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Report:

The project concerns XPCS measurements of the dynamics of the layer fluctuations associated with the low-dimensional ordering in smectic membranes. The results from the first part of the long-term beamtime have been published in PRL **88**, 115503 (2002), attached earlier to the interim report of August 1, 2002, and in the ESRF Highlights 2001, p. 41.

Using avalanche photodiodes as detector and a fast correlator, technically the lower limit of XPCS has been brought down close to the limit of 2.8 ns given by the bunch-to-bunch distance of the storage ring in the uniform filling mode. This allows overlap with neutron-spin-echo measurements, carried out at IN15 of ILL in November 2002 (see ILL report 9-11-937). To the best of our knowledge this is the first time that XPCS and NSE have been applied together to investigate the dynamics of a single system. This combination allows distinguishing different relaxation regimes as a function of the off-specular wave vector $q_\perp$. For small $q_\perp$ a 'surface regime' is found for which the relaxation time is proportional to the film thickness. Here the smectic membrane behaves essentially as a fluid film, without any reference to elasticity typical for liquid crystals. For larger $q_\perp$ a 'bulk elasticity regime' is observed, in which the relaxation time is independent of membrane thickness (and thus of the surfaces) and develops wave-vector dependence according to $q_\perp^{-2}$. The results are at present under review at PRL (*preprint attached*).

The off-specular relaxation behavior in NSE and XPCS can be treated in the same way, which evidently stems from the same underlying quasi-elastic scattering. However, upon shifting towards the specular position, the XPCS correlation function changes. In the specular region the relaxation time approximately doubles compared to the value at the diffuse tail. This difference can be attributed to homodyne and heterodyne detection schemes, respectively.

For thicker samples we reached the limits of stability of the smectic membranes. Local heating by x-ray absorption probably caused uncontrolled internal flow, influencing the local mosaic structure and probably also the correlation function via the effective resolution. This problem could be partly overcome by working at 13.4 keV, where absorption is less.

Apart from the major results mentioned, a whole series of other aspects has been established. Essentially we plan two longer papers. A first paper extends the present theory of fluctuations in smectic membranes. This will allow analyzing the coherent properties of the set-up including the membrane itself and should account for the following aspects.

1. Measurements at different q_z positions along the specular ridge showed a variation of the correlation function with increasing q_z. This can be related to a change in the effective correlation volume, which has to be incorporated in the resolution.
2. We rotated the sample and thus the scattering plane, leading in the new geometry to $\xi_t \approx 150$ µm. Now ξ_t can be changed in an independent way by reducing the pinhole size in steps from 100 µm down to 4 µm. No conclusive results were obtained so far regarding the dependence described under point 1.
3. The role of the speckle size has been studied in relation to the setting of the pre-detector slits. The known properties of the coherence length in the horizontal and vertical direction are reflected in the contrast when varying the horizontal and vertical slit size, respectively. However, variation of the horizontal slits also influences the relaxation time.
4. In several situations we found that with improving mosaic of the membrane the contrast in the correlation function diminished. This is probably related to the shift from homodyne and heterodyne detection, still to be sorted out in more detail.

A second paper should put the experimental results from the two PRL's and additional measurements together and discuss them in a comprehensive and systematic way on the basis of the first paper.

In conclusion we feel that the long-term beamtime has allowed us (1) to reach important technical improvements in XPCS, in particular reaching the short-time limits and thus overlap with NSE, and (2) to establish new insight in the complex relaxation behavior of smectic membranes as a model system of low-dimensional ordering. The results seem to be well appreciated by the x-ray community as evidenced by many invitations to talk about this work. We want to thank ESRF and the staff of ID10 for this opportunity.