pore-spanning lipid bilayers, which are individually addressable for electrical recordings.

We have therefore designed microchips for simultaneous electrical recording and fluorescence microscopy to study ion channels. The substrates were produced using standard clean-room techniques. Apertures of micrometer size were etched into silicon nitride membranes forming several porous microarrays. Integrated Ag/AgCl electrodes surrounding each microarray were fabricated by chemical vapour deposition to make them individually addressable for electrical recordings and to be able to switch between the microarrays during the measurement. The substrates were further functionalized by depositing a titanium/gold layer on the microporous arrays. A self-assembled octadecane-thiol monolayer was grown via thiol-gold interaction to stabilize the lipid bilayers. Lipid bilayers were formed by GUV-spreading. The substrates and lipid bilayers were visualized by fluorescence microscopy and atomic force microscopy.

BP 13.6 Mon 17:15 P3

The process of symmetry break on two-dimensional, biofunctionalized surfaces — •Alexander Körner[1], Fernanda Rossetti[1], Christina Deichmann[2], Almut Köhler[2], Doris Wedlich[2], and Motomu Tanaka[1] — [1]Institut of Physical Chemistry, University of Heidelberg, Germany — [2]Institut of Zoology 2, Institut of Technology Karlsruhe, Germany

A challenge in developmental biology is to understand how tissue structures evolve from uniform cell ensembles. The initial step can be generalized as the break of symmetry, which can be characterized by changes in cell polarity. In-vivo studies suggested that a change in cell polarity is induced by the gradient of morphogens (e.g. Wnt), little is known about the quantitative mechanisms. The main focus of this study is to design a model system for the formation of central nerval systems in Xenopus. Our strategy is to use two-dimensional, model membranes functionalized with cell adhesion molecules (Xcadherin 11) to give a cue that guides the symmetry break in tissue explants (animal caps) in a quantitative manner. The precise control of the lateral density of cadherin on the membrane surface was confirmed from changes in the mass density detected by a Quartz Crystal Microbalance. The thickness, roughness, and electron density of supported membranes in the presence and absence of cadherin molecules were determined by high energy X-ray reflectivity measurements. After confirming the quantitative functionalization, we placed Xenopus animal cap onto supported

membranes exposing Xcadherin 11, and found that cells injected with a promoter gene showed a sign of the change in their polarity.

BP 13.7 Mon 17:15 P3

Characterization of polymer-supported lipid membranes by X-ray and neutron reflectivity — •Fernanda F. Rossetti[1], Emanuel Schneck[1], Giovanna Fragneto[2], Oleg Konovalov[3], and Motomu Tanaka[1] — [1]Physical Chemistry of Biological Systems, University of Heidelberg, 69120 Heidelberg, Germany — [2]Institut Laue-Langevin, 6 rue Jules Horowitz, BP 156, 38042 Grenoble, France — [3]European Synchrotron Radiation Facility, Beamline ID 10B, 38043 Grenoble, France

Polymer-supported lipid membranes recently attracted increasing interest as planar models of cell membranes. Their major advantage over solid-supported membranes is a reduced frictional coupling between transmembrane proteins and the solid support, which reduces the risk of protein denaturation. However, the structures of such two-dimensional model membranes on the molecular level are still unknown. Here, we present a quantitative study–performed by X-ray and neutron reflectivity at the solid-liquid interface–of artificial and native lipid membranes prepared on polymer cushions made of ultrathin films of regenerated cellulose. The reflectivity results were consistent with the formation of homogeneous membranes over a macroscopically large area and allowed us to extract the properties of both the membrane and the cellulose layer. The interfacial forces acting between the membranes and the substrates were calculated by including contributions from Van der Waals, Helfrich and hydration forces. The resulting membrane-substrate equilibrium distance was found to coincide with the measured thickness of the hydrated cellulose films.

BP 13.8 Mon 17:15 P3

Confocal Raman Microscopy of Ternary Phase Domains in Model Membrane Systems — •Guillermo Beltramo, Magret Giesen, and Agnes Csiszár — Institute für Complexe Systeme Biomechanik ICS-7, Forschungszentrum Jülich, D 52425 Jülich, Germany

Recently lipid micro domains in cellular membranes as well as in model membranes like lipid bilayers and vesicles have been extensively investigated. The micro domains are formed due to a phase separation between areas of different cholesterol and lipid concentration. These membrane structures have been frequently studied using confocal fluorescence microscopy. Fluorescent dyes, however, may alter the properties of the molecules of interest. With the recent development of microscopic techniques, based on vibrational optical spectroscopy, novel means appeared to characterize lipid micro domains in model systems. Molecular vibrations are excited by non-elastically scattered photons. This is known as Raman effect: Laser light interacts with molecular vibrations in the molecule, resulting in a red-, respectively, blue-shift of the laser light. The energy shift gives detailed information on the chemical components in a membrane with high spatial and time resolution. In confocal Raman microscopy, the laser beam scans a sample volume and the membrane is imaged based on its vibrational properties. Hence, information about the membrane chemical composition is achieved bypassing the need for any staining procedures. In our work we present confocal Raman microscopy studies on model membranes composed of sphingomyeline, phospholipid, and cholesterol.

BP 13.9 Mon 17:15 P3

Self Organized Criticality and Fractal characteristics in Ion Channels: studies on Voltage Dependent Anion Channel — •Subhendu Ghosh[1], Jyotirmoy Banerjee[2], Smarajit Manna[2], Mahendra K. Verma[3], Naveen K. Bhatraju[4], and Mrinal K. Das[2] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Department of Biophysics University of Delhi South Campus New Delhi 110021, India. — [3]Indian Institute of Technology, Kanpur Kanpur 208016, India. — [4]School of Life Sciences University of Hyderabad Hyderabad, 500046, India

Self Organized Criticality (SOC) is a phenomenon which is highly talked about in various fields. We discuss the existence of SOC in the electrical behavior of the artificial and cell membranes, specifically in ion channels. We have measured the single-channel and multi-channel currents (with noise) through Voltage Dependent Anion Channel (VDAC) isolated from rat brain mitochondria, reconstituted into Bilayer Lipid Membrane (BLM) under various applied voltages. Power Spectrum analysis of Open Channel current time series data indicates power-law noise of 1/f nature. We argue that the origin of 1/f noise in open ion channels is self-organized-criticality as evident from waiting time statistics of big events. In addition we demonstrate that the experimental time series data of gating of VDAC at selected membrane potentials have Fractal behavior. On the other hand, we demonstrate that the multi-channel VDAC current (open) shows Multi-fractal properties. We conclude that Self-Organized-Criticality and Fractals are the realities of Ion Channels.

BP 13.10 Mon 17:15 P3

Biophysical applications of Brewster angle microscopy and imaging ellipsometry - an overview — •Peter H. Thiesen[1], Dirk Hönig[1], and Michael Howland[2] — [1]Accurion GmbH, Stresemannstr. 30, 37079 Göttingen — [2]UC Davis, USA

Ellipsometry is a very sensitive optical method, which has been used for about a hundred years to derive information about surfaces. It makes use of the fact that the polarization state of light may change when the light beam is reflected from a surface. If the surface is covered by a thin film (or a stack of films), the entire optical system of film & substrate influences the change in polarization. It is therefore possible to deduce information about the film properties, especially the film thickness. By using imaging technology, one can extend the classical ellipsometer to a new form of visualization tool or a microscope with extreme sensitivity to thin films. The following examples give an idea about the capability of imaging ellipsometry in the field of lipid layers. One focus will be the current developement in Brewster angle microscopy.

BP 13.11 Mon 17:15 P3

Crystallinity of purple membranes comprising the chloride-pumping bacteriorhodopsin variant D85T — •Daniel Rhinow[1], Ivan Chizhic[2], Roelf-Peter Baumann[2], Frank Noll[2], and Norbert Hampp[2] — [1]Max-Planck-Institut für Biophysik, Max-von-Laue-Str. 3, 60438 Frankfurt — [2]Philipps-Universität Marburg, Fachbereich Chemie, Hans-Meerwein-Str., 35032 Marburg

Purple membranes (PM) from Halobacterium salinarum comprise bacteriorhodopsin (BR) and lipids only and form a 2-D crystalline lattice in the cell membrane. In PMs comprising the chloride-pumping BR-variant D85T we have observed a tuneable tendency to form crystalline domains, which depends on pH-value and chloride ion concentration. We have combined small angle X-ray scattering, atomic force microscopy and freeze-fracture electron microscopy to analyze structural transitions within PM-D85T statistically as well as on the single membrane level. PM-D85T is a model system to study membrane protein association upon substrate binding in a native environment.

BP 13.12 Mon 17:15 P3

Atomistic Simulations of Hydration Forces between Biological Surfaces — •Emanuel Schneck, Felix Sedlmeier, and Roland Netz — Technical University of Munich

Biological surfaces interact via a complex interplay of various forces, some of which still elude a quantitative theoretical description. For instance, the experimentally observed repulsion between hydrophilic surfaces at short distances, known as hydration repulsion, is not yet fully understood, despite its crucial role in controlling the equilibrium distance between biomembranes. In this study we use atomistic molecular dynamics simulations to quantify the water-mediated repulsion between extended hydrophilic surfaces as a function of their distance. By using a novel method, based on the determination of the pressure-dependent chemical potential of water between the surfaces, we obtain pressure-distance relationships with very high accuracy. For rigid surfaces we find oscillations in the repulsion strength, originating from the discrete nature of water molecules. For soft surfaces we find a monotonic increase in the repulsion strength with decreasing water layer thickness. The latter case resembles the interaction of soft, hydrophilic biomembrane surfaces. Here, our results show quantitative agreement with experiments over the whole data range.

BP 13.13 Mon 17:15 P3

Membrane Adhesion via Homophilic Saccharide-Saccharide Interactions Investigated by Neutron Scattering — •Emanuel Schneck[1], Bruno Demé[2], Christian Gege[1,3], and Motomu Tanaka[1,4] — [1]University of Heidelberg — [2]Intitut Laue-Langevin, Grenoble — [3]University of Konstanz — [4]Karlsruhe Institute of Technology

Solid-supported membrane multilayers doped with membrane-anchored oligosaccharides bearing the LewisX motif (LeX lipid) were utilized as a model system of membrane adhesion mediated via ho-

mophilic carbohydrate-carbohydrate interactions. Specular and off-specular neutron scattering in bulk aqueous electrolytes allowed us to study multilayer structure and membrane mechanics at full hydration at various Ca2+ concentrations, indicating that membrane-anchored LeX cross-links the adjacent membranes. In order to estimate forces and energies required for cross-linking, we theoretically modeled the interactions between phospholipid membranes and compared this model with our experimental results on membranes doped with LeX lipids. We demonstrated that the bending rigidity, extracted from the off-specular scattering signals, is not significantly influenced by the molar fraction of LeX lipids, while the vertical compression modulus and thus the inter-membrane confinement increases with the molar fraction of LeX lipids.

BP 13.14 Mon 17:15 P3

Electroformation of super-giant unilamellar vesicles containing cationic lipids — •Christoph Herold, Petra Schwille, and Eugene P. Petrov — Biophysics, BIOTEC, TU Dresden, Tatzberg 47/49, 01307 Dresden, Germany

Super-giant unilamellar vesicles (SGUVs) of sizes > 100 μm are a convenient model system for freestanding lipid bilayers with a negligible curvature at a scale of tens of microns. This facilitates the investigation of dynamics and conformation of molecules/polymers interacting with the non-supported membrane by means of single molecule tracking [1].

Electroformation on indium-tin-oxide (ITO) coated glass slides is a standard method to produce GUVs [2]. When applied to lipid mixtures containing cationic lipids (e.g. DOTAP, EDOPC, etc.) the standard electroformation method frequently produces GUVs with sizes not exceeding 10-20 μm, which are additionally surrounded by a dense network of lipid tubules.

We demonstrate that annealing of the ITO slides at t $\sim$ 150 °C before the electroformation procedure allows one to reliably produce samples containing cationic SGUVs with diameters of 100 to 300 μm not contaminated by lipid tubular structures.

[1] C. Herold, P. Schwille, E.P. Petrov, Phys. Rev. Lett. 104, 148102 (2010)

[2] M. I. Angelova, S. Soleau, P. Meleard, J. F. Faucon, P. Bothorel, Prog. Colloid Polym. Sci. 89, 127 (1992).

BP 13.15 Mon 17:15 P3

Lipid layer studies at the LISA liquid interface diffractometer at PETRA III — •Klaas Loger[1], Annika Elsen[1], Lars Joergensen[2], Benjamin Runge[1], Christian Koops[1], Matthias Greve[1], Oliver Seeck[3], Beate Kloesgen[2], Olaf Magnussen[1], and Bridget Murphy[1] — [1]IEAP, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 19, D-24098 Kiel, Germany — [2]MEMPHYS, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, Denmark — [3]PETRA III at DESY, Notkestr. 85, D-22603 Hamburg, Germany

Lipid monolayers and bilayers at liquid-air and liquid-liquid interfaces are important model systems for biological membranes. The study of their molecular structure and properties by x-ray scattering methods requires special diffractometers, capable of tilting the beam at precise angles down onto the interface. The new liquid interface scattering apparatus (LISA) for the High Resolution Diffraction Beamline at PETRA III uses a non-dispersive tilting double crystal monochromator which allows reflectivity measurements without moving the sample. Here we present dedicated instrumentation for model membrane studies, specifically a newly developed experimental sample environment and first results on lipid layers at liquid interfaces.

BP 13.16 Mon 17:15 P3

Phase separation and near-critical fluctuations in two-component lipid membranes: Monte Carlo simulations on experimentally relevant scales — •Jens Ehrig, Eugene P. Petrov, and Petra Schwille — Biophysics, BIOTEC, TU Dresden, Tatzberg 47/49, 01307 Dresden, Germany

By means of lattice-based Monte Carlo simulations, we address properties of two-component lipid membranes on the experimentally relevant spatial scales of order of a micrometer and time intervals of order of a second, using DMPC/DSPC lipid mixtures as a model system. We find that, within a certain range of lipid compositions, the phase transition from the fluid phase to the fluid-gel phase coexistence proceeds via near-critical fluctuations. The line tension characterizing lipid domains in the fluid-gel coexistence region is found to be ~ 2 pN. When approaching the critical point, the line tension, the inverse correlation length of fluid-gel spatial fluctuations, and the corresponding inverse order parameter susceptibility of the membrane vanish. All these results are in agreement with recent experimental findings for model lipid membranes. We observe transient subdiffusive behavior of lipids in the presence of near-critical fluctuations, which is a new result important for understanding the origins of subdiffusion in cell membranes. The effects of the interaction of the membrane with the cytoskeleton will be discussed as well.

[1] J. Ehrig, E. P. Petrov, and P. Schwille, *Biophys. J.* **99** (2010), doi:10.1016/j.bpj.2010.11.002.

[2] J. Ehrig, E. P. Petrov, and P. Schwille, arXiv:1009.4860.

BP 13.17 Mon 17:15 P3

Interaction of charged colloidal beads with oppositely charged freestanding lipid membranes — •Markus Anton, Christoph Herold, Eugene P. Petrov, and Petra Schwille — Biophysics, BIOTEC, TU Dresden, Tatzberg 47/49, 01307 Dresden, Germany

Membrane-mediated interactions are believed to be important in lateral organization of membrane proteins and peptides. A system consisting of charged (sub)micrometer-sized colloidal particles interacting with an oppositely charged lipid membrane can serve as a simple model of a membrane with interacting inclusions.

Previously it was reported [1] that negatively charged micron-sized latex beads can form stable ordered clusters at oppositely charged surfactant membranes. In contrast, no mutual attraction between smaller ($<$ 100 nm in diameter) negatively charged polystyrene beads on cationic freestanding lipid membranes was observed [2]. To resolve this controversy, we carry out a systematic investigation of the interaction of negatively charged polystyrene beads with positively charged lipid membranes as a function of the bead size, surface density of membrane-attached beads, and the membrane charge density using fluorescence video microscopy with a sub-second time resolution.

[1] H. Aranda-Espinoza et al., Science 285, 394 (1999); L. Ramos et al., Science 286, 2325 (1999)

[2] C. Herold, P. Schwille, E. P. Petrov, Phys. Rev. Lett. 104, 148102 (2010)