Experimental report

14/11/2023

Proposal: 4-01-1784 **Council:** 4/2023

Title: Helical magnons in non-reciprocal multiferroic Ni3TeO6

Research area: Physics

This proposal is a new proposal

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Samples: Ni3TeO6

Instrument	Requested days	Allocated days	From	To
IN5	4	4	02/11/2023	06/11/2023

Abstract:

Multiferroic materials with well-understood properties may lead the way to engineer novel multi-purpose materials such as magnetic sensors, actuators, and magnetic RAM. Here we propose to study Ni3TeO6 where a colossal magneto-electric response has been observed across the phase transition from its low field commensurate magnetic structure to a high field helical order. Based on our current results we developed a magnetic Hamiltonian, which accounts for the lowest-lying magnetic modes in the commensurate phase, their energy behavior in magnetic field, and their polarity. With this proposal, we aim to study the magnetic excitation spectrum of Ni_3TeO_6as a function of field and across the high field magnetic transition to elucidate the origin of the multiferroic properties in the material and to further refine our Hamiltonian. Because of the stringent requirement of the field direction and strength, this experiment can only be performed on IN5 using its vertical 10 T magnet.

Helical Magnons In Ni3TeO6
IN5 November 2023
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2^{nd}-6^{th} November 2023

1 Data and logbook

Run Number	λ [A]	A3 [deg]	B [T]	T [K]	Time [min]	Comment
250853-250885	5	278-310	0	5	5	
250886	3.8	310	0	5	5	
250887	3.6	281	0	5	5	
250888-250922	3.6	278-312	1.5	5	10	
2590923-250957	3.6	278-312	4.5	5	16	
251015-251064	3.6	278-328	9	5	8	
251065-251142, 251255-251410	2	255-332	9	5	8	Second run 8.5 min interlace, third 8.15 min integer A3
251143-251254	5	570-325	9	5	10	First 2 deg, then interlace, then half degrees for 11 min

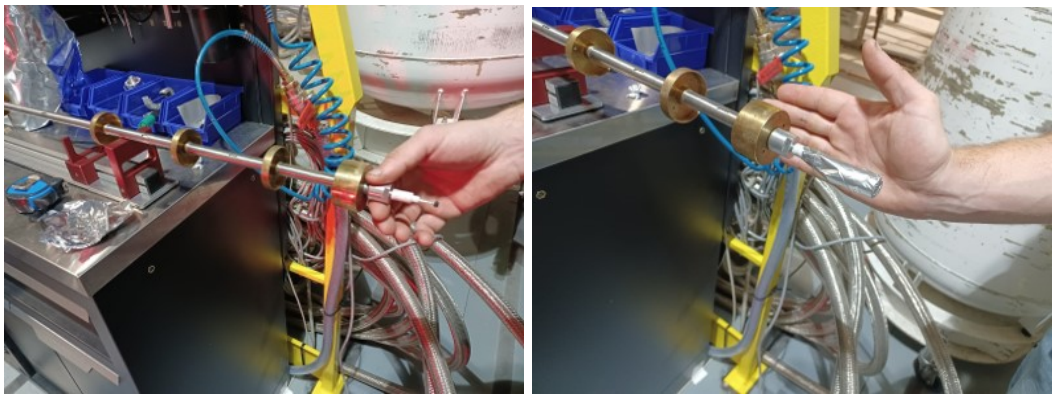
Table 1: Overview of file numbers with corresponding energies, fields, and statistics.

Experiment started: 02/11-23 with insertion of sample on sample stick, see fig. 1.

First night, sample alignment checked and inelastic signals measured at B 1.5 T, and 4.5 T at standard temperature of 5 K to ensure overlap with previous data.

After initial setup and measurement at lower fields (up to 4.5 T), ramped field towards 9 T. However, magnet quenched at 8.37 T and had to be cooled down again using around 2 helium dewars. In high magnetic field (B = 9 T), the excitation spectrum was measured in 3 different settings: High resolution with λ = 5 A, medium resolution λ = 3.6 A, and low resolution λ = 2 A to ensure good enough data quality to fit complex spectrum above magnetic ordering vector of (0,0,1.5$\pm\delta$) or equivalently (1,0,-0.5$\mp\delta$), see fig. 3a. Medium resolution allows comparison in coverage with previous magnetic fields and shows the magnetic field dependence changing, see fig. 2. Lastly, the low resolution data provide a great over view of the full excitation spectrum, seen to extend to around 14 meV, as well as a potential flat mode around 16 meV previously measured by powder measurement but only speculated to be flat, see fig. 3b.

Data conversion, cutting, and extraction pipeline has been setup and data will be fitted and treated using (most probably) the SpinW program, or more sophisticated RPA calculation tools.



(a) (b)

Figure 1: Pictures of sample before insertion with and with out the sachet, respectively.

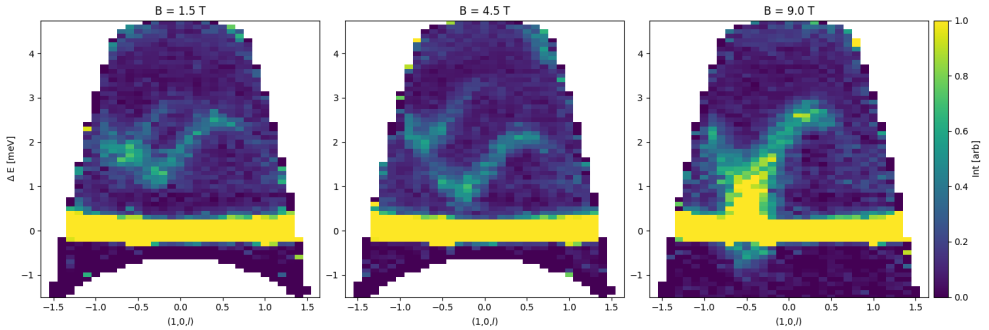
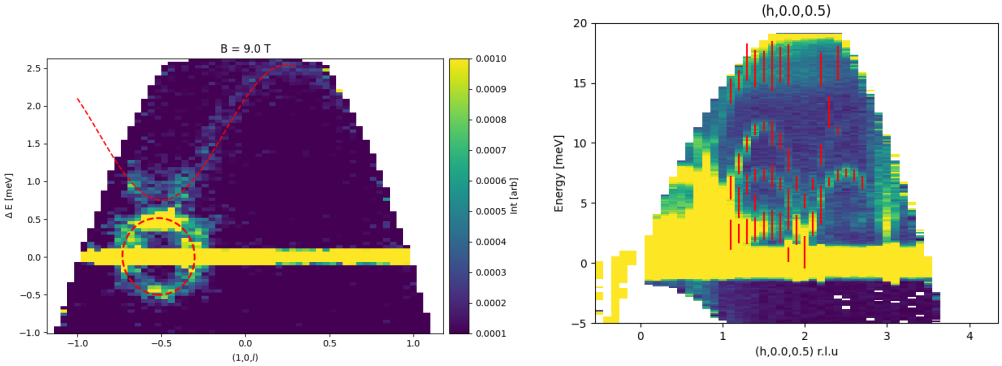


Figure 2: Magnetic field dependence on signals along (1,0,l) for 1.5 T, 4.5 T, and 9 T applied vertically along crystallographic c-axis.

After the end of the experiment, magnetic field ramped to 0 and sample taken out at 110 K. However, stick was slightly stuck and it sample got a little shaken on the way out of the cryostat. Sample not attached to sample stick when sachet was taken of, but scattering data from the last night confirm that sample was attached at this point corroborating that the sample fell off during dismounting. Sample returned to sample box and stored in the IN5 sample storage cabinet until activity level reached to be measured out.



(a) (b)

Figure 3: Inelastic scattering intensity in the high field phase for the high (a) and low (b) resolution setups.