BP 21: Posters - Membranes and Vesicles

Time: Tuesday 14:00–16:00 Location: P1A

BP 21.1 Tue 14:00 P1A

Direct proof of spontaneous translocation of lipid-covered hydrophobic nanoparticles through a phospholipid bilayer — Yachong Guo[1], Emmanuel Terazzi[2], Ralf Seemann[3], •Jean-baptiste Fleury[3], and Vladimir Baulin[1] — [1]Universitat Rovira i Virgili, Tarragona, Spain. — [2]University of Geneva, Geneva, Switzerland. — [3]Universität des Saarlandes, Saarbrücken, Germany.

It is generally accepted that small hydrophobic nanoparticles are blocked by lipid bilayers and accumulate in the bilayer core, whereas big nanoparticles can only penetrate cells through slow energy-dependent processes, such as endocytosis, lasting minutes. In contrast to expectations, we demonstrate that lipid-covered hydrophobic nanoparticles may translocate through lipid membranes by direct penetration within milliseconds. We identified the threshold size for translocation: nanoparticles with diameters smaller than 5 nm stay trapped in the bilayer, whereas those with diameters larger than 5 nm insert into the bilayer, opening pores in the bilayer. The direct proof of this size-dependent translocation was provided by an in situ observation of a single event of a nanoparticle quitting the bilayer. This was achieved with a specially designed microfluidic device combining optical fluorescence microscopy with simultaneous electrophysiological measurements. A quantitative analysis of the kinetic pathway of a single nanoparticle translocation event demonstrated that the translocation is irreversible and that the nanoparticle can translocate only once.

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BP 21.2 Tue 14:00 P1A

Shear-thinning and shear-thickening of a confined suspension of vesicles — •Abdessamad Nait Ouhra[1,2], Marine Thiébaud[1], Othmane Aouane[1,3], Hamid Ez-Zahraouy[2], Abdelilah Benyoussef[2], Christian Wagner[3], and Chaouqi Misbah[1] — [1]Université Grenoble Alpes France — [2]Université Mohammed V Rabat Maroc — [3]Experimental Physics, Saarland University, Saarbrücken, Germany

Widely regarded as an interesting model system for studying flow properties of blood, vesicles are closed membranes of phospholipids that mimic the cytoplasmic membranes of red blood cells (RBCs). In this study we analyse the rheology of a suspension of vesicles in a confined geometry: the suspension, bound by planar planes on each side, is subjected to a shear flow. Flow properties are then anaylzed as a function of shear rate $\dot{\gamma}$, the concentration of the suspension ϕ and the viscosity ratio $\lambda = \eta_{in}/\eta_{out}$, where η_{in} and η_{out} are the fluid viscosities of the inner (hemoglobin solution for RBC) and outer fluids, respectively. We find that the apparent (or effective viscosity) of the suspension exhibits either shear-thinning (decreasing viscosity with shear rate) or shear-thickening (increasing viscosity with shear rate). The shear thinning or thickening behaviors appear as subtle phenomena, dependant on viscosity contrast λ. We provide arguments about the possible sources of these phenomena.

BP 21.3 Tue 14:00 P1A

Analytical description of nanoparticle motion near an elastic membrane — •Rebecca Benelli, Abdallah Daddi-Moussa-Ider, and Stephan Gekle — Biofluid Simulation and Modeling, Fachbereich Physik, Universität Bayreuth

We investigate analytically the motion of an extended nanoparticle near an elastic membrane endowed with shearing rigidity. For the simpler case of a point particle or rather a particle distant to the membrane this has been done recently[1]. Taking the conditions resulting from an elastic membrane and combining them with the description of the motion of an extended spherical particle near a fluid-fluid-interface[2] leads to a linear equation system. This can be solved numerically in order to get the frequency dependent mobility of the particle.

[1] A. Daddi-Moussa-Ider, A. Guckenberger and S. Gekle. Long-lived anomalous thermal diffusion induced by elastic cell membranes on nearby particles. *Phys. Rev. E*, **93**(1):012612, 2016

[2] SH. Lee and LG. Leal. Motion of a sphere in the presence of a plane interface. *J. Fluid Mech.*, **98**(01):193-224, 1980

BP 21.4 Tue 14:00 P1A

Monte Carlo lattice modelling of a bilayer system — •Fabian Keller, Davit Hakobyan, and Andreas Heuer — Institute of Physical Chemistry, Corrensstraße 28/30 48149 Münster, Germany

Recently, a lattice model has been developed which allows one to describe the properties of lipid bilayer mixtures, containing DPPC and/or DLiPC [1]. It was introduced to examine the local phase separation and aggregation behavior of the respective lipids. The free energy functional is based on the lipid interaction enthalpy and lipid conformational chain entropy. All contributions can be extracted from short atomistic simulations. The model approach has proven to be able to correctly reproduce phase separation behavior and predict melting temperatures of gel phases for the lipid binary mixtures.

As cholesterol plays a crucial role in the dynamics of lipid bilayers, especially being prominent for its property to form the basis of lipid rafts, we present an extension of the lattice model by incorporation of cholesterol. We have to deal with different challenges, related, e.g., to the different sizes of cholesterol and DPPC/DLiPC. Adding cholesterol to the model will allow one to gain deeper insight into the fundamental mechanics of lipid raft formation and the basics of lipid-cholesterol interaction.

[1] D. Hakobyan, A. Heuer, submitted to J. Chem. Phys.

BP 21.5 Tue 14:00 P1A

Flat-to-curved transition of clathrin-mediated endocytosis — •Felix Frey[1,2], Delia Bucher[3], Kem Sochacki[4], Justin Taraska[4], Karl Rohr[2,5,6], Steeve Boulant[3], and Ulrich Schwarz[1,2] — [1]Institute for Theoretical Physics, Heidelberg University, Germany — [2]BioQuant, Heidelberg University, Germany — [3]Department of Infectious Diseases, Virology, Heidelberg University, Germany — [4]National Institutes of Health, Bethesda, U.S.A. — [5]Department of Bioinformatics and Functional Genomics, Heidelberg University, Germany — [6]DKFZ, Heidelberg, Germany

The self-assembly of proteins into supramolecular complexes is essential for many cell functions. Examples are the growth of cell adhesion contacts, the formation of the cytoskeleton or the assembly of clathrin-coated vesicles mediating endocytosis. Here we investigate the assembly of flat clathrin arrays at the cell membrane that subsequently reshape to form curved pits. By combining metal replica electron microscopy, correlative light and electron microscopy, live fluorescence microscopy, image analysis and mathematical modeling we demonstrate that acquisition of membrane curvature during clathrin-mediated endocytosis in mammalian cells does not show a linear correlation with clathrin coat assembly. Instead we show that clathrin structures first grow flat and then undergo a substantial ultra-structural reorganization prior to invagination of the plasma membrane. We determine at what stage of coat assembly curvature occurs and demonstrate a relation to plasma membrane tension.

BP 21.6 Tue 14:00 P1A

Diffusion of membrane-bound ligand-receptor bonds — •Henning Stumpf[1], Daniel Schmidt[1], and Ana-Sunčana Smith[1,2] — [1]PULS Group, Institut für Theoretische Physik I, Friedrich-Alexander-Universität Erlangen-Nürnberg — [2]Division of Physical Chemistry, Institute Ruđer Bošković, Zagreb

Protein-mediated membrane adhesion plays a crucial role in a number of biological processes including the immune response and morphogenesis. We aim to understand the effect of lateral interactions between two adhesion bonds on the mobility of the bonds. In the current work, we address this problem by numerical and simulation means. In principle, we find that two adhesive bonds strongly attract each other at short distances and repel at large distances. Naturally such an interaction has a barrier at intermediate separations. We calculate the time it takes for one bond to escape from the attractive well. We also determine the effective diffusion constant of a bond diffusing through an adhesion domain represented by a periodic arrangement of affixed ligand-receptor constructs. This is an important step in understanding the diffusion of bonds, which have recently been measured, and consequently understand the role of the membrane in the process of cell adhesion.

BP 21.7 Tue 14:00 P1A

Element-specific Density Profiles in Single and Interacting

Solid-supported Biomembrane Models — •Georgi Gochev[1,2], Ernesto Scoppola[1], Ignacio Rodriguez-Loureiro[1], Luca Bertinetti[1], Dmitri Novikov[3], Oleg Konovalov[4], Philippe Fontaine[5], and Emanuel Schneck[1] — [1]Max Planck Institute Colloids and Interfaces, Potsdam, Germany — [2]Institute of Physical Chemistry, Sofia, Bulgaria — [3]Deutsches Elektronen-Synchrotron, Hamburg, Germany — [4]European Synchrotron Radiation Facility, Grenoble, France — [5]Synchrotron SOLEIL, Gif-sur-Yvette, France

Surface interactions involving biomembranes, such as cell-cell interactions or membrane contacts inside cells play important roles in numerous biological processes. Structural insight into the interacting surfaces is a prerequisite to understand the interaction characteristics as well as the underlying physical mechanisms. Here, we work with simplified planar experimental models of membrane surfaces, composed of lipids and lipopolymers. Their interaction is quantified in terms of pressure-distance curves using ellipsometry at controlled dehydrating (interaction) pressures. For selected pressures, their internal structure is investigated by standing-wave x-ray fluorescence (SWXF). This technique yields specific density profiles of the chemical elements P and S belonging to lipid headgroups and polymer chains, as well as counter-ion profiles for charged surfaces. Along this line we further establish methodology for the element-specific structural characterization of lipid monolayers at the solid/liquid interface with atom-scale resolution.

BP 21.8 Tue 14:00 P1A

Preparation and characterization of 2D phospholipid and copolymer nanomembranes — •Roland Hillmann[1], Dominic Gilzer[2], Marlén-Viviane Eickmann[1], Niklas Biere[1], Martina Viefhues[1], Tilman Kottke[2], and Dario Anselmetti[1] — [1]Experimental Biophysics and Applied Nanoscience, Faculty of Physics, Bielefeld University, Germany — [2]Physical and Biophysical Chemistry, Department of Chemistry, Bielefeld University, Germany

We investigated Langmuir-Blodgett (LB) nanomembranes (NM) of UV-polymerized phospholipids and of copolymers as free-standing as well as substrate-supported 2D-systems. As a model for artificial and robust biological membranes, they will serve for various applications, such as for artificial filters or for the functional incorporation of channel proteins. The diacetylene phospholipids (PTPE and DC(8,9)PC) as well as the PB-PEO copolymers were prepared by spreading them at an air-water interface and consecutively transferred to a TEM-grid as well as onto mica and graphite substrates. UV-polymerizing of the phospholipids was performed by a 4W 254nm UV lamp. Successful formation of pore-spanning monolayers up to 2um x 8um was verified by helium-ion-microscopy. Further investigation of the UV-polymerized nanomembranes with attenuated total reflection infrared (ATR-IR) spectroscopy allowed us to monitor the polymerization process.

BP 21.9 Tue 14:00 P1A

Biological Signaling by Sound. A Physics Approach. — •Carina Fedosejevs and Matthias Schneider — TU Dortmund, Germany

Lipid bilayers build up all biological interfaces in cells. We study the prediction that perturbations can propagate and have characteristics of acoustic waves. These perturbations can be local changes of parameters like pH, temperature or density. The pulses increase also the activity of embedded enzymes during their propagation. We examine whether these acoustic pulses can explain how intercellular communication happens. For lipid monolayers this is already proven. Here we attempt to study the propagation in bi-/ multilayers because of their biological relevance. To measure these pulses a Langmuir Trough is used with two pressure sensors holding a Wilhelmy Plate. With the Langmuir-Blodgett Technique lipid layers are transferred onto a glass slide. The bi-/multilayer results by connecting the slide to the monolayer on the subphase. The excitation happens with the embedding of e.g. ethanol molecules in the layer, which causes a local density change. Pulses were measured in bilayers for different phospholipids in varied phase states. By using more layers a correlation between number of layers and velocity is expected. Additionally the lipid dynamics on the glass slide are investigated with fluorescence measurements. A correlation between diffusion velocity in the outer layer and number of layers could show the influence of the glass slide in the experiments. We could prove that our assumptions are also true for lipid bilayers, which is an important step transferring this theory to the living system of cells.

BP 21.10 Tue 14:00 P1A

Electro-mechanical Coupling during Action Potentials — •Julia Muchowski, Christian Fillafer, and Matthias Schneider — TU Dortmund, Germany

Action potentials are a classical phenomenon in biological cells. Their electrical component has been studied in detail whereas little is known about other components. Action potentials were investigated in excitable plant cells (Chara Braunii).

The membrane potential was monitored by intracellular recording. The cell membrane was separated from the cell wall by plasmolysis and observed by light microscopy. During a pulse not only the electrical potential of the membrane changed (depolarization) but also a mechanical displacement of the cell membrane was observed. The displacement of the membrane took place on a timescale of 1-2 min. The electrical signal preceded the mechanical displacement by 2+/-0.5 s. To further study the mechanical properties of the excitable membrane, one method was established to obtain large plasma membrane vesicles (r=50-100 micrometer) from the cell. This was achieved by plasmolysing the cell, cutting the cell wall, deplasmolysing the cell and extracting a membrane vesicle via osmotic pressure. Size and stability of the vesicles depended on the length of the cut and the speed of plasmolysis and deplasmolysis.

Our results demonstrate electro-mechanical coupling during an action potential. Further work aims at obtaining thermodynamic state diagrams of the excitable membrane.

BP 21.11 Tue 14:00 P1A

Nonlinear fractional waves in elastic membranes — •Julian Kappler[1], Shamit Shrivastava[2], Matthias F. Schneider[3], and Roland R. Netz[1] — [1]Freie Universität Berlin, Germany — [2]University of Oxford, United Kingdom — [3]TU Dortmund, Germany

Recently, there has been experimental interest in nonlinear sound waves in interfaces. In our contribution, we provide a theory for such sound waves. Starting from standard hydrodynamics, we derive a nonlinear fractional wave equation for interfacial sound waves in an elastic membrane on a viscous fluid. Our result constitutes the first derivation of a physical fractional wave equation from first principles. In addition, we compare predictions of our theory to experimental data and find that our model reproduces several key experimental features, such as an abrupt increase in both range and velocity as a function of excitation amplitude.

BP 21.12 Tue 14:00 P1A

Detachment of membrane bound virions by competitive ligand-binding induced receptor depletion — •Nagma Parveen[1], Stephan Block[2], Vladimir Zhdanov[1,4], Gustaf Rydell[3], and Fredrik Höök[1] — [1]Department of Physics, Chalmers University of Technology, Gothenburg, Sweden — [2]Department of Chemistry and Biochemistry, Freie Universität Berlin, Berlin, Germany — [3]Department of Infectious Diseases, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden — [4]Boreskov Institute of Catalysis, Russian Academy of Sciences, Novosibirsk, Russia

Multivalent interactions between virions and receptors in a lipid membrane can be weakened using competitive non-pathogenic ligand binding. In particular, the subsequent binding of such ligands can induce detachment of bound virions, a phenomena of crucial relevance for the development of new antiviral drugs. Focusing on the simian virus 40 (SV40) and recombinant cholera toxin B subunit (rCTB), and using (monosialotetrahexosyl)ganglioside (GM1) as their common receptor in a supported lipid bilayer (SLB), we present the first detailed investigation of this phenomenon by employing the quartz crystal microbalance with dissipation (QCM-D) and 2D single particle tracking (SPT) techniques. Analysis of the QCM-D-tracked release kinetics made it possible to determine the binding strength of a single SV40-GM1 pair. The release dynamics of SV40, monitored by SPT, revealed that a notable fraction of SV40 become mobile just before the release, allowing to estimate the distribution of SV40-bound GM1 receptors just prior to release.

BP 21.13 Tue 14:00 P1A

Cancer specific plasma membrane association of Hsp70-1A - AFM and fluorescence imaging of model membranes — •Constanze Lamprecht[1], Josef Madl[2,3], Winfried Römer[2,3], Mathias Gehrmann[4], and Andreas Ebner[1] — [1]Institute of Biophysics, Johannes Kepler University Linz, Austria — [2]Centre for Biological Signalling Studies (BIOSS) , University Freiburg, Germany — [3]Faculty of Biology, University Freiburg, Germany — [4]Klinikum rechts der Isar, TU Munich, Germany

Hsp70A1A is the major stress-inducible member of the HSP70 chaperone family and has been implicated in cancer diseases with the development of tumor resistances to standard therapies, increased invasiveness and poor prognosis. In normal cells Hsp70A1A is expressed in response to external stimuli such as physical exertion and heat to deal with denatured proteins and prevent toxic aggregations. In a majority of human tumors the protein is produced permanently in high amounts and a significant fraction of the cytosolic protein is found associated with cellular membranes. In this work we study the cancer specific plasma membrane localization of Hsp70A1A. As the protein lacks a consensus sequence for translocation to the cell membrane as well as known membrane binding domains, its anchorage may follow a new paradigm of protein-lipid interactions that may hold the key for deciphering membrane associated functions of Hsp70A1A in cancer evolution. We conduct AFM investigations in combination with fluorescence microscopy on model membranes to determine the anchoring mechanism and function on the cell surface.

BP 21.14 Tue 14:00 P1A

Functional reconstitution of ion channels in lipid bilayers in a microfluidic device — •Philipp Hannibal[1], Thomas Baukrowitz[2], Stefan Klumpp[3], and Christoph F. Schmidt[1] — [1]III. Physikalisches Institut, Universität Göttingen, Germany — [2]Physiologisches Institut, Christian-Albrechts-Universität zu Kiel, Germany — [3]Institut für Nichtlineare Dynamik, Universität Göttingen, Germany

Membrane channel proteins play crucial roles for signaling and sensory processes across the cell membrane. We work with potassium-selective K2P channels that are sensitive to temperature, voltage, pH, drugs or mechanical forces. Several of these K2P channel proteins show diode-like current-voltage-dependencies when they are embedded in lipid bilayers [1].

The goal of this work is to create a microfluidic device with reconstituted lipid bilayers and inserted functional channels with electrical access so that channel currents can be measured in simple and complex geometries.

[1] Schewe, M. et al., A Non-canonical Voltage-Sensing Mechanism Controls Gating in K2P K+ Channels, Cell, 2016, Vol. 164-5, pp. 937-949.