Experimental report

04/04/2016

Proposal: 4-01-1416 **Council:** 10/2014

Title: Inelastic neutron scattering studyof alpha-SrCr2O4

Research area: Physics

This proposal is a new proposal

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Samples: SrCr2O4

Instrument	Requested days	Allocated days	From	To
IN8	7	7	16/07/2015	23/07/2015

Abstract:

Our aim is to study the spin wave excitation spectrum of a two dimensional triangular lattice antiferromagnet, SrCr2O4, and to compare it with that of alpha-CaCr2O4, in which inelastic neutron scattering has revealed unusual minima understood by the instability of the nearly 120° incommensurate ground state.

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α-$SrCr_2O_4$ is a distorted two-dimensional triangular antiferromagnet and belongs to the α-ACr_2O_4 family (A = Ca^{2+}, Sr^{2+}, Ba^{2+}). It exhibits a layered structure consisting of compact CrO_2 triangular planes separated by Sr cations, for which the inter-plane magnetic interaction can be considered negligible. The A = Ca^{2+}, Sr^{2+}, Ba^{2+} compounds order magnetically (at TN = 42.5, 42.6 and 21.2 K respectively), the ordered state being an incommensurate structure (**k**=(0, 1/3-ε, 0)), close to the 120° configuration of the undistorted triangular Heisenberg antiferromagnet. The spin dynamics was investigated in the Ca^{2+} compound [1] and reveal a very complex and distorted structure with four different nearest-neighbor interactions. In particular, the excitation spectrum shows a softening of spin wave modes due to the strong distortion in the exchange parameters, which places α-$CaCr_2O_4$ at the phase boundary of the 120° structure; quantum fluctuations are actually invoked to stabilize this 120° structure, despite the lattice distorsion.
Preliminary measurements at LLB-Orphée on a single crystal of α-$SrCr_2O_4$ evidenced a less distorted lattice and magnetic structure than in the Ca counterpart. Several directions were mapped out and the measured dispersions along the different directions allowed us to determine the four nearest-neighbor exchange couplings. Spinwave calculations were performed with the chosen model and revealed a lowering of the spinwave mode in the (0 0 L) (fig.1b)) due to the distortion in the exchange parameters, as seen in α-$CaCr_2O_4$.

The aim of the experiment was therefore to check the presence of this low energy mode in the (0 0 L) direction, which would confirm the model chosen to describe the preliminary data.
Hence, we mapped out the dispersion along the (0 0 L) direction (fig.1a)). The data showed a very broad and blurred signal and no clear dispersion corresponding to the calculation could be distinguished. In addition, an unexpected strong quasi-elastic signal was measured around the (0 0 1.2) position, which, according to the crystallographic and magnetic structures, does not seem to come from a nuclear or magnetic contribution.
The dispersions in the (0 K 0) and (0 2/3 L) directions were also re-measured in order to test the reproducibility of our past measurements. The data were consistent with the existing results but showed additional flat signals at around 6 and 10 meV in both directions (fig.1c)). In order to check their magnetic origin, we measured the evolution of these flat mode at T>>TN (T=120K). At high temperature, the T=1.5K signal was replaced by a paramagnetic-like one (fig.1c)), which indicates that either the flat modes do not come from the sample and their signal was drowned in the paramagnetic one, or they were magnetic.
We also mapped out the reciprocal space at E=0 meV. The data show an unexpected ring-shaped signal at Q=1.2 Å-1 probably due to the aluminum sample box.

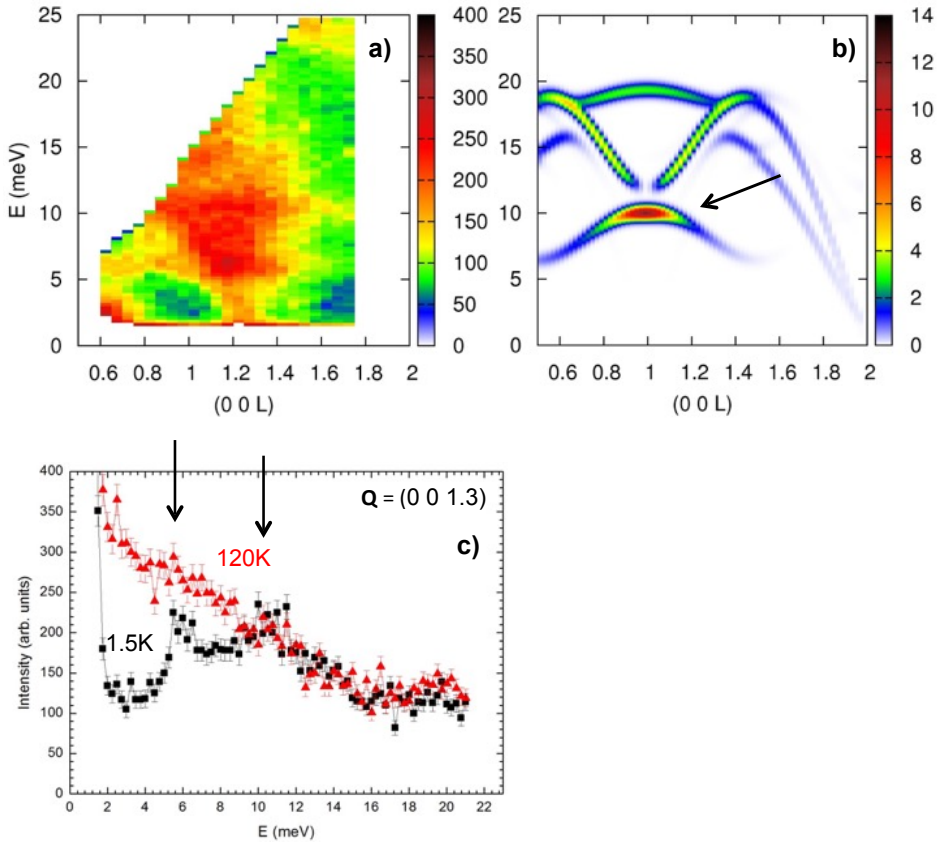

Fig. 1 : a) Inelastic neutron scattering spectrum along (0 0 L) at T = 1.5K. b) S(Q,ω) calculated along (0 0 L) with a model inferred from preliminary data [2]. The arrow indicates the low energy mode described in the text. c) Constant-Q scan at Q=(0 0 1.3) at T = 1.5 and 120 K. The arrows indicate the two flat modes at E= 6 and 10 meV.

[1] S. Toth et al., Phys. Rev. Lett. 109, 127203 (2012)
[2] S. Petit, Collection SFN 12, 105-121 (2011)