	Experiment title:	Experiment number:
	Single layer surface crystallisation of a smectic-A phase: Investigating the nature of the Kosterlitz-Thouless transition	SC-682
Beamline: ID10B	**Date of experiment:** from: May 10, 2000 to: May 17, 2000	**Date of report:** 29-8-2000
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Report:

In liquid crystals a free surface may stabilise a higher ordered phase. An extraordinary example is found in free standing smectic films of the compound abbreviated as 4O.8, which shows with decreasing temperature layer-by-layer crystallisation starting at the film surfaces. Moreover, this transition from a smectic–A (SmA) phase with liquid layers into a crystalline B phase (CrB) is mediated via a surface induced hexatic smectic-B (SmB) phase not observed in the bulk. The phase transition temperatures of the top layers of 4O.8 are:

SmA 61.5°C hexatic SmB 54.5°C CrB.

The SmA-SmB transition of the neighbouring layers occurs at 51.5°C only. Hence the behaviour of a single top layer is accessible in temperature and should be a good model of a 2-dimensional Kosterlitz-Thouless transition.

The SmB-CrB transition of the outermost layers is accompanied by a gradual damping of the thermal fluctuations. As in the hexatic SmB top layers (with long-range bond-orientational order) the positional order is still not complete, we have postulated that the transition to CrB takes place via an increase in the positional correlation length. This should be reflected directly in the linewidth of the in-plane diffraction peak. The aim of the experiment was to quantify this effect via grazing incidence surface diffraction of a top layer.

Considerable experimental difficulties were encountered due to a mosaic structure of the top layers, which varied with time during the surface diffraction experiment. Also we could not work with an incident beam below the critical angle, because for unclear reasons in that situation the – otherwise very stable films – tended to thicken locally. We compromised to an incident angle at about twice the critical one. As a consequence the diffracted intensity also contains information about the liquid structure of the inner layers. To be able to distinguish this effect from the top layer diffraction we have chosen an 8-layer film. Then we can expect with decreasing temperature to monitor the crystallisation process of the two outer layers (supposed to behave independently) on top of a constant liquid layer structure of 6 inner layers. Finally good results were obtained in a somewhat unusual horizontal scattering geometry (films positioned vertically). A linear detector was also mounted vertically to catch in a single shot the lineshape associated with the internal positional ordering of the layers. In terms of scattered intensity this was only possible thanks to the recently installed focussing mirror.

A full quantitative analysis of the width of the in-plane diffraction peak as a function of temperature is in progress. The figures below show some typical raw data of this peak directly from the linear detector. In the SmA phase (fig.1, 8 liquid layers) a broad liquid peak is observed as expected. The transition to the hexatic SmB phase with limited positional order was found to be gradual. Fig. 2 shows the result for 6 inner liquid layer and 2 hexatic top layers. The peak can be easily deconvoluted into these two contributions. The transition from hexatic to crystalline top layers is abrupt within our temperature resolution of about 0.1°C. This fully new result is somewhat surprising in relation to both the theory and the absence of any effect at this transition in calorimetry. The final picture in the CrB phase is given in fig. 3. It shows a sharp resolution limited peak from the two crystalline top layers with underneath still the liquid peak from the 6 inner layers.