Experimental report

12/02/2017

Proposal: 5-42-426 **Council:** 4/2016

Title: Short range correlations in novel ferrimagnetic spinel Mn(Sc0.5M0.5)2O4

Research area: Physics

This proposal is a new proposal

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Local contacts: Andrew WILDES

Samples: Mn(Sc0.5Mn0.5)2O4

Instrument	Requested days	Allocated days	From	To
D7	7	7	07/12/2016	14/12/2016

Abstract:

ScMn2O4 (space group I41/amd) is structurally analogous to Mn3O4 with half of the 8d Mn sites replaced by the small Sc ion, suppressing the Jahn-teller distortion of the BO6 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 Mn3O4, and the incommensurate 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. We have performed an experiment on IN8 to measure the excitations and discovered a strong, detailed diffuse component to the scattered intensity due to short-range correlations. Given the large number of parameters in the spin-hamiltonian and the possibility for short-range ordering of Sc atomic positions, it is extremely important to understand the diffuse scattering and determine whether it is structural, magnetic, or both.

$Mn(Sc_{0.5}Mn_{0.5})_2O_4$ is a new material with the inverse-spinel structure which shows suppressed Jahn-Teller distortion on the BO_6 (B = $(Sc_{0.5}Mn_{0.5})$) octahedra. As a result, the geometric frustration inherent in the ideal spinel structure is not removed in Mn(Sc0.5Mn0.5)2O4, making it a very interesting example of a highly frustrated magnetic system.
Recently, we have shown that $Mn(Sc_{0.5}Mn_{0.5})_2O_4$ exhibits a phase transition to nearly fully-compensated ferrimagnetic order at 58K and performed measurements on the magnon spectrum of a single crystal at IN8 [1]. In the latter experiment, in addition to broad magnon modes we found strong, diffuse, low energy scattering which may be either structural or magnetic in origin.

The present experiment (4-01-1519) aimed to establish the origin of this diffuse scattering and measure it in detail.

We used the ORIENTEXPRESS instrument to align the crystal in the desired scattering plane before measuring on D7. A first attempted alignment left the crystal in a so far unidentified orientation which was not a high symmetry orientation, however after re-orientation the crystal was successfully aligned to measure scattering in the (h,k,h) plane. We performed a full measurement on D7 in this plane with x, y and z polarisation in both spin-flip and non-spin-flip channels.

Fig. 1 shows these results. We identify the diffuse scattering as primarily magnetic in nature and see evidence for low energy magnetic dispersive modes. In addition to these desired results, however, we also see evidence for twinning, multiple crystallites, and a parasitic magnetic phase we were not previously aware of, with these sample difficulties meaning that unfortunately we do not expect to be able to extract any useful conclusions from this dataset after analysis. We are in the process of trying to grow a higher quality sample of this composition in order to take this study further.

We would like to acknowledge a sample environment and beamline working without technical difficulties, excellent support by the local contact as well as the useful data analysis utilities provided by the ILL. In addition, we were very grateful for the use of ORIENTEXPRESS for sample alignment, without which the experiment would not have been possible since the sample was too large to reliably align except on a neutron instrument.

[1] Experimental report for proposal 4-01-1444

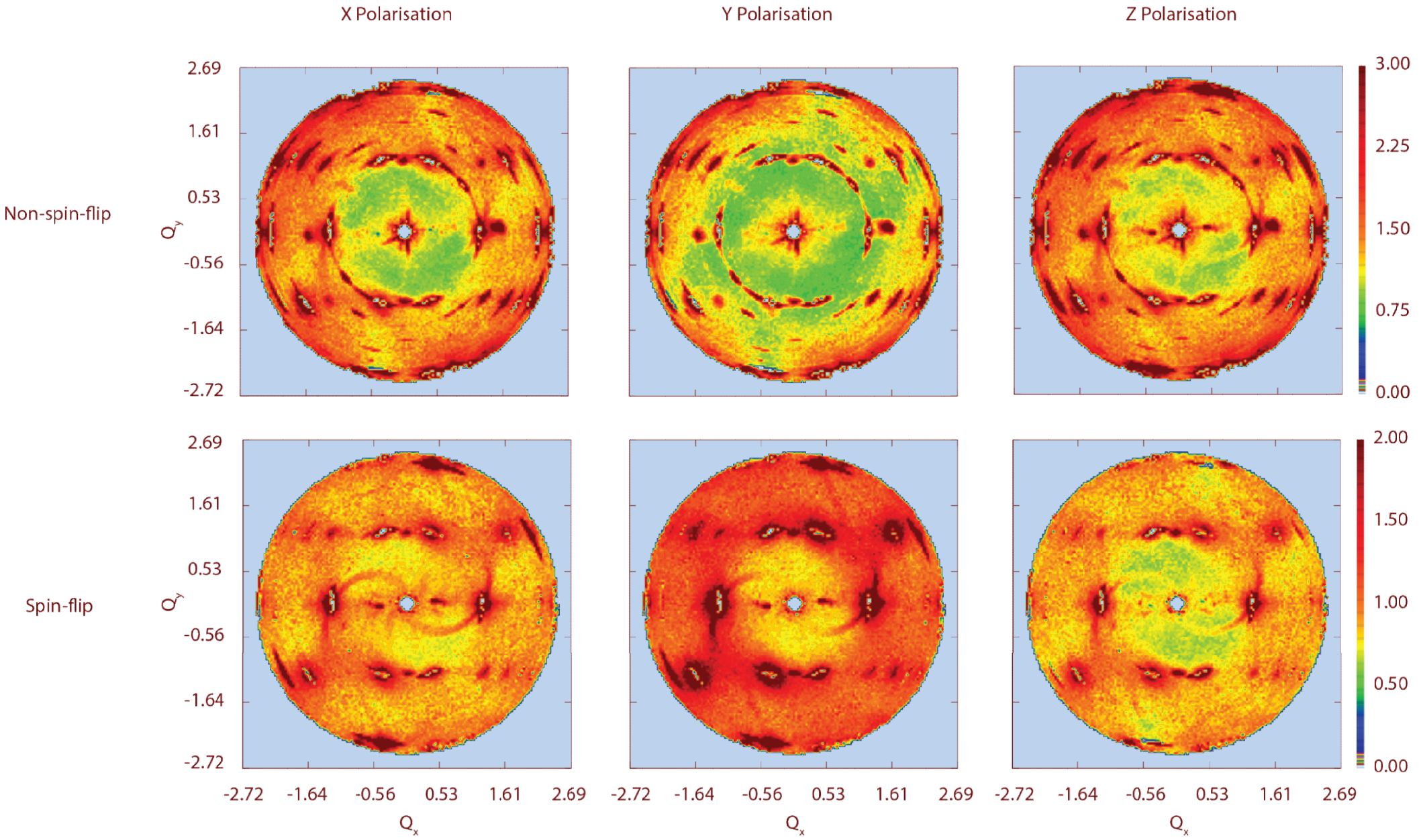

Fig. 1: Measured elastic scattering in the (hkh) plane from $Mn(Sc_{0.5}Mn_{0.5})_2O_4$