# Experimental report

16/07/2021

**Proposal:** **TEST-3213**

**Council:** 4/2021

**Title:** Magnons in $Cu_2OSeO_3$

**Research area:**

**This proposal is a new proposal**

**Main proposer:** **Tobias WEBER**

**Experimental team:**

**Local contacts:** Paul STEFFENS

**Samples:** $Cu_2OSeO_3$

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| THALES | 5 | 5 | 07/07/2021 | 09/07/2021 |

**Abstract:**

# Band-sticking of magnons at the zone boundary of a chiral magnet – part 2

T. Weber,[1,*] M. Böhm,[1] P. Steffens,[1] M. Stekiel,[2] A. P. Schnyder,[3] M. A. Wilde,[2] and C. Pfleiderer[2]

[1] *Institut Laue-Langevin (ILL), 71 avenue des Martyrs, 38000 Grenoble, France*

[2] *Physik-Department E21, Technische Universität München (TUM), James-Franck-Str. 1, 85748 Garching, Germany*

[3] *Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany*

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The lack of an inversion symmetry for compounds crystallising in the $P2_13$ space group has led to the theoretical prediction of energetic degeneracies in their electron and magnon band structures, a so-called "band-sticking" [1]. This effect has been predicted to be centred around the corner R = (0.5 0.5 0.5) of the cubic Brillouin zone [1]. Performing de Haas-van Alphen measurements of the magnetisation, Wilde *et al.* very recently confirmed the appearance of electronic band degeneracies around the R point of the chiral magnet MnSi [2]. They could influence and lift these degeneracies by changing the angle of the applied external magnetic field. We chose a $Cu_2OSeO_3$ single-crystal over MnSi because for the latter the R point would lie in the Stoner continuum of non-collective single-particle excitations [3], see also our experimental report #4-01-1734. $Cu_2OSeO_3$ shares similar magnetic phases as MnSi, including a skyrmion phase, and its magnons had already been comprehensively mapped out in zero external field [4], allowing us to focus on detail scans.

For the present experiment we continued our measurements which we had recently begun on IN8 [5], see our report #7-01-562, DOI: 10.5291/ILL-DATA.7-01-562. We continued investigating the magnon dispersion branches around the cubic R point in single-crystalline $Cu_2OSeO_3$, but this time using the Thales spectrometer [6]. For increased resolution, we chose $k_f = 1.5\,\text{Å}^{-1}$, compared to the thermal $k_f = 2.662\,\text{Å}^{-1}$ we had in our previous experiment. As beamtime was limited for this internal experiment, we opted for an open collimation, a focusing Si(111) monochromator and HOPG(002) analyser.

The $Cu_2OSeO_3$ single-crystal was cooled to $T = 10$ K and the experiment was performed around its (220) Bragg reflection. (220) was selected for its large nuclear structure factor and its wave vector being low enough for a sufficiently strong magnetic form factor as well as a strongly diminished phonon intensity compared to our last experiment, where we centred around the (440) peak. The crystal was oriented in the (hhl) plane, and we applied a horizontal field of magnitude $B = 0.2$ T in two scan series along the [001] and [110] directions, respectively, using an Oxford cryomagnet [7].

Figure 1 shows our results for the zone boundary magnon dispersion propagating from the (0.5 0.5 0) edge to the (0.5 0.5 0.5) corner of the nuclear Brillouin zone. Compared to our IN8 results, the phonon contributions are not visible anymore, we instead observe the pure magnon spectra. The 8.5 meV and 10.5 meV magnons at $q = (0.5\ 0.5\ 0.5)$ are now also clearly distinguishable from one another due to the increased resolution. For lower $q$ there is some line shape and intensity differences between the present Thales and the previous IN8 results which we attribute to effects of the instrument resolution. These will be further investigated using resolution convolution once a theoretical model is available.

The scans depicted in figure 2 focus on the (0.5 0.5 0.5) magnons. Here, we gradually rotated the magnetic field from 0°, which corresponds to the [001] direction, to 90°, which corresponds to the [110] direction. For 0°, the 8.5 meV magnon is not yet observable, whereas the 10.5 meV magnon is very intense. Increasing the angle of the field, the 10.5 meV magnon loses intensity, which the 8.5 meV gains.

Our results are very promising and a thorough theoretical analysis is in order to decipher the observed effects.

Data DOI: 10.5291/ILL-DATA.TEST-3213.

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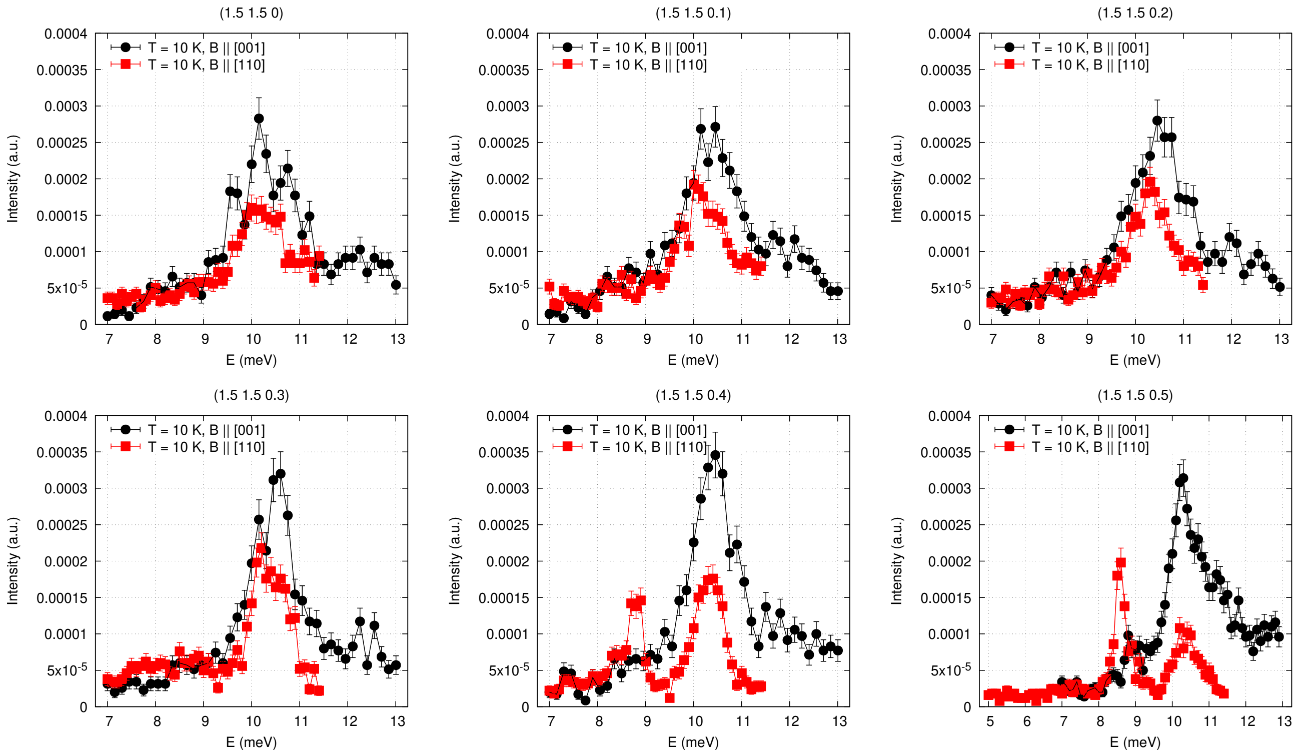


Figure 1. Measurements along the cubic zone boundary from $q_i = (0.5\ 0.5\ 0)$ (left top) to $q_f = (0.5\ 0.5\ 0.5)$ (right bottom). The black and red points depict scans with field $B \parallel [001]$ and $B \parallel [110]$, respectively.

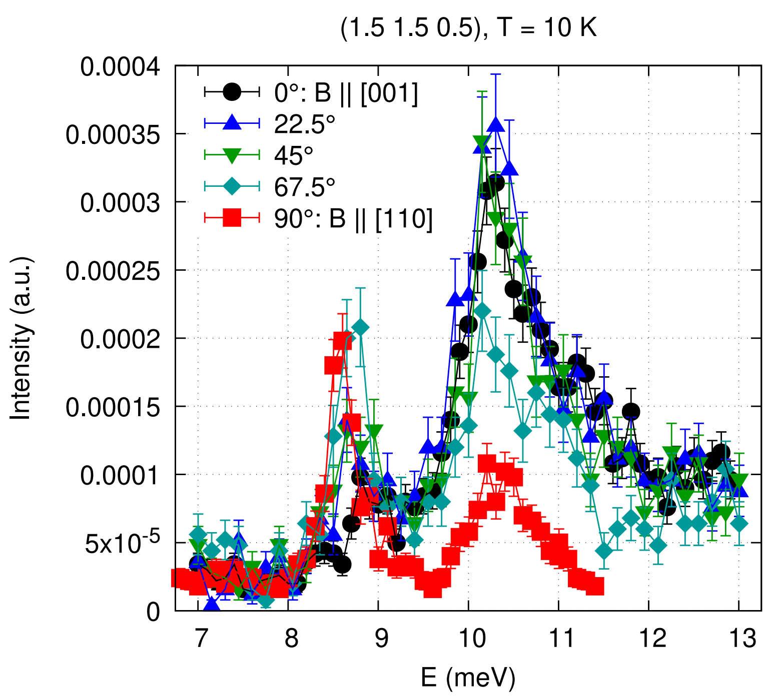


Figure 2. Scans for $q = (0.5\ 0.5\ 0.5)$ for several magnetic field directions rotated from $0^\circ \equiv [001]$ to $90^\circ \equiv [110]$.

* Correspondence: tweber@ill.fr