Experimental report

08/09/2022

Proposal: 4-04-505 **Council:** 10/2020

Title: Evolution of the Dy3+ magnetic anisotropy in Dy3B2C3O12 garnets

Research area: Physics

This proposal is a new proposal

Main proposer: Francoise DAMAY

Experimental team: Francoise DAMAY
Sylvain PETIT

Local contacts: Stephane ROLS

Samples: Dy3In2Ga3O12
Dy3Sc2Al3O12
Dy3Sc2Ga5O12
Dy3Te2Li3O12

Instrument	Requested days	Allocated days	From	To
PANTHER	5	5	10/06/2021	15/06/2021

Abstract:

The general magnetic phase diagram calculated for an anisotropic S=1/2 spin on the hyperkagome lattice found in garnets predicts complex magnetic ground states when the magnetic anisotropy departs from the Ising case. We would like to study crystal electric field (CEF) excitations in a series of four dysprosium garnets, in which the A site has been varied to modify the Dy environment. We expect this study to clarify how the Dy3+ Landé g tensor can be tuned with A ; this will lead to the design of dysprosium garnets with unusual and possibly disordered magnetic ground states.

Evolution of the Dy^{3+} magnetic anisotropy in $Dy_3B_2C_3O_{12}$ garnets

The hyperkagome is built on corner sharing triangles, and can be seen as a 3D analog of the planar kagome networks (Figure 1) [1, 2]. Such hyperkagome networks can be found in rare-earth (RE) garnets $RE_3A_5O_{12}$ (A = Al, Ga) : they crystallize in a cubic structure (SG : *Ia*-3*d*), in which the magnetic RE^{3+} ions occupy the sites of two nesting hyperkagome networks.

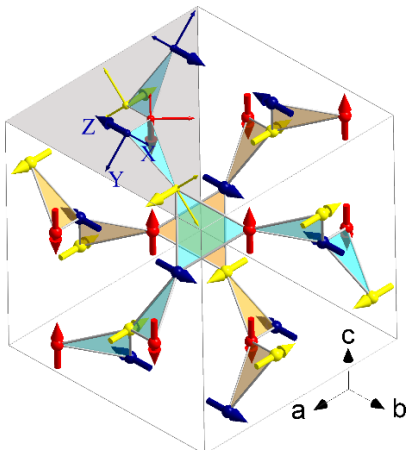

Figure 1. Intertwined hyperkagome networks (in blue and orange) of rare-earth triangles in garnets $RE_3A_5O_{12}$ (A = Al, Ga). The magnetic ordering shown corresponds to the AFA one [6] (Ia-3d'), with three magnetic sublattices having moments parallel or antiparallel to the cubic axis (a, b, c in yellow, blue and red, respectively), for each hyperkagome network. First-neighbor spins are orthogonal to each other.

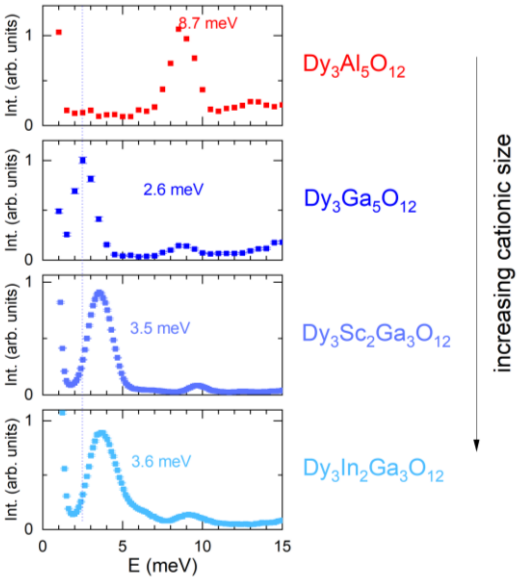

Figure 2. Constant Q = 2.5 $Å^{-1}$ cut of the S(Q,ω) of DyGG (top) and DyAG (bottom) (2T @LLB). Panther data from experiment 4-04-505, on $Dy_3Sc_2Ga_3O_{12}$ and $Dy_3In_2Ga_3O_{12}$ is shown alongside for direct comparison.

It is well known that changes in the RE-O environment will modify the crystal electric field and therefore the single-ion anisotropy of a magnetic RE^{3+}. In this context, we have investigated in 2020 the effect of chemical pressure for RE = Dy, working on $Dy_3Al_5O_{12}$ (DyAG) and $Dy_3Ga_5O_{12}$ (DyGG) [3]. This work was then extended to $Dy_3Sc_2Ga_3O_{12}$, and $Dy_3In_2Ga_3O_{12}$, in which chemical pressure has been further decreased. We investigated the inelastic neutron scattering spectra of these two compounds on Panther, between 1.8 and 160 K, at various incident energies (10 meV up to 50 meV), to get an accurate picture of the crystal field excitations of Dy^{3+} in each case and compare them with those of DyAG and DyGG.

The lowest crystal field excitation (Figure 2), found around 2.6 meV in DyGG but at much higher energy in DyAG (8.7 meV), is seen to increase in the Sc and In substituted compounds. This result cannot be understood based on size effects only and modelling is in progress to understand its origin.

References

[1] R. Cava R et al., Introduction to Frustrated Magnetism: Materials, Experiments, Theory (Springer Berlin Heidelberg) pp 131–54 (2011)
[2] J. Hopkinson et al., Phys. Rev. Lett. 99, 037201 (2007)
[3] I. Kibalin et al., Phys. Rev. Research 2, 033509 (2020)