Experimental report

21/04/2016

Proposal: **4-03-1706** **Council:** 10/2014

Title: Field-dependence of the magnetic excitations in the SrHo2O4 quantum magnet

Research area: Physics

This proposal is a new proposal

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Samples: SrHo2O4

Instrument	Requested days	Allocated days	From	To
IN5	5	6	23/04/2015	29/04/2015

Abstract:

SrHo2O4 is part of a family of rare-earth frustrated magnets which are good candidates to study strongly correlated fluctuating ground states. At low temperature, two types of order coexist in this compound, each of them associated to a different inequivalent rare earth site: a 3D long range order (LRO) with Néel structure on site 1 and a short range order with magnetic peaks at incommensurate positions on site 2. The temperature dependence of the incommensurate peaks is suspected to be due to domain wall rearrangements. The zero field inelastic spectrum has previously been measured and we are now proposing to study its field dependence. We want to investigate the excitations associated with both sites, look for the emergence of exotic excitations in the 1/3 magnetization plateau and understand the domain wall rearrangements with field on site 2 which brings a quasi-Double Néel order in zero field to the stabilization of the up-up-down state in the plateau.

Field-dependence of the magnetic excitations in the $SrHo_2O_4$ quantum magnet

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Abstract

The experiment 4-03-1706 on IN5 was performed from April 23rd to 29th, 2015. The inelastic spectra of $SrHo_2O_4$, a geometrically frustrated magnet, was measured at 0, 0.9 and 2 T at 60 mK and at 10 K in zero field. We observed magnetic correlations in the elastic signal at 0.06 K in zero field showing the one dimensional correlations along the c-axis. We also observed excitations which are dispersing in only along the l direction. Under applied field, the maximum of the elastic magnetic scattering changes from $l = 1/2$ at 0 T to $l = 1/3$ at 0.9 T. Furthermore, the excitations bandwidth diminishes with increasing field and strong quasielastic scattering is observed at 0.9 T.

$SrHo_2O_4$ is part of a family of rare-earth frustrated magnets which are good candidates to study strongly correlated fluctuating ground states. At low temperature, two types of order coexist in this compound, each of them associated to a different inequivalent rare earth site: a three dimensional (3D) long range order (LRO) with Néel structure on site 1 and a short range order with a nearly double Néel structure on site 2 [1]. A field induced phase is observed for $H \parallel b$ corresponding to 1/3 magnetization plateau. The objective of this experiment was to study the field dependence of the inelastic spectrum.

Single crystals with a total mass of 9 g were coaligned in the hl plane and inserted in dilution refrigerator in a 2.5 T vertical magnet and mounted on the IN5 time-of-flight spectrometer. Data was collected using $\lambda = 2.0$, 3.5, 7 and 8.5 Å. At 10 K, we observed the 1D correlations already setting in at $l = 0.5$ (fig. 1 top). This signal is much sharper at 0.06 mK, indicating a significative increase in the correlation length along the c-axis. In the inelastic spectrum, a dispersion of a crystal electric field level is apparent at 10 K (fig. 1 bottom). This dispersion is not significantly changed at 0.06 mK but new dispersive magnetic modes appear, most likely related to the LRO on site 1.

In the 1/3 magnetization plateau phase at 0.9 T, the scattering that was at $l = 0.5$ moves to $l = 1/3$ and 2/3 (fig. 2 top), indicating $\uparrow\uparrow\downarrow$ state on site 2, as expected in zig-zag chains. In the fully polarized state at 2 T, the magnetic scattering sits on top of nuclear peaks, describing the ferromagnetic structure. Under applied field, no drastic changes appear in the inelastic spectrum. The bandwidth of the excitations diminishes slightly and the change in energy is not significant (fig. 2 bottom). However, the quasielastic scattering is much stronger in the magnetization plateau at 0.9 T and could be related to the predicted emergence of exotic excitation [2].

References

[1] O. Young *et al.*, Phys. Rev. B **88**, 024411 (2013).

[2] K. Okunishi *et al.*, Phys. Rev. B **68**, 224422 (2003).

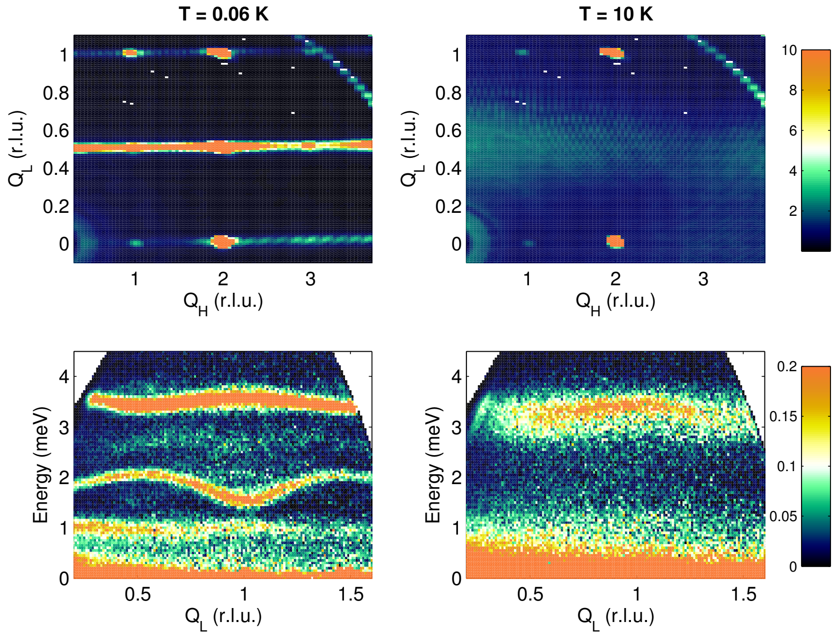

Figure 1: Top: Elastic scattering in the $(h, 0, l)$ plane at 0.06 K and 10 K in zero field. Bottom: Inelastic spectra along $(0.5, 0, l)$ at 0.06 K and 10 K in zero field. Data collected with $\lambda = 3.5$Å.

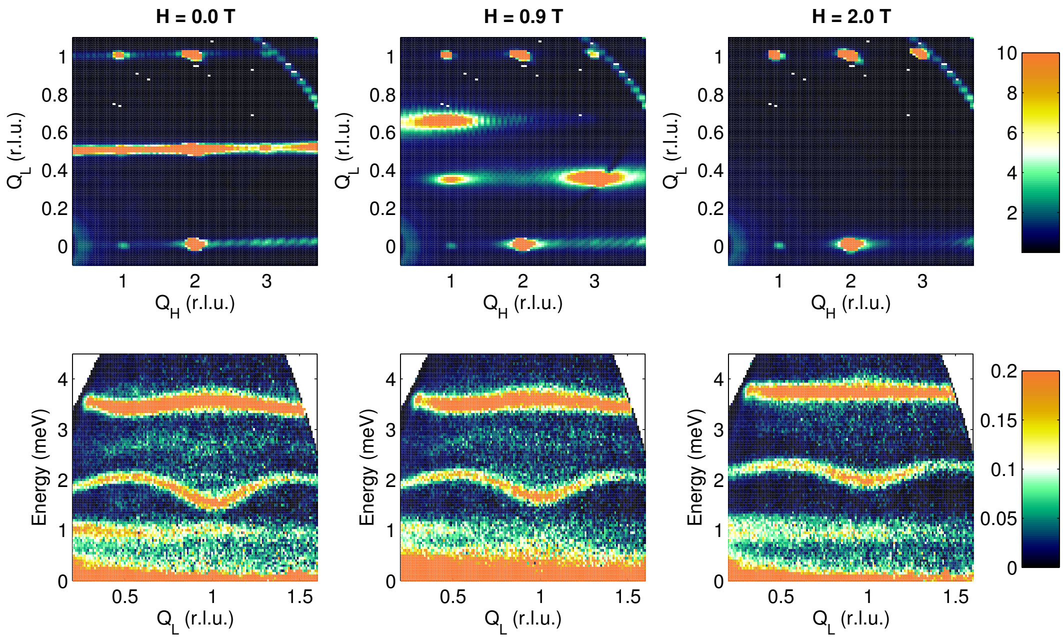

Figure 2: Top: Elastic scattering in the $(h, 0, l)$ plane at $H = 0$, 0.9 and 2 T at 0.06 K. Bottom: Inelastic spectra along $(0.5, 0, l)$ at $H = 0$, 0.9 and 2 T at 0.06 K. Data collected with $\lambda = 3.5$Å.