Experimental report

25/01/2024

Proposal:	**CRG-3002**	**Council:**	4/2023
Title:	Coupled magnonic excitations in TbFeO3		
Research area:	Physics		

This proposal is a new proposal

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Samples: TbFeO3

Instrument	Requested days	Allocated days	From	To
IN12	5	6	14/11/2023	20/11/2023
ORIENTEXPRESS	1	1	13/11/2023	14/11/2023

Abstract:

We want to determine the low-energy magnon dispersions relation in TbFeO3. Its phase diagram suggests a competition of the Tb and Fe lattice ordering which should manifest in the excitation spectrum. Previous reports have focused on the characterization of the Fe sublattice, which hosts magnons with energies up to 60 meV. None of these report any shift in the Fe magnons crossing various spin-reorientation transitions at low temperatures. With the large single crystal we have recently synthesized we aim at determining the low-energy magnetic excitations in TbFeO3 across different phases. This knowledge should allow to accurately determine the inter-lattice exchange parameter J(Fe-Tb) and characterize the sublattice coupling that leads to exotic incommensurate phase in TbFeO3.

Experimental report
CRG-3002 beamtime, OrientExpress and IN12
Coupled magnonic excitations in $TbFeO_3$

We have oriented various crystals of $TbFeO_3$ at OrientExpress. The large crystal (V=800 mm^3) was already mounted on a holder and we verified its orientation. Next, we determined the orientation and quality of three small crystals (V=20 mm^3), and chose one as a backup sample.

Next, we performed inelastic neutron scattering measurements on $TbFeO_3$ at IN12 with a 6 T vertical field magnet.

First, we measured the large crystal. Main goal was to investigate the terbium sublattice excitations, which should become dispersive below 3.2 K, where terbium sublattice orders. This corresponds to magnon energies around 0.3 meV. We have looked for dispersive band of excitation in the low energy range, below 1 meV, and various Brillouin zones, but did not identify any signal that would correspond to Tb sublattice magnons.

Next, we turned to investigate Fe -sublattice excitations. They are characterized by a gap around 5 meV, as reported by Skorobogatov et al. (doi: 10.1103/PhysRevB.106.184404). We have found the gap at lower energies and investigated the influence of the Tb sublattice on the low-energy excitations. Results are shown in Figure 1, where we performed constant energy scans, at various temperatures, which corresponds to the paramagnetic phase of Tb sublattice, partial ordering, and completed ordering. There are only small changes visible in the spectra, however, the gap shifts, consistent with the reorientation of Fe moments.

We attempted to measure the excitations spectra also with applied field, particularly in the incommensurate phase above 2.5 T. Unfortunately, the sample rotated upon applying field, as it exhibits large torque in the low temperature phase. We have mounted the second, small sample, clamped in a holder. The Bragg reflections were visible and clear, however the sample was too small to provide sufficient signal for inelastic scattering. We have followed the evolution of reflections as a function of field and correlated with the existing phase diagram. These measurements allow to verify the nature of the transitions (1^{st}, 2^{nd} order).

We learned that Tb sublattice magnons are potentially overdamped, and do not show strongly dispersive excitations. Their characteristics should be investigated with diffuse scattering instruments. We are analyzing the Fe-sublattice gap and got significant information about the character of magnetic transitions. Also, measurements with applied field require large samples clamped strongly in an appropriate holder to prevent rotation.

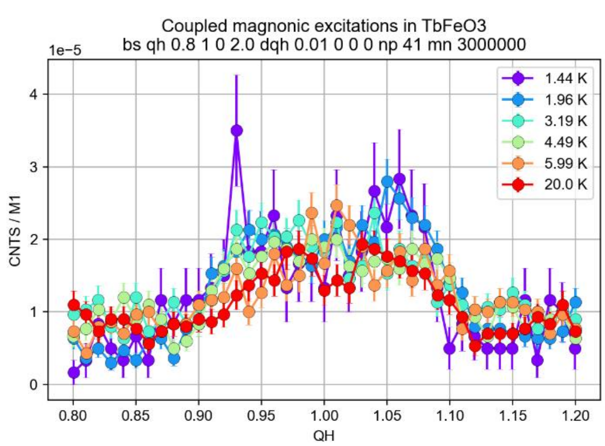

Figure 1. Constant energy scans measured at various temperatures. There are small differences in the spectral weight, attributed to the change of the gap as a function of temperature.