Experimental report

09/02/2016

Proposal: **4-01-1444** **Council:** 10/2014

Title: Magnetic excitations in novel ferrimagnetic spinel $ScMn_2O_4$

Research area: Physics

This proposal is a new proposal

Main proposer: **Andrew PRINCEP**

Experimental team: Nathaniel DAVIES
Andrew PRINCEP

Local contacts: Andrea PIOVANO

Samples: $ScMn_2O_4$

Instrument	Requested days	Allocated days	From	To
IN8 Flatcone	6	6	10/07/2015	16/07/2015

Abstract:

$ScMn_2O_4$ (space group I41/amd) is structurally analogous to Mn_3O_4 with half of the 8d Mn sites replaced by the small Sc ion, suppressing the Jahn-teller distortion of the BO_6 octahedra. The compound orders ferrimagnetically at T=58K (shubnikov group I41/am'd') but the observed Mn moments are about 3/4 of those found in Mn_3O_4, and the incoommensurate magnetic phase of the undoped compound is not observed. The curie-weiss temperature of nearly 600K indicates that this material is highly frustrated, possibly due to Sc/Mn site disorder disrupting exchange pathways. Likely as a result of this, there are anomalous magnetic fluctuations observed at low temperatures causing a novel feature in the susceptibility and the absence of a stable magnetic signal in uSR. We propose to use inelastic neutron scattering to study the spin excitations in the region of the susceptibility anomaly, and determine the nature of these anomalous low temperature phenomena.

Experimental report 4-01-1444 and TEST-2539 (instrument IN8)

Magnetic Excitations in Novel Ferrimagnetic Spinel $ScMn_2O_4$

Scientific Background

Experiments 4-01-1444 and TEST-2539 form the basis of our attempts to understand the nature of the fluctuating magnetic moments that remain at low temperature in $ScMn_2O_4$. The compound orders in a ferromagnetic structure similar to the collinear phase of Mn_3O_4 [1], although the ordered moments on the Mn atoms is reduced even from the values found in Mn_3O_4 (and thus well below the free-ion values). Diffraction measurements show a diffuse magnetic component, and susceptibility finds an unusual peak at low temperatures which does not correspond to any features in, for example, the heat capacity.

Aim of the experiment

To study the magnetic excitations in $ScMn_2O_4$ and search for an explanation for the anomaly in the susceptibility.

Technical

A 1.8 g single crystal was mounted in the HK0 and HHL planes, and flatcone scans were performed from 0meV (elastic) to 36meV (the band maximum, determined during the experiment).

Instrument performance

We experienced no technical difficulties with the instrument or sample environment. The control interface of IN8 is quite good although some features could be improved. The instrument responsible Dr. Andrea Piovano was extremely helpful and contributed crucial experimental advice, providing truly exceptional out of hours at key times (such as during the alignment).

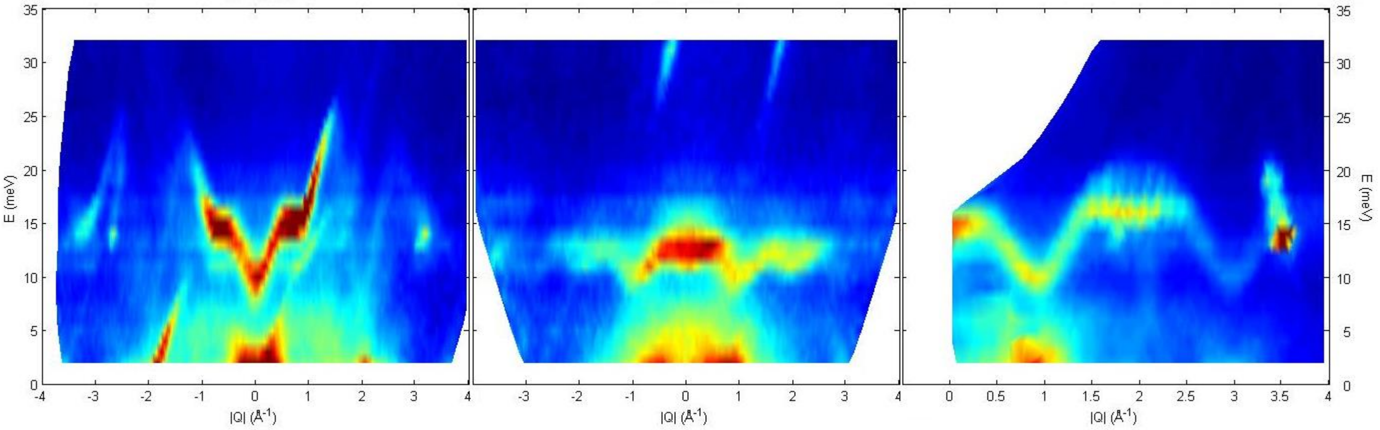

Figure 2. *Representative cuts through the data. Several strong features are spurions, but the bulk of the figure indicates the presence of a number of dispersive modes.*

Key results

We obtained a substantial amount of data covering the excitations and useful scans of the diffuse component at around 2meV. The diffuse scattering appears to be highly structured, which could indicate short-range order of scandium atoms, which were previously assumed to be randomly substituted into the Mn^{3+} sites. We also determined the size of the anisotropy gap (about 7meV) and the bandwith of the magnetic excitations (about 28meV).

Data analysis

We are in the process of attempting to model the excitations using SpinW [2] and have been working with the author of the code, Sandor Toth, to model the partially disordered structure (treating Sc atoms as magnetic vacancies). So far our models always find a flat mode which does not appear well supported by the data. We are in the process of applying for continuation beamtime to complete our study of the excitation spectrum, and we will also attempt to model the diffuse scattering, which seems to indicate short range magnetic/structural correlations that could substantially impact our model of the magnetic structure.

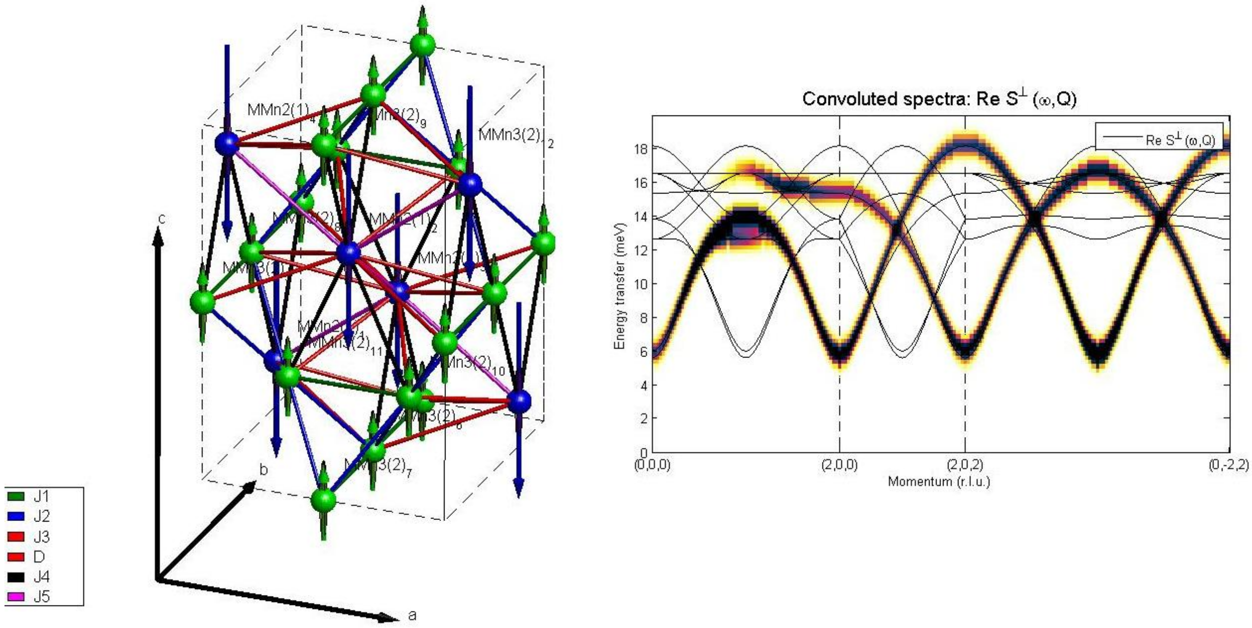

Figure 2. *The magnetic structure model (indicating important exchanges) and a representative dispersion that arises from such a model.*

Overall evaluation

Although the beamtime was successful (despite the relatively small crystal size, and the broadness of the excitations), it is clear that follow-up measurements are necessary in order to fully unravel the nature of the magnetism in this compound.

References

[1] G B Jensen and O V Nielsen, J. Phys. C **7**, 409 (1974).

[2] S. Toth and B. Lake. J. Phys.: Condens. Matter 27, 166002 (2015).