Experimental report

21/02/2017

Proposal: 5-42-418 **Council:** 4/2016

Title: Determination of low temperature spin correlations of terbium galliumgarnet(Tb3Ga5O12).

Research area: Physics

This proposal is a new proposal

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Samples: Terbium gallium garnet(Tb3Ga5O12)

Instrument	Requested days	Allocated days	From	To
D7	7	7	14/09/2016	21/09/2016

Abstract:

Magnetic frustration preventing the simultaneous satisfaction of all magnetic interactions in a system is well known as a contributor to unconventional behavior in spin systems. Rare-earth garnet lattices, formed of two interpenetrating half-garnet lattices, which form a twisting 3d arrangement of corner sharing triangles, are promising model systems for investigation of the effects of magnetic frustration. Terbium gallium garnet (TGG/Tb3Ga5O12) is well known as an advanced material - due to its high Verdet constant it is used as a Faraday rotator for optical applications - but its low temperature magnetism has been relatively little studied. TGG is known to undergo a transition to an antiferromagnetic phase at TN=0.35 K, but the relatively large Curie-Weiss temperature (-8.6 K) strongly implies the existence of a correlated but disordered regime for TN<T<8.6 K, which has never been investigated experimentally. We propose to use D7 to search for a correlated spin liquid phase just above the ordering temperature TN, and to gain a good understanding of its spin correlations.

Determination of frustrated spin correlations in terbium gallium garnet ($Tb_3Ga_5O_{12}$).

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D7 diffuse scattering spectrometer was used to investigate short-range spin correlations in $Tb_3Ga_5O_{12}$ rare-earth garnet. We have determined the temperature of the onset of long-range order T_N ∼260 mK. Above this temperature there was observed strong diffuse intensity marking indicating appearance of short range correlations whose character is currently being determined.

Experimental details Single crystal of length ∼ 45 mm and mass ∼ 10 g was mounted and oriented on copper sample mount (ORIENT EXPRESS and IN3). TGG is a cubic crystal system and [111] direction of the rod's axis was set perpendicularly to the scattering plane. All patterns were measured with $\lambda = 4.855$ Å an temperatures in range 40 mK - 300 K.

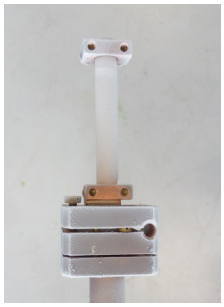

FIG. 1. Sample on copper mount.

For all temperature points Z and Z'(non-spin-flip and spin-flip) diffraction patterns were measured. Additionally, at 1.5 and 50 K, we have performed full XYZ polarization analysis.

Results of the measurements Fig. 2 shows the scattering in non-spin-flip (NSF) ans spin-flip (SF) channels at base temperature (40 mK) and above ordering temperature T_N 0.5 K and 6 K. In base temperature, spin-flip channel exhibits visible development of strong diffuse scattering in form of 'bell-shaped' features close to (110) ordering vector. After crossing T_N into cooperative paramagnet phase observed 'bell-shaped' structures broaden as well as diffuse intensity around other magnetic positions. Temperature dependence of 1D cut through this feature is shown in Fig. 3. By analysis of (110) magnetic Bragg reflection we were able to determine $T_N \sim 260$ mK.

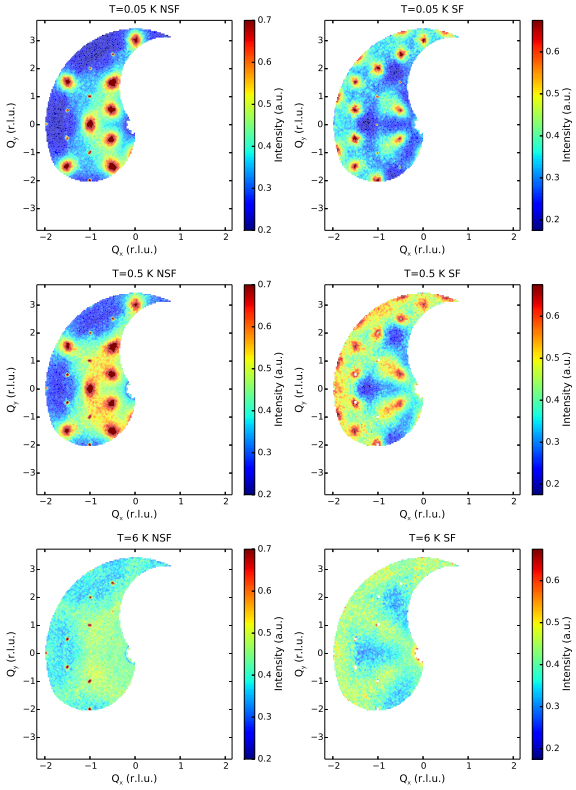

FIG. 2. Non-spin-flip(left) and spin-flip(right) scattering measured at 50 mK, 0.5 K and 6 K.

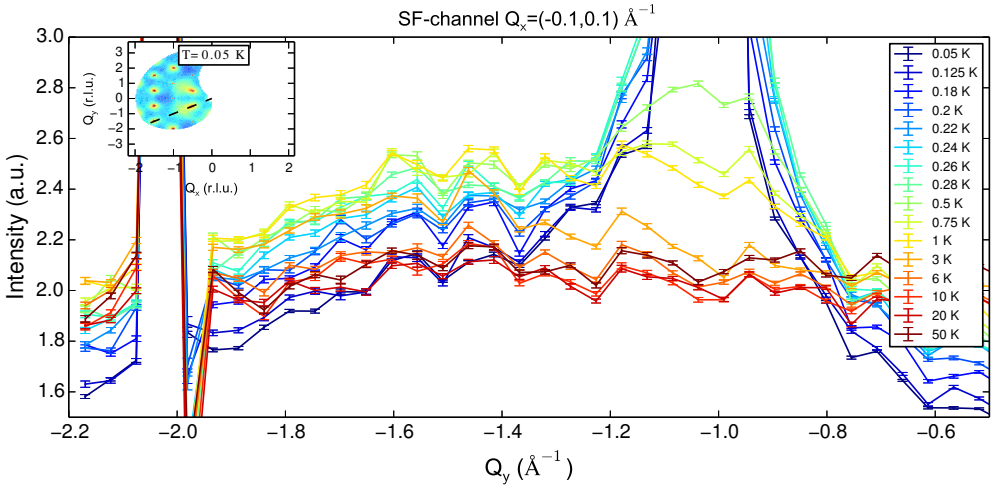

FIG. 3. 1D cut along the 'bells-shaped' feature observed around (110) type magnetic Bragg reflections. BLack dashed line in the inset shows the direction of the cur.