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Measurement of Dynamic Coherent Excitations in Phospholipid Membranes

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Phospholipid membranes are the basic construction material of cell membranes. Also, solutions of phospholipid vesicles find a wide array of applications in technical, medical and biological applications. Hence, the basic understanding of these membranes, both in terms of structure and dynamics is of paramount importance in order to better understand the mechanisms of cell membrane permeability, stability, and solubility in vesicle solutions.
In our previous publications, we showed both the structure and the dynamic behavior of phospholipid membranes made from L-α-phosphatidylcholine (SoyPC). [1,2] The investigations presented there were performed by means of grazing-incidence small-angle neutron scattering (GISANS) and grazing-incidence small-angle neutron spin echo spectroscopy (GINSES). We established a multi-lamellar structure with repeat distances of approximately 6 nm as well as a mode in the GINSES data, that we attributed to a coherent dynamic mode in the membranes, a kind of thermally excited eigenmode.
Following up on this experiment, we performed additional GISANS measurements in order to identify features in the coherent scattering that we could attribute to the coherent mode in the membrane.[3] For that, we specifically adapted the resolution settings during the GISANS experiment and were then able to find the coherent scattering contribution of the dynamic modes of the phospholipid membranes. Moreover, as we assumed the coherent mode was linked to a specific phase of the lipid membrane, we investigated the system at different temperatures and could show that the excitation mode indeed disappeared at temperatures below 25℃ and reappeared when the system was reheated.
The experimental advantage of identifying modes such as these in a coherent scattering experiment, such as GISANS is the time required for an experiment. While the GINSES measurements take up to 5 days for a single curve at a single Q-value, GISANS experiments can be performed within hours. This gives an approximated gain of one order of magnitude. After the modes have been identified in GISANS, additional detailed scans using GINSES become feasible. This allows to access a wide range of the parameter space, that would be impossible to cover with GINSES.

References

[1] S. Jaksch, H. Frielinghaus et al., Phys. Rev. E 91(2), (2015) 022716.
[2] S. Jaksch, H. Frielinghaus et al., Scientific Reports 7(1), (2017) 4417.
[3] S. Jaksch, H. Frielinghaus et al., Colloids and Interfaces 2(3), (2018) 31.

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