Experimental report

14/09/2022

Proposal:	**4-01-1686**		**Council:**	4/2020

Title: Spin dynamics in hyperkagome Nd3Ga5O12

Research area: Physics

This proposal is a new proposal

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Samples: Nd3Ga5O12

Instrument	Requested days	Allocated days	From	To
IN5	7	6	16/03/2021	23/03/2021

Abstract:

At the heart of frustrated magnetism physics, the studies of the magnetic properties of rare-earth (RE) ion systems have led to ground-breaking theoretical concepts, such as Coulomb phase physics or emergent quantum electrodynamics. Studies of rare-earth pyrochlore oxydes have quite contributed in this field, yet, other structures, like the "hyperkagomé", made of corner sharing triangles are also prone to geometric frustration. Whether or not the concepts developed in the context of pyrochlores might be adapted to this structure represents an important issue. This motivates new research on the RE gallium garnets RE3Ga5O12 (space group Ia-3d) which belong to this family of hyperkagomé compounds. We wish to determine the interactions at play in Nd3Ga5O12 following our detailed investigation of its (H,T) phase diagram by means of neutron diffraction.

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This proposal received beamtime to study the néodymium garnet $Nd_3Ga_5O_{12}$. Unfortunately, we were compelled to study this sample during an experiment on IN12 (CRG 2774, see the experiment report), because a delayed sample. Because this IN12 experiment was successful and did not require further investigations on IN5, it was decided to use the IN5 beamtime on another garnet, $Dy_3Ga_5O_{12}$, which exhibits very similar physics. This is also a rare-earth garnet, the CEF ground state is nearly the same, and the low temperature magnetic structures are almost identical up to some details.

The experiment was thus devoted to the study of the low energy magnetic excitation spectrum of the dysprosium gallium garnet $Dy_3Ga_5O_{12}$ and its behaviour in an applied magnetic field. IN5 was operated with a dilution fridge inserted into a cryomagnet, at the base temperature of 50 mK. We used several incident energies (from 2.3 to 7 Å), and various magnetic fields (0 to 2 T).

The crystal field level around 3 meV, that had been observed previously on a powder sample, is clearly seen (Figure 1). We could follow its field dependence (Figure 2). As shown in Figure 3, this CEF mode shows a striking structure factor: its intensity apparently increases with increasing Q, a dependence rather unusual, as it does not follow the Dy^{3+} magnetic form factor. Furthermore, the cuts at constant energy suggest a weak dispersion, which we are currently trying to understand with spin wave calculations. Figure 3 shows especially a spot around (004) that remains to be understood.

In addition, a preliminary experiment on IN6 on a powder sample (CRG-2729) had revealed a very low energy signal around 0.3 meV, akin to some quasi-elastic signal, as shown in Figure 4, which displays powder spectra taken at low temperature in $Dy_3Al_5O_{12}$ and $Dy_3Ga_5O_{12}$. Unfortunately, we were not able to confirm the nature of this feature in the IN5 experiment. The signal that is observed in Figure 5 below 0.1 meV is extremely weak, does not change in magnetic field up to 0.15 T, and is still present at 5 K. **We suppose it is a spurious effect due to some parasitic scattering (likely the elastic line) on the sample environment**. Further investigations are necessary to understand and check the consistency of those results.

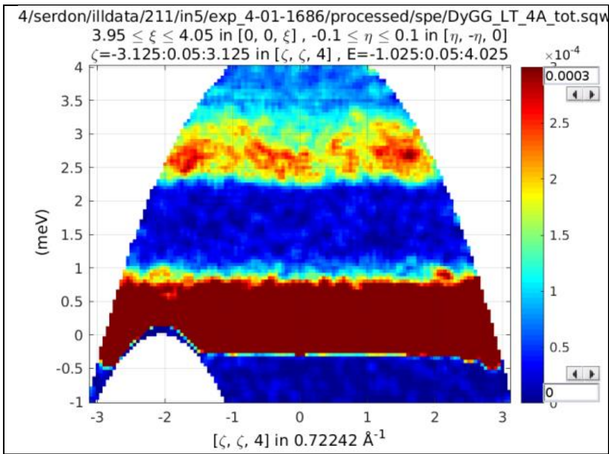

Figure 1 : Excitation spectrum of DyGG along hh4, IN5 incident wavelength 4 Å (50 mK)

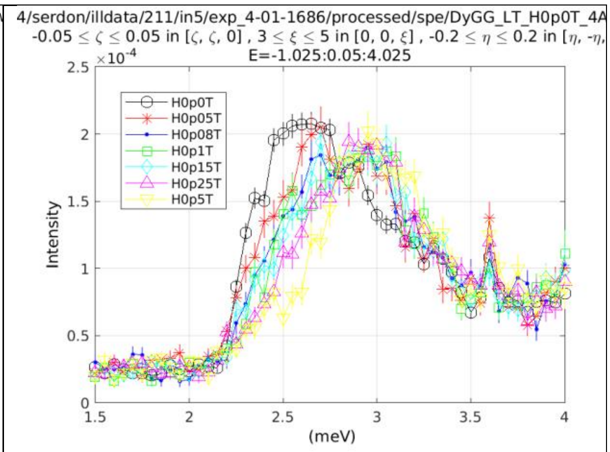

Figure 2 : CEF level position as a function of magnetic field. IN5 incident wavelength 4 Å (50 mK).

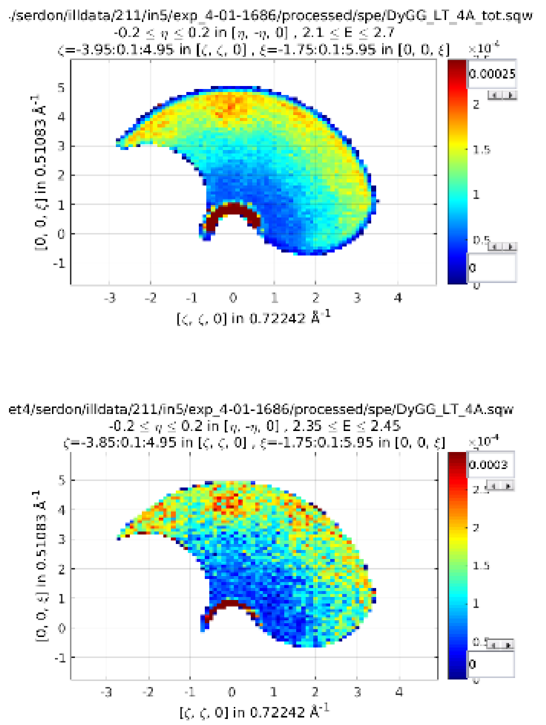

Figure 3 : constant energy cuts in Dy3Ga5O12 measured at IN5. In the upper panel, the cut integrates over [21.-2.7] meV, while the lower panel integrates over [2.35-2.45] meV. Both highlight the strong spot at (004) and the anomalous form factor.

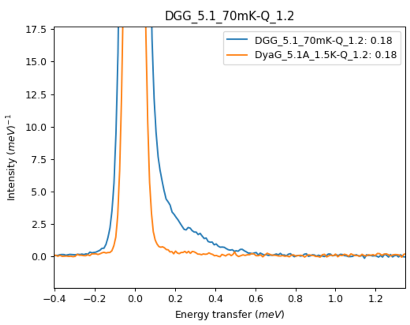

Figure 4 : Excitation spectrum of DyGG (blue) and DyAlG (orange) taken at IN6 (incident wavelength 5.1 Å, 50 mK, Q= 1.2 Å^{-1}).

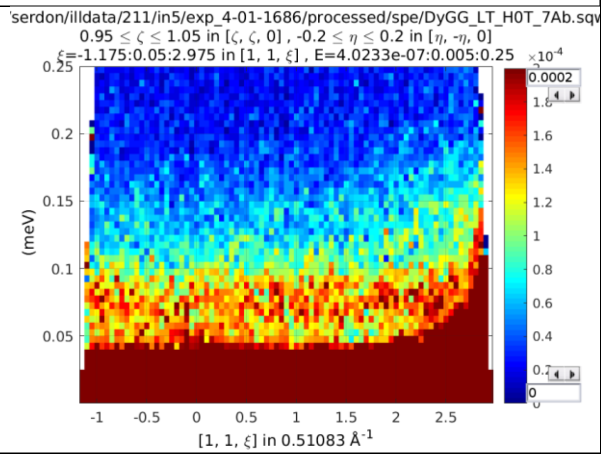

Figure 5 : Excitation spectrum of DyGG along 11l, IN5 incident wavelength 7 Å (50 mK).