BP 5: Membranes and Vesicles I

Time: Monday 11:30–13:00 Location: H46

BP 5.1 Mon 11:30 H46

In-Plane Correlations in Fluid Lipid Monolayers - Experiments and Molecular Dynamics Simulations — •Kay-Robert Dormann[1], Joshua Reed[1], Matej Kanduč[2], Benno Liebchen[1], and Emanuel Schneck[1] — [1]Institut für Physik kondensierter Materie, Technische Universität Darmstadt, Hochschulstr. 8, 64289 Darmstadt, Germany — [2]Department of Theoretical Physics, Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia

Biological membranes predominantly consist of fluid lipid phases featuring lateral mobility and a considerable disorder of their hydrocarbon chains. Langmuir monolayers of lipids at the air/water interface are versatile model systems for fundamental physicochemical and biophysical membrane investigations. Recent experimental studies utilizing grazing-incidence x-ray diffraction (GIXD) have probed the chain correlation peak in fluid phospholipid monolayers as a function of the lipids' lateral packing. However, interpretation of the peak characteristics with over-simplified models based, for example, on rod-like chains yields only limited insights.

Here, we perform molecular dynamics (MD) simulations of phospholipids in the same monolayer configuration and predict the diffraction patterns originating from the chain correlations for a rigorous comparison with the experimental ones. The MD simulations reproduce the peak characteristics and their dependence on lateral packing well. Moreover, the experimentally validated simulation trajectories contain comprehensive information on the underlying chain correlations.

BP 5.2 Mon 11:45 H46

Modelling Wave Propagation on Monolayers — •Philipp Zolthoff and Jan Kierfeld — TU Dortmund, Dortmund, Germany

Recent experimental advances have enabled precise studies of pressure wave propagation through monolayers at the air-water interface, triggered by embedded azobenzenes and light-induced trans-to-cis isomerization. This talk presents theoretical results, which show that fractional nonlinear wave equations of Lucassen type can describe wave propagation on monolayers quantitatively. The nonlinear differential wave equation includes fractional time derivatives, incorporates measured Langmuir isotherms and a dynamic second viscosity that depends on the local state of the monolayer.

BP 5.3 Mon 12:00 H46

Artificial Membranes Through Physical Vapor Deposition (PVD): Exploring the Lipid Rafts Model — •Nancy Gómez-Vierling[1], D.A. Saavedra[1], M.A. Cisternas[2], M. Soto-Arriaza[3], C. Shen[4], P. Huber[4], and U.G. Volkmann[1] — [1]Instituto de Física, Pontificia Univ. Católica de Chile, Santiago, Chile — [2]Escuela de Ingeniería Industrial, Univ. de Valparaíso, Santiago, Chile — [3]Facultad de Medicina y Ciencia, Univ. San Sebastian, Santiago, Chile — [4]DESY, Hamburg, Germany

Essential to life, cell membranes are currently modelled as functional microdomains known as lipid rafts. These cholesterol- and sphingolipid-enriched domains are fundamental for organizing and categorizing key cellular processes. This research explores the assembly of artificial membranes inspired by the lipid raft model using PVD. This solvent-free technique previously demonstrated in DPPC membranes, is now applied to mixtures of sphingomyelin, cholesterol, and DOPC to investigate the self-assembly of microdomains under controlled conditions. Optimizing parameters such as temperature, deposition time, and thickness enables the successful formation of thin films on silicon substrates. Preliminary FTIR and GISAXS analyses confirm molecular integrity after cholesterol and DOPC evaporation, while ongoing studies examine the desorption and thermal stability of these SLBs. This work advances our understanding of membrane physics and establishes a versatile platform for creating model membranes with potential applications in biotechnology and materials science. Acknowledgements: ANID Fellowships (DS, NGV); Puente UC 2024-25.

BP 5.4 Mon 12:15 H46

Structural and mechanical properties of lipid monolayers at the water-air interface — •Hyunyou Kim[1], Ivo Buttinoni[1], Laura Alvarez Frances[2], and Pantelis Mpourazanis[3] — [1]Institute of Experimental Physics of Condensed Matter, Heinrich-Heine University, Universitätsstr.1, 40225 Düsseldorf, Germany — [2]University of Bordeaux, CNRS, CRPP, UMR 5031, 33600 Pessac, France — [3]Fraunhofer IOSB, Gutleuthausstraße 1, 76275 Ettlingen, Germany

Lipid monolayers play a crucial role at air-water interfaces of body, such as in alveoli, where they regulate surface tension. When surface pressure increases, the interface transitions from liquid-expanded (LE) to liquid-condensed (LC) phases.

As experimental model, Dipalmitoylphosphatidylcholine (DPPC) and Cholesterol (Chol) are used. Langmuir-Blodgett trough monitors lipid monolayers during compression, while fluorescence microscopy visualizes the domains. Rheology is measured at various frequencies using an interfacial shear rheometer coupled with trough.

During compression, pure DPPC monolayers transition from LE to LC, with a plateau at surface pressure Π = 5-6 mN/m and collapse at Π = 60-65 mN/m. The domain shape changes from round to fractal. Adding Chol lowers the collapse pressure (Π = 45-50 mN/m) and eliminates the plateau when Chol exceeds 8.6 mol %. Rheology shows that Chol decreases surface viscosity and makes the monolayers more elastic at higher frequencies.

BP 5.5 Mon 12:30 H46

Study of Giant Unilamelar Vesicles' Fluidity in Microgravity Conditions — •Georgios Stogiannidis[1], Paulina Blair[1,3], Laura Alvarez[2], Thomas Voigtmann[1,3], and Ivo Buttinoni[1] — [1]Heinrich-Heine University, Düsseldorf, Germany — [2]Université de Bordeaux, Bordeaux, France — [3]Deutsche Zentrum für Luft- und Raumfahrt, Köln, Germany

In this study, we examine the effect of microgravity on the membrane fluidity of giant unilamellar vesicles (GUVs) made of DOPC and Cholesterol. GUVs are prepared using electroformation technique, during which a thin film of lipids is deposited on a conductive glass substrate while the application of AC electric field accelerates the swelling of the lipid film. We first study the fluidity of the vesicles over a range of DOPC/Cholesterol ratios using Fluorescence Recovery After Photobleaching (FRAP): a disk shaped area of the vesicle is bleached using a laser for a short amount of time and the fluidity is computed from the time of fluorescence-recovery time. The same fluidity also is investigated by means of fluorescence polarization anisotropy (FPA) technique, where the intensity of the sample's fluorescence emission is measured along two orthogonal polarization axes. The latter method can be implemented under microgravity conditions. We report a significant fluidity changes in microgravity conditions, where the vesicles display approximately 20% higher membrane fluidity compared to those measured on the ground. Our findings provide valuable insights on the cells' behavior in zero-gravity conditions and more specifically about the absorption of pharmaceuticals in the human body.

BP 5.6 Mon 12:45 H46

Translocation of vesicles through membrane-covered pores — •Nishant Baruah[1], Gerhard Gompper[1], Anil Kumar Dasanna[2], and Thorsten Auth[1] — [1]Theoretical Physics of Living Matter, Institute of Biological Information Processing and Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Department of Physical Sciences, Indian Institute of Science Education and Research (IISER) Mohali, Sector 81, Knowledge City, Mohali 140306, India

Apicomplexan parasites like Plasmodium, which transmits malaria, invade their host cells by translocating through a tight junction at the host plasma membrane. This process involves significant physical challenges, including the need for the parasite to deform its own membrane while squeezing through the tight junction and contending with the host membrane tension [1]. Here, we study as a model system the translocation of vesicles through membrane-covered pores driven by a contact interaction [2]. The calculations are performed using triangulated membranes and energy minimization. We predict stable translocation states for various vesicle- and host-membrane elastic properties and vesicle-to-pore size ratios. A finite-host membrane tension strongly suppresses pore translocation, which may explain protection against severe malaria in the Dantu blood group [3].

[1] S. Dasgupta et al, Biophys. J. 107, 43 (2014).
[2] N. Baruah et al. (https://doi.org/10.1101/2024.05.20.594296).
[3] S. N. Kariuki et al, Nature 585, 579 (2020).