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Report:

The Blue bronze $KMoO_3$ undergoes a Peierls transition which stabilises a $2k_F$ (k_F is the Fermi wave vector) incommensurate periodic lattice distortion coupled to a Charge-Density Wave (CDW). Below this transition, the soft mode (Kohn anomaly) splits into amplitude- and phase-modes. This phenomena has been observed by neutron scattering on blue bronzes by using sample of exceptional size[1] (~5cm^3). However, the study of the low temperature dynamics was impossible with this technique due to the weakness of the signal. The aim of this experiment was to study the low temperature CDW modes by inelastic X-ray scattering (IXS).

Measurements were performed on a small sample of blue bronze (1*2*.5 mm^3). IXS spectra were obtained from T=300 K down to T=40K with reasonable counting time in the (9 9 9) configuration (E_i=17794 eV). The counting time never exceeded 3 hours to cover the $-20<\omega<20$meV energy range (see figure) for measurements near the (15 -0.75, -1.5) satellite reflection. The use of the (11 11 11) configuration, which would have provided higher resolution, was impossible due to the high absorption coefficient of the crystal (Molybdenum K-edge is 20000eV). The energy resolution function of the apparatus was obtained by fitting the elastic part of the spectra close to the satellite reflection position at 40 K, and was found to be 3.2 meV in the (9 9 9) configuration.

Due to the surprising high intensity of the inelastic scattering, we were able to test different Bragg reflections The strongest inelastic intensity was obtained around the (15, 0.75, -1.5) reflection. Some of our best results are displayed below.

In agreement with the neutron scattering data[1], the amplitude mode was clearly observed at ~1.5 THz (~6 meV). A low-energy mode was needed to fit the spectra, that we ascribed to the phase-mode. This low energy contribution is clearly visible in the T=170 K spectra displayed below. From the spectra taken along the **b*** axis, we have deduced the phase-mode velocity, which is found to increase by decreasing temperature (ν=70 THz.Å at 130K; ν=100 THz.Å at 100K), values which are consistent with the neutron scattering results[2]. At last, **no** low energy mode was needed to fit the 40 K spectra, which indicates a further hardening of the phase-mode. This is the main result of this experiment.

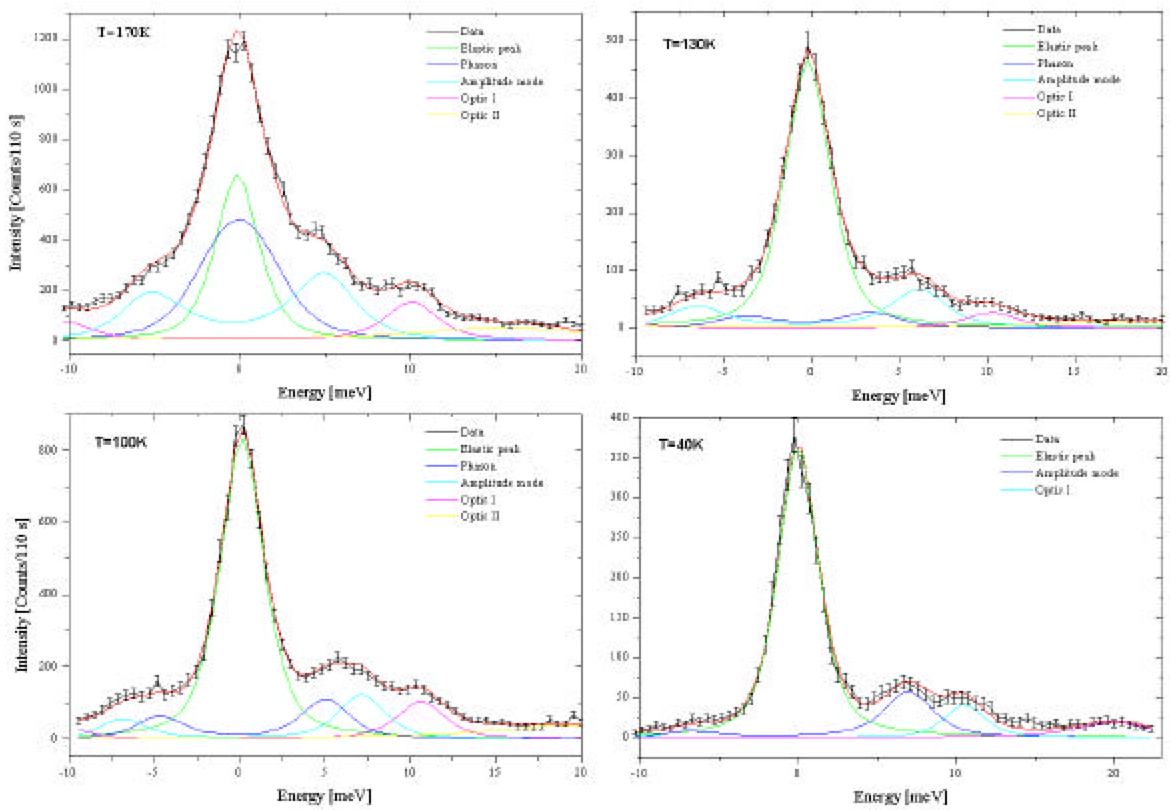

Figure 1: *Energy scans at the (15 -0.75, -1.5)+ 0.02(1 0 1) position for various temperatures between T=40K and T=170K.*

These results confirm and complete the neutron scattering results. At variance with other incommensurate crystals, the CDW systems have their dynamics dominated by Coulomb interactions[3]. Indeed, phase deformations locally change local electron density, leading to long-range Coulomb interactions. At high temperature, normal carriers can screen these interactions, which decreases the phase rigidity of the CDW. By cooling down this screening is less efficient, which stiffen the phase-mode, as observed. If the phase-mode velocity exceeds the electron thermal velocity, screening is no longer possible: the phase-mode transforms into an optic-like[4] mode. This regime, which can be expected to occur below ~100 K in the blue bronze, has never been observed so far. This experiment gives the first indication of such a phenomena.

[1] J.-P. Pouget, B. Hennion, C. Escribe-Filippini and M. Sato, Phys. Rev. B **43**, 8421 (1991).
[2] B. Hennion, J.-P. Pouget and M. Sato, Phys. Rev. Lett. **68**, 2374 (1992).
[3] H. Fukuyama and P.A.Lee, Phys.Rev. B**17**, 535 (1977); PA.Lee and M.Rice, Phys.Rev. B**19**, 3970 (1979).
[4] A. Virosztek and K. Maki, Phys. Rev. B**48**, 1368 (1993).