Surface Dynamics of a Liquid Crystal near the Nematic-Smectic Phase Transition

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Recently it was demonstrated that the height-fluctuation dynamics of a simple liquid surface can be investigated by coherent X-ray scattering [1]. This was accomplished by reflecting the coherent X-ray beam from the liquid surface and detecting the intensity fluctuations of the diffuse surface scattering by X-ray Photon Correlation Spectroscopy (XPCS). The intensity fluctuations are caused by the thermally activated capillary waves that decorate any liquid surface and by XPCS the dispersion relation of the waves can be determined. From the slope of the dispersion relation the viscosity and the surface tension can then be deduced. In this talk I will show that this technique also is applicable on anisotropic liquids like for example a liquid crystal. The viscosity of a liquid crystal is anisotropic in the nematic phase. It depends on the orientation of the molecular axis with respect to the wave-vector of the capillary wave and usually three viscosity coefficients η_{1-3} are defined where η_3 is diverging at the nematic-smectic phase transition [2].

By use of XPCS we have investigated the diverging viscosity of the liquid crystal 8OCB at the second order nematic-to-smectic A structural phase transition. In the talk I will show that our η_3 data can be well described by a power-law $At^{-x} + B$ where $t = (T - T_{NA})/T_{NA}$ is the reduced temperature and x is a critical exponent. T_{NA} is the phase transition temperature and X-ray scattering provides an independent way to determine T_{NA}, namely by static, critical scattering whereby we found T_{NA}=337.74 K for the 8OCB sample. The best power-law fit to our η_3 data is obtained with x=0.94 [3] which contradicts previously published light scattering results. However, as I will show in the talk, our result x=0.94 is in good agreement with theoretical predictions and it illustrates that the hydro-dynamic behavior of a liquid crystal surface strongly depends on the structural ordering.

References

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