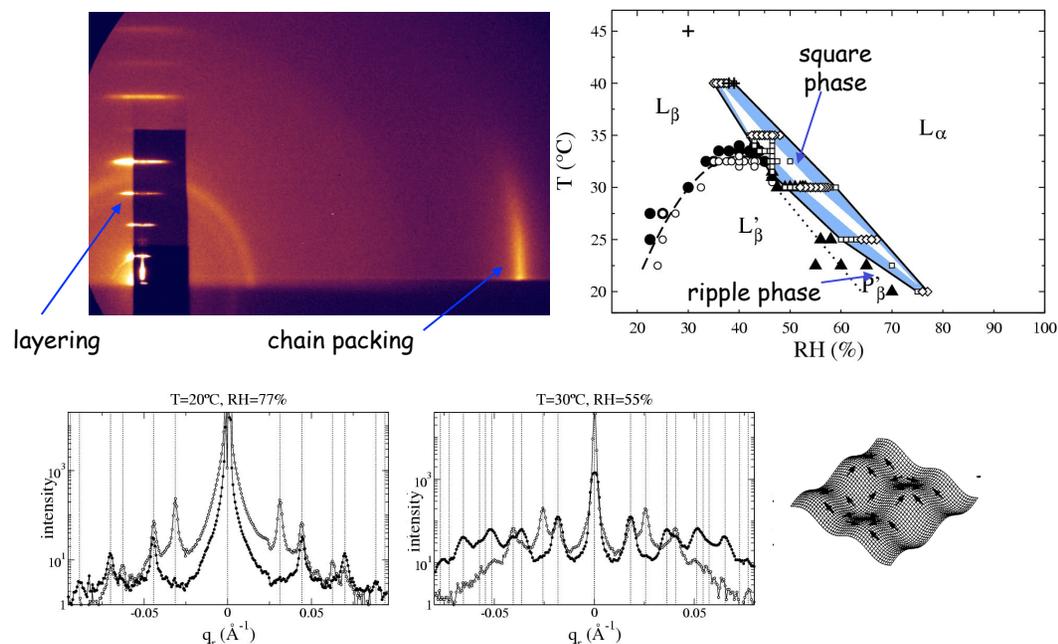
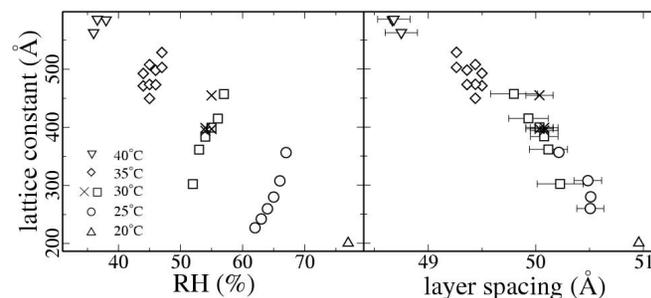


Lipid square phase

Motivation: In attempt to understand the formation of the well-known lipid ripple phase, in which lipid membranes form saw-tooth like profiles, theorists have predicted (Chen & MacKintosh, PRE, 1996) the existence of other modulated phases. The theoretical model includes the bending energy of the membrane as well as a phenomenological Landau free energy based on a vectorial order parameter that can be related to lipid chain tilt.



Key result 1: Phase diagram based on X-ray scattering data of lipid layer spacing as well as lipid chain packing indicate the presence of a new lipid phase in the vicinity of the boundary between the L_α phase with disordered lipid chain and the ripple phase. This phase also exist between the L_α phase and the non-tilted gel phase L_β (smectic A).



Key result 3: The wide range of observed square lattice constant appears to have a simple monotonic dependence on the lipid layer spacing, which may be attributed to thickness of water between membrane layers, and therefore the interaction energy between membranes, which is not included in the current theoretical model,

Key result 2: High resolution diffraction results show that the new phase contain structures with in-plane square symmetry in each layer, which are stacked up with full layer-to-layer correlation, consistent with the prediction of a square phase.

Conclusion and significance: We have experimentally observed the square phase predicted by the theory. Our data showed that the current theory is not adequate to account for all observed results. The results also demonstrate the capability of collecting very high resolution scattering data at beamline X21.

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