ESRF	**Experiment title:** Inelastic x-ray scattering studies of electromagnons in $TbMnO_3$.	**Experiment number:** HC-1396
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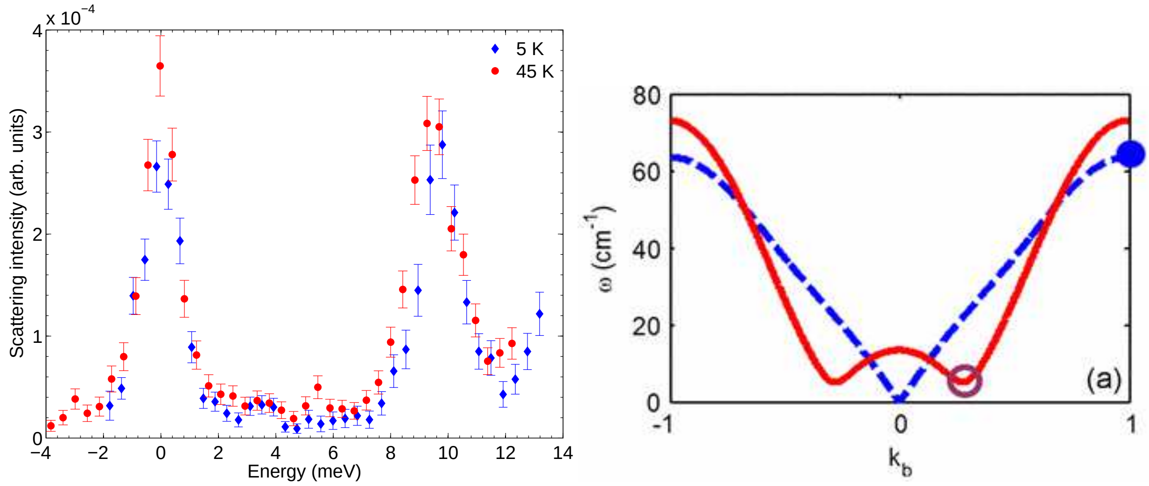
Report:
Magnetoelectric multiferroics are a class of materials in which magnetism and ferroelectricity coexist and interact. An example of such a magnetoelectric multiferroic is the distorted pervoskite $TbMnO_3$ (*Pbmn* space group), which exists in the following phases.

- 28K<T<42K, Collinear phase: The Mn magnetic moments are sinusoidally modulated along the *b*-axis, with an incommensurate propagation vector of (0 q_m 1), where $q_m \approx$0.29-0.28.
- T<28K, Cycloidal phase: The Mn moments form an incommensurate cycloidal magnetic structure within *bc*-plane, the propagation vector is: (0 q_m 0) , where $q_m \approx$0.28 [1]. In addition, an electric polarization parallel to the *c*-axis is observed [2]. This electric polarization is believed to be a consequence of the Dzyaloshinski-Moriya interaction, implying a polar lattice distortion.
- T<7K, Tb moments order with an incommensurate propagation vector of (0 0.42 1).

Another interesting characteristic of these materials is a dynamical magnetoelectric effect; here magnetic excitations are linked to oscillations of the electric polarization, such coupled exciations are known as electromagnons.
For the case of $TbMnO_3$, two different types of electromagnons have been identified. The first type corresponds to a rocking of the magnetic cycloid in the *bc*-plane around the magnetic propagation vector, q_m [3]. The second type of electromagnon has been attributed to an exchange-striction mechanism [4]. Absorption measurments have assigned this electromagnons as coupling to between to the zone-edge mode of the spin wave, and another to a spin wave with a magnetic propagation vector of: $q=\pi-2q_m$.



(a) (b)

Figure 1: (a) IXS spectra at Q=(4 0.5 1), the red(blue) data was collected at a temperature above(below) the ferroelectric phase transition. (b) The theroetical dispersion of the Dzyaloshinski-Moriya (red) and exchange-striction (blue) electromagnons along the k_b direction, the cirlces mark where the scattering signal from the electronmagnon should be strongest. This figure should be taken from [4].

The purpose of this experiment was to measure the phononic half of the different electromagnon types, and determine how they disperse. Results from a successful experiment would have been compared to theoretical perdictions (see figure 1b). The scattering signal from the electromagonons is belived to be at a low energy transfer and signifcantly weaker than the phonons. Therefore the ID28 spectrometer was used in the Si(11 11 11) configuration, because it offered a balance between flux and energy resolution. The sample was mounted in the *ab* scattering plane, and measurements were taken along the b^* direction in the (4 0 1) and (6 0 1) Brillouin zones. These zones were choosen because they maximised the component of the scattering vector parallel to the *a*-axis, and thus should increase the scattering from the electromagnons . Measurements of the IXS spectra were intially taken at 5 K, as the ferroelectric polarisartion is belived to be enanched by the ordering of the Tb moments [5]. Special attention was paid to the q-points corresponding to q_m and the Brillouin zone boundary, as it has been predicted that the electromagnons are strongest here (see figure 1b). After this, the same measurements were taken in at 45 K for comparison.
Unfortunately the experiment failed to conclusively indentify a signal corresponding to an electromagnon. For example figure 1a shows that at 5 K there is a weak signal at ≈3.5meV, this is correct energy for the predicted electromagnon, see figure 1b. However this signal does not dissapear at 45K , suggesting that the feature does not correspond to a electromagnon.

References

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