ESRF

Experiment title: High resolution X-ray scattering from sliding CDWs in $NbSe_3$.	**Experiment number:** HS 633

Beamline: ID10 A	**Date of Experiment:** from: 27 jan. 1999 to: 2 feb. 1999	**Date of Report:** 10 feb. 1999
Shifts:	**Local contact(s):** G. Grübel	*Received at ESRF:* 02 MAR. 1999

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Report:

The quasi-one-dimensional metal $NbSe_3$ undergoes a Peierls phase transition at T_p=145K. Below T_p the system is characterised by an electronic charge density wave (CDW):$\rho(x) = \rho_0 + \rho_1 cos(2k_F x + \phi)$ together with a modulation of the lattice ionic positions. The phase ϕ of the condensate with respect to the parent lattice is pinned by random impurity centers. The application of an electric field above a finite threshold value unpins the condensate and gives rise to *collective* electron transport. The velocity of the sliding condensate is limited by the rate of conversion between normal and condensed carriers near the contact electrodes. This conversion is mediated by phase slip processes which play a similar role as vortices in type II superconductors or superfluids. Experimentally one observes a stretching (compression) of the CDW periodicity near the injection (extraction) contact.

The purpose of this experiment was twofold:

- to extend the results obtained in Expt. HS 194, on the deformation profile of a sliding CDW in $NbSe_3$, at 90 K (see Fig. 1 of accompanying proposal).

- to explore the origin of the assymetry between the amplitudes q_+ and q_- of the satellite shifts observed with positive and negative current polarities.

To this end we tested a series of thin $NbSe_3$ whiskers for crystalline quality, by monitoring the width of the (020) main reflection, using a rotating anode setup. The selected specimen, equipped with electrical leads, was mounted in a closed-cycle refrigerator on ID10 A. Measurements of satellite positions were performed at 90K and 75K, using a 30 μm-wide x-ray spot (sample size: 15 μm x 5 μm x 4.2 mm between contacts). The application of dc currents of up to 7 mA (3-4 times the collective depinning threshold), revealed the existence of a localised defect in the central section of the specimen (x_s = -0.75 mm in Fig. 1), acting as a strong pinning center. The CDW shift changes sign abruptly upon crossing the defect position. The amplitude of the shift near the defect is about half the value at the current electrodes (x_s= -2.7 mm and 1.5 mm), suggesting that about half of the condensed carriers are transformed into normal carriers at the defect position (and recondensed immediately after). The defect does not appear to have a simple crystallographic origin since its presence could not be detected by monitoring the width of the (020) main reflection, either on the rotating anode setup or on ID 10A.

Allowing for the presence of this strong pinning center (or 'pseudo-contact') at the center of the sample, the observed overall deformation profile is reasonably consistent with our previous observations. The detailed behaviour of $q_+(x_s)$ and $q_-(x_s)$ is clearly influenced by the presence of other types of defects and cannot be assumed to be strictly intrinsic. In particular the assymetry between $q_+(x_s)$ and $q_-(x_s)$ is clearly observed near the l.h.s. electrode (Fig. 2) and almost absent near the r.h.s. one. Physically one can understand an assymetry between current injection and current extraction electrodes. However since the roles of the r.h.s. and l.h.s. electrodes are exchanged upon reversing the current polarity, the double shift $q_+(x_s)$ - $q_-(x_s)$ should be the same on both electrodes. The fact that this is not quite the case for the data in Fig. 1 can probably be ascribed to a difference in the quality of the two electrodes.

Part of the allocated beamtime was devoted to another aspect of the experiment, namely the study of the relaxation of the deformed CDW upon switching off the current. The corresponding time-resolved data are discussed in the accompanying proposal (Fig. 2).

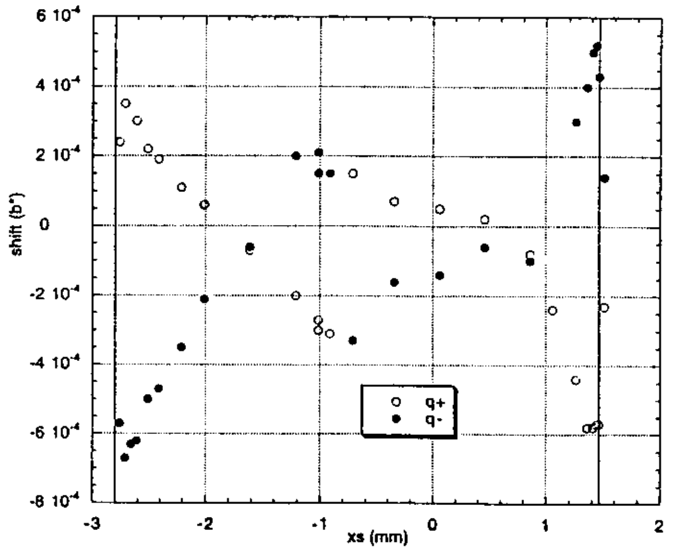

Figure 1. Shift of the (0, 2-2k_f, 0) CDW satellite for positive and negative current polarities, I=4.5 mA, T=90 K. The vertical lines show contact boundaries.

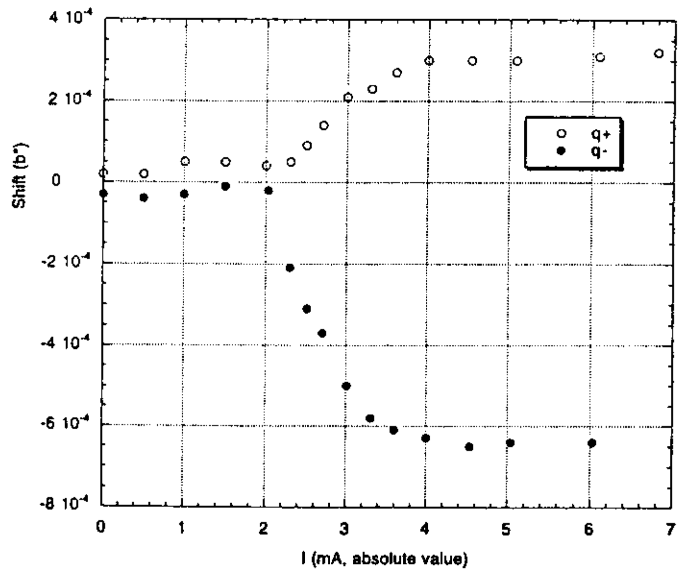

Figure 2. Current dependence of the satellite shift at a position 50 μm to the right of the l.h.s. electrode. The CDW deformation develops above a threshold current of 2.2 mA, corresponding to the onset of collective CDW transport, in agreement with independent in-situ resistivity measurements, T=90 K.