Experimental report

26/09/2018

Proposal: **4-01-1572** **Council:** 4/2017

Title: Magnon spectrum in a candidate Weyl semi-metal with magnetic order

Research area: Physics

This proposal is a new proposal

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Samples: $YbMnBi_2$

Instrument	Requested days	Allocated days	From	To
IN3	0	4		
IN8 Flatcone	7	7	19/09/2018	26/09/2018

Abstract:

We propose to investigate the magnon spectrum in the antiferromagnetic phase of $YbMnBi_2$. This material has recently been identified as a candidate Weyl semi-metal driven by time-reversal symmetry breaking. Magnetic order is therefore key to its behaviour as a topological material, and the magnon spectrum and exchange parameters derived from it could reflect the presence of Weyl fermions near the Fermi energy. We shall use IN8 with the flatcone analysers to map out the magnon dispersion in all high symmetry directions. To identify any anomalies associated with the presence of Weyl fermions we shall compare the observed magnon spectrum with that in $CaMnBi_2$, which we have studied previously on IN8 and which does not host Weyl fermions.

Summary of IN8 experiment on $YbMnBi_2$

September 26, 2018

1 Introduction

The experiment was carried out on IN8 between 18/9 2018 and 26/9 2018. Present were Henrik Jacobsen (19/9-26/9), Andrew Boothroyd (19/9-24/9), Jian Rui Soh (18/9-21/9 and 24/9-26/9). Originally the experiment was scheduled to start on 19/9, but the previous users left early and the experiment was started early. The local contact was Alexandre Ivanov (Sasha) on 18/9-21/9) and Andrea Piovano for the rest. The experiment number is 4-01-1572, with the title "Magnon spectrum in a candidate Weyl semi-metal with magnetic order".

The instrument was set up to use FlatCone which has a constant k_f = 3.0 Å^{-1}. The slits were set fairly loosely. For measurements with $\Delta E < 40$ meV we used the Si111 monochromator, for higher energies the PG002 monochromator was used. For elastic measurements "plexi" was inserted.

The sample was $YbMnBi_2$, which has a magnetic moment on the Mn atoms. The space group is P 4/n m m and the lattice parameters are $a = b = 4.535$ Å, $c = 10.852$ Å. The magnetic moments are aligned along the c axis, and the main goal of the experiment was to measure the spin waves with sufficient accuracy to determine the relevant exchange constants, particularly J_c, and the anisotropy which confines the spins to align along the c axis.

All measurements were performed at base temperature. When heating and cooling we also measured around the magnetic peaks to get a temperature dependence of the magnetic order.

In the first half of the experiment, 18/9-21/9 the sample was mounted in the $(H, 0, L)$ orientation and constant energy maps were measured at energies of 0:5:65 meV. Furthermore, constant Q scans were performed at the minimum and maximum of the dispersion for $L = 0$ (~ 10 meV and ~ 60 meV) and at the minimum of the dispersion for $L = 0.5$ (~ 15 meV). The L dependence can be used to determine J_c, the gap at $L = 0$ can be used to determine the anisotropy and the peak energy is of course important for the other exchange constants.

The beam was turned off for 12 hours to allow the smaple to cool down sufficiently to be handled. Then the sample was rotated 90° to allow for measurements of the HK plane. Here, constant energy maps were measured at energies of 0, 5, 10, 20, 26.5, 30, 32.5, 35, 37.5, 40, 44, 48, 52, 56 and 60 meV. Furthermore, constant Q cuts were measured at the top of the dispersion along (110) (0.25,±0.25,0), at the bottom (0.5, ±0.5,0) and at the (1,0,0) position.

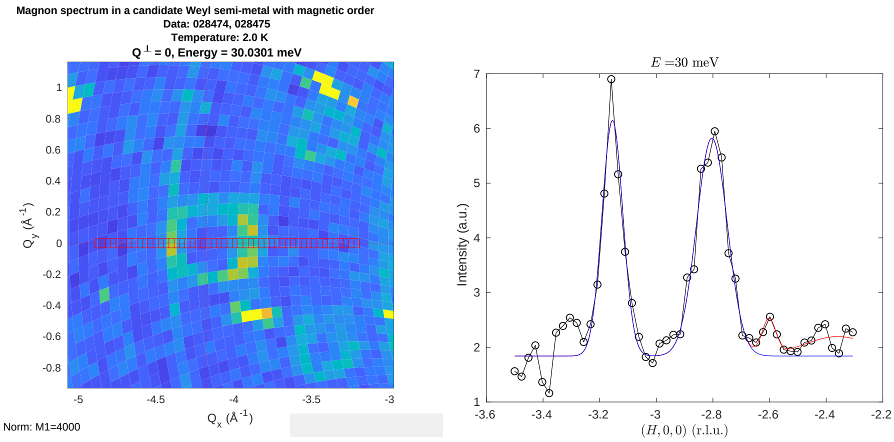

Figure 1: Example of the procedure used to extract the spinwave dispersion from the data. Left figure shows a zoom in of the colormap at 30 meV and where a cut has been made. Right figure shows the cut along with the fit.

2 Results

For each map, 1 dimensional cuts were taken through the spin wave dispersion as illustrated in Fig. 1. These were fitted to an appropriate number of Gaussians to deal with the peaks and the background. The resulting parameters were saved. A SpinW model was made and fitted to the dispersion. The result is shown in Fig. 2. The analysis is still in progress; among other tihngs cuts along the (110) direction need to be made.

To conclude, we have mapped out the spin wave dispersion in $YbMnBi_2$ with sufficient detail to determine the size of the relevant exchange constants and anisotropy parameters, and the experiment is overall a success. However, we might need to measure more points along the $(0, 0, L)$ direction in single detector mode to better map out the dispersion here.

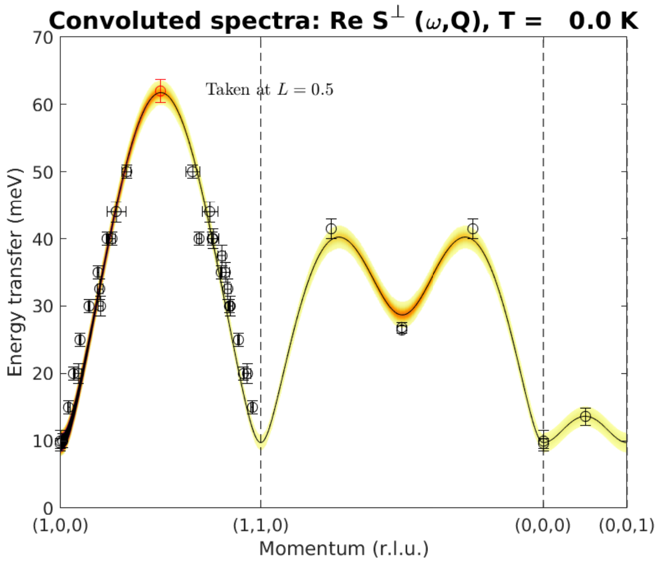

Figure 2: The dispersion measured in our experiments. All coordinates have been transformed to the reduced Brillouin zone.