Experimental report

17/01/2017

Proposal: 4-01-1493 **Council:** 4/2016

Title: Temperature Dependence of the Different Flavors of Magnetic Excitations in Sr3Cr2O8

Research area: Physics

This proposal is a new proposal

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Samples: Sr3Cr2O8

Instrument	Requested days	Allocated days	From	To
IN12	0	5	10/11/2016	16/11/2016
THALES	7	0		

Abstract:

In Sr3Cr2O8 a strongly correlated gas of magnons persists at finite temperatures contrary to the long standing view of thermal decoherence in magnetic systems. These results, together with those for one-dimensional systems have inspired multiple new theories and calculations of thermal effects on strongly correlated systems. The sign of the strong correlation between the excited pseudoparticles –magnons- in an inelastic neutron scattering signal is an asymmetric development of the lineshape when increasing temperature. Here, we propose to investigate the thermal dependence of the excitations in Sr3Cr2O8 while applying a magnetic field to separate the different flavors of the triplet state. This information will contribute in the development of theories for 3-dimensional systems.

Magnetic field inducing co-existing antiferromagnetic phases in $SrYb_2O_4$

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$Sr_3Cr_2O_8$ consists of a three dimensional arrangement of spin-1/2 Cr5+ ions, that are coupled together into dimers and give rise to a singlet ground state and triplet excited states. The dispersion relation of the magnetic excitations at low temperature (1.6K) was successfully modelled using a random phase approximation [7]. However, this model is unable to predict how the lineshape broadens when increasing temperature. When temperature is raised and the population of thermally excited dimers increases, the excitations scatter in a highly correlated way due to the interactions between them and the limited density of states available. An asymmetric lineshape evidences magnon-magnon correlations, as can be seen in Fig. 1. A fully functioning theory for the 3D systems is not yet available and key information is needed to formulate the theory, such as the thermal development of the different flavours of the excited triplet.

We have carried out an experiment at IN12, in which a magnetic field is applied to the Sr3Cr2O8 sample in order to split the triplets on to the different spin flavours. A maximum possible field of 14.9T was applied and the measurements were carried out at different temperatures at the same wavevector.

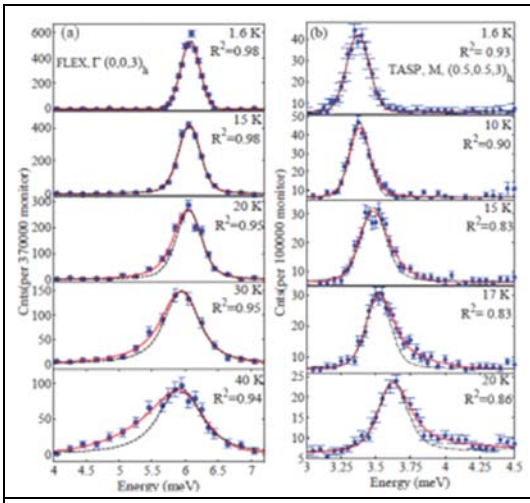

Fig 1. Constant-wavevector scans at different temperatures measured on (a) FLEX at $(0, 0, 3)_h$, and (b) TASP at $(0.5, 0.5, 3)_h$ compared to symmetric (black line) and asymmetric (red line) lineshape functions [1].

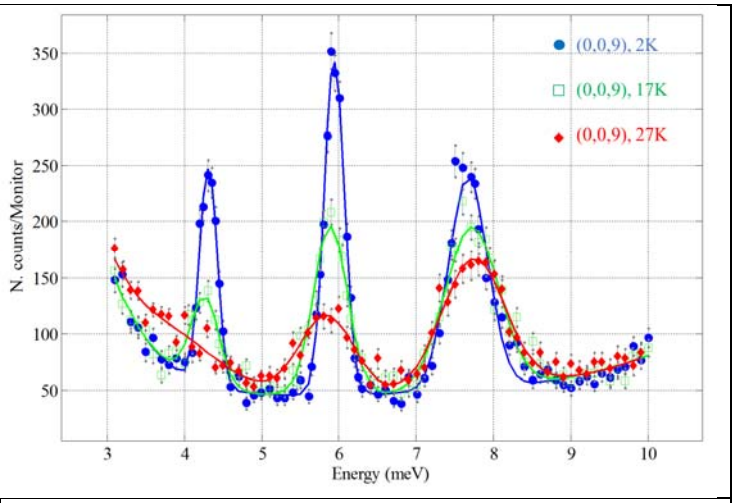

Figure 2. Constant-wavevector energy scans at different temperatures measured at (0,0,9) with an applied field of 14.9T at IN12.

The instrumental settings were adjust to have the best compromise between energy resolution and flux. A final wave vector of $1.5Å^{-1}$ was used together with a collimation setting of 60'-open-open. The full width half maximum of the Vanadium incoherent line with this instrumental conditions was 0.15meV. This resolution should have been sufficient to detect an

asymmetrical lineshape according to our previous experiments at TASP-PSI and FLEX-HZB. Within the given beamtime only 3 temperatures have been measured at one wavevector positon. Some beamtime has been used to find the best point in reciprocal space for the measurement, in order to avoid phonons, extreme values of wavevector transfer and to get the highest flux.

Figure 2 shows the three temperature scans measured at (0,0,9). The counting times per scan were: 19, 23 and 24 hours. The solid lines in the figure are fits to a Gaussian function with a fixed background. From this fit we can see a symmetric broadening and a simple Gaussian function is enough to describe the data. Further measurements with a better energy resolution and flater background will be necessary to distinguish the lineshape of the excitations in field. A continuation proposal will be submitted.

References:

[1] Quintero-Castro, D.L.; et al.; Phys. Rev. Lett. **109**, 127206 (2012)