Experimental Report

Proposal: **5-32-795** **Council:** 4/2014

Title: Emergent excitations and long range order in Gd3Al5O12

This proposal is a new proposal

Researh Area: Physics

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Samples: Gd3Al5O12

Instrument	Req. Days	All. Days	From	To
D7	6	6	02/09/2014	08/09/2014

Abstract:

Gd3Ga5O12 (GGG) is the archetypal frustrated magnet with unusual magnetic short range order that shows no long range order down to the lowest temperatures measured (25 mK). In this work we would like to study the homologous compound, Gd3Al5O12 (GAG), with a frustration index of 13. A recent specific heat study shows a broad maximum around 1~K, analogous that that found in GGG, followed by a sharp peak at T = 0.175~K indicative of long range order, unlike GGG. The diffuse scattering spectrometer D7 will probe the development of short ranged order correlations in GAG below 1~K that should develop into longer ranged correlations below 0.175~K. The comparison between GGG and GAG will determine the importance of the (already ascertained) exchange interactions for the development of short range and longer ranged magnetic order in hyperkagome structures and shed light on the ordered state of GAG below 0.175~K.

Report of neutron diffraction exp. on D7 on GAG

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1 Introduction and setup

The experiment was performed on D7 at ILL in the time period 2/9 2014 to 7/9 2014, experiment number 5-32-795. Present were Henrik Jacobsen (1/9-5/9), Pascale Deen (1/9-5/9), Paul Henry (1/9-4/9) and Andrew Wildes and Gøran Jan Nilsen (local contacts).

The sample was approximately 1.5 g of powder of $Gd_3Al_5O_12$ (Gadolinium Aluminum Garnet, GAG). The Gd^{3+} ions form two interpenetrating hyperkagome lattices, which give rise to magnetic frustration and interesting behavior. GAG does not down to the lowest temperatures. The aim of the experiment was to investigate the low temperature magnetic structure.

The sample was loaded in a hollow cylindrical container such that the sample thickness was 0.5 mm. The sample was 98.5% enriched with the ^{160} Gd isotope, leading to an acceptable transmission of $\sim 60\%$ of the beam. The sample was cooled with a dilution fridge. It was measured at 60 mK, 200 mK, 300 mK, 800 mK and 1200 mK.

The wavelength was $\lambda = 3.14$ Å, leading to a q-range of 0.22-3.83 Å^{-1}. xyz-polarization analysis allowed for separation of the magnetic signal from the nuclear and spin incoherent.

Using standard procedures (using the Large Array Manipulation Progam, LAMP), quartz, vanadium and cadmium measurements were used to calibrate the polarization, detector efficiency and absolute units and absorption corrections, respectively. Measurements of the empty can were abandoned in favor of more data. As a result, the background subtraction is not perfect at the Bragg peaks of Al and Cu.

2 Results and Conclusions

The magnetic signal at all temperatures (with the Bragg peaks at higher q and the small angle scattering removed) is seen in Fig. 1. We see a clear peak from

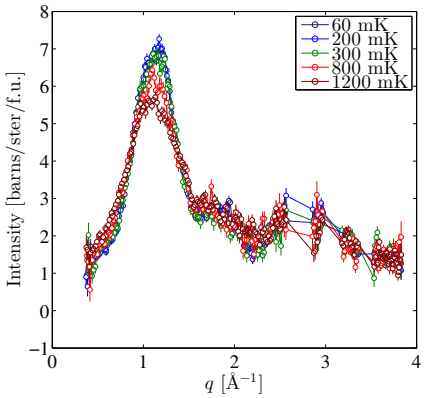

Figure 1: SPINVERT refinement on the GAG data at 60 mK (top left), 200 mK (top right), 300 mK (center left), 800 mK (center right) and 1200 mK (bottom left). Bottom right shows all the data in one plot. The Bragg peaks have been cut out. A very large signal is seen in the SPINVERT refinement at low q. This does not seem right.

short range order near 1 Å^{-1} as well as bumps near 2 Å^{-1} and 3 Å^{-1}. As the temperature is increased the magnetic signal decreases.

We have done SPINVERT refinements on the data with the Bragg peaks and the small angle scattering removed. The unit cell was $4 \times 4 \times 4$. The results are shown in Fig. 1 as full lines.

The experiment provided interesting results but the measuring time was severely limited. First, the reactor power was reduced by 35 % due to reactor problems. Second the total time had been reduced by a day since the reactor had to be shut down early.
Third, we lost 12 hours due to a dilution error and finally we lost a further 15 hours due to Nomad crashing that resulted in the instrument completely shutting down. We therefore lost nearly three days of measuring time if compared with a full allocation at nominal reactor power. Only 60 mK, 200 mK and 1200 mK were measured with adequate statistics.