Experimental report

09/12/2025

Proposal: 4-01-1902 **Council:** 4/2025

Title: Magnon splitting of the altermagnetic FeBO3

Research area: Physics

This proposal is a new proposal

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Samples: FeBO3

Instrument	Requested days	Allocated days	From	To
IN8	6	6	03/10/2025	09/10/2025

Abstract:

The prediction of electronic spin splitting in combination with a linear magnon dispersion boosted the interest in altermagnetism. A promising material for investigating the impact of altermagnetic character on the magnon dispersion is FeBO3. The altermagnetic character of FeBO3 is well established by DFT and can be directly seen in the magnetic structure. We propose to study the magnon dispersion on FeBO3 by INS on the thermal TAS IN8 in order to search for the predicted altermagnetic magnon splitting.

Experimental Report

Instrument	IN8
Proposal Number	4-01-1902
Proposal	Magnon splitting of the altermagnetic $FeBO_3$
Experimentalist	Lara Kiefer, Markus Braden
Local Contact	Andrea Piovano

Altermagnets have been proposed as a new class of magnetic materials that combine characteristics of both ferromagnets and antiferromagnets [1,2]. The prediction that, in fully compensated antiferromagnetic systems where the spin sublattices are related by rotational or mirror symmetries, the spin degeneracy can be lifted—leading to electronic spin splitting combined with a linear magnon dispersion—has significantly boosted interest in these materials and points toward promising applications in spintronics and magnonics [2]. One of the key features altermagnets is the predicted chiral magnon splitting that has attracted strong interest in the neutron community. Using unpolarized and polarized INS experiments signatures of chiral splitting of the magnons have been reported in MnTe [3], MnF_2 [4] and α-Fe_2O_3 [5].

Another altermagnetic material is $FeBO_3$, which crystalizes in the trigonal space group R-3c with a magnetic ordering temperature of 364K [6]. It develops an antiferromagnetic order in the ab-plane with moments of about $4.7\mu_B$ and an additional weak FM component [7]. This FM part does not contradict the idea of altermagnetism as shown by Cheong *et al*. [8] and even allows one to detwin the system, which might be a problem in other studied systems.

The aim of the experiment was to characterize the magnon dispersion of the altermagnetic $FeBO_3$ in order to study the predicted altermagnetic magnon splitting. To investigate the magnon dispersion two large single crystals with scattering geometries [100]/[001] and [110]/[001] were used. A PG (002) and a Cu (200) monochromator and PG (002) analyser were used; the Cu-monochromator was chosen to improve the energy resolution. Temperature control was provided by an orange-type cryostat. Scans were performed with fixed final neutron momentum, $k_f = 2.66 Å^{-1}$.

Despite its many advantages such as the strong scattering of Fe with S = 5/2, the material already being in its magnetic phase at room temperature, the ability to pole the magnetic domains by applying a magnetic field, and the large available single crystals in comparison to other altermagnetic materials, it should be noted that due to its boron content $FeBO_3$ is highly absorbing, which however can be tolerated due to the plate-like shape of the crystals. We were able to obtain strong signals and data with high statistics due to the high flux of IN8 and the adequate mounting of our single crystals (see Fig. 1).

In Fig. 1 shows constant-energy scans along (ξ, 0, 3), (0, 0, 3 + ξ), and (ξ, ξ, 3) indicating the overall high data quality and revealing no additional spurious signals or background features.

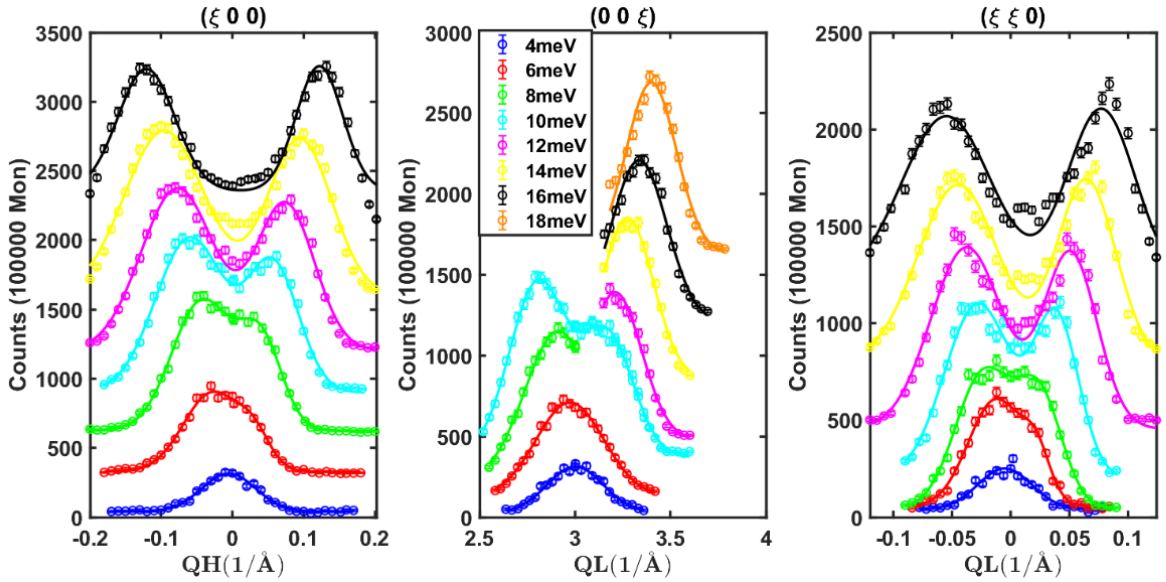


Fig. 1 Constant energy scans along the (ξ,0,3), the (0,0,3+ ξ) and the (ξ, ξ,3) direction showing the nice signal quality and high statistics; Mon. 100000 corresponds to about 30 sec counting time with the PG monochromator.

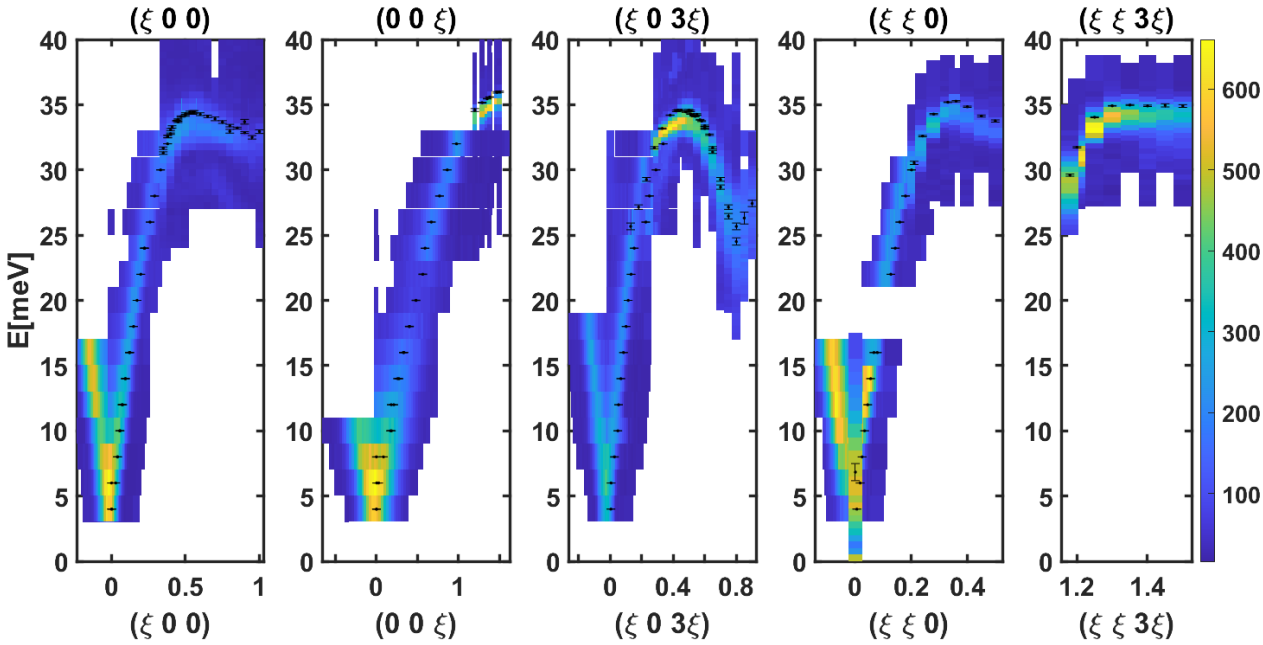


Fig. 2 Intensity maps of the inelastic neutron-scattering signal at 2K, plotted as intensity versus energy transfer and momentum, in addition the crosses indicate points on the dispersion that have been obtained from fits to the individual constant-E and -Q scans.

Fig. 2 presents the magnon dispersion along high-symmetry directions of the Brillouin zone, which were measured to characterize the magnetic excitation spectrum. The figure presents intensity maps of the inelastic neutron-scattering signal, plotted as intensity versus energy transfer and momentum. In addition, we show the data points that have been obtained from fits to the individual constant-E (see Fig. 1) and -Q scans. The measurement of magnon

energies as a function of momentum transfer facilitates the identification of the characteristic features of the spin-wave spectrum.

From simulations of the magnon dispersion with linear spin-wave theory we expect the splitting of the magnon branches along [ξ, ξ, 3ξ] and [ξ, ξ, ξ] directions. In the dispersion shown in Fig. 2 no splitting or broadening can be observed along [ξ, ξ, 3ξ] most likely due to the only small chiral splitting. Fig. 3 shows constant Q scans along the [ξ, ξ, 3ξ] direction using the copper monochromator to enhance the resolution with the corresponding FWHM obtained by Gaussian fits.

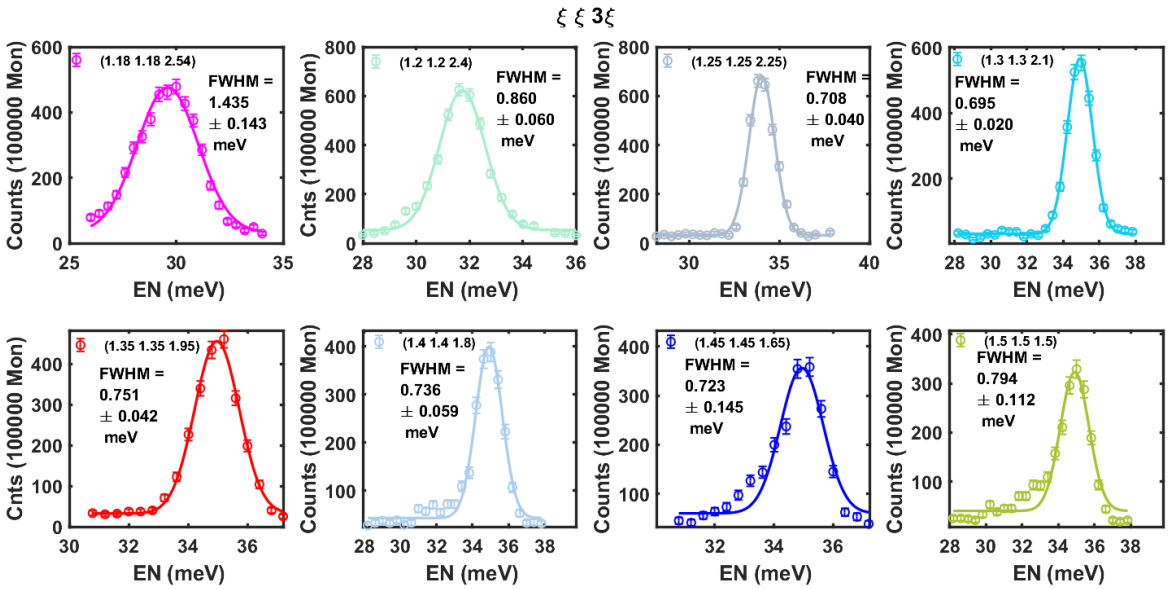


Fig. 3 Constant Q scans along [ξ, ξ, 3ξ] on the [1,1,3] using the copper monochromator do not show any signature of splitting or broadening. The FWHM is determined based on the fits. Mon. 100000 corresponds to about 80 sec counting time with the Cu monochromator.

The expected splitting is on the order of a few tenths of meV, comparable to the signal width (see FWHM in Fig. 3). Thus, even with the high resolution provided by the copper monochromator, it was not possible to resolve the splitting within the statistical accuracy of our experiment. To detect any chiral splitting, polarized inelastic neutron scattering would be the ideal tool.

[1] Šmejkal *et al. Physical Review Letters* 131.25 (2023): 256703. **[2]** Šmejkal *et al. Physical Review X* 12.4 (2022): 040501. **[3]** Liu *et al. Physical Review Letters* 133.15 (2024): 156702. **[4]** Faure *et al*. *arXiv preprint arXiv:2509.07087* (2025). **[5]** Sun *et al. Physical Review Letters* 135.18 (2025): 186703. **[6]** Y. Guo et al., Mater. Today Phys. 32, 100991 (2023) ; Autieri *et al. Physical Review B* 111.5 (2025): 054442. **[7]** Pernet *et al. Solid State Communications* 8.20 (1970): 1583-1587. **[8]** Cheong *et al. npj Quantum Materials* 9.1 (2024): 13.