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Collective dynamics of membranes in and out-of thermal equilibrium

Biological membranes are intrinsically out-of-thermal equilibrium, driven by a vast range of external forces, exerted for example by motor proteins, ion channels, or interactions with other membranes such as in membrane fusion. We would like to gain a quantitative understanding in the generic differences of membrane dynamics under such out-of-equilibrium conditions. To this end, we have used different diffraction experiments probing the collective dynamics of well controlled model membranes, in particular aligned lipid membrane stacks, both in thermal equilibrium as well as in an active state, subjected to external driving forces (optical or acoustoelectric). While the equilibrium collective membrane dynamics (in plane density waves, undulations) can be well captured by inelastic neutron scattering in terms of characteristic dispersion relations [1], we turned to time-resolved x-ray diffraction in order to probe the relaxation pathway of membranes which are driven out of thermal equilibrium [2,3]. Beyond dynamics of multilamellar phases, I will then present ongoing work on membrane shape transformation and in particular membrane fusion in vesicle suspensions, using advanced x-ray optics and microfluidic devices. I will finish with an outlook on novel opportunities by the x-ray free electron lasers as well as the European Spallation Source (ESS).

[1] M.C. Rheinstädter, W. Häussler, and T. Salditt, Dispersion Relation of Lipid Membrane Shape fluctuations by Neutron Spin-Echo Spectrometry Phys. Rev. Lett. 97, 048103, (2006).

[2] T. Reusch, F.J.R. Schülein, J.D. Nicolas, M. Osterhoff, A. Beerlink, H.J. Krenner, M. Müller, A. Wixforth, and T. Salditt, Collective Lipid Bilayer Dynamics Excited by Surface Acoustic Waves, Phys. Rev. Lett. 113, 118102 (2014).

[3] T. Reusch, D. D. Mai, M. Osterhoff, D. Khakhulin, M. Wulff, T. Salditt Nonequilibrium Collective Dynamics in Photoexcited Lipid Multilayers by Time Resolved Diffuse X-Ray Scattering, Phys. Rev. Lett. 111, 268101 (2013).

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