Experimental report

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Proposal: **4-01-1408** **Council:** 4/2014

Title: Magnetic Excitations in a new 1D, spin-1/2 chain magnet: CuSb2O4

Research area: Physics

This proposal is a new proposal

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Samples: CuSb2O4

Instrument	Requested days	Allocated days	From	To
IN6	3	3	03/11/2014	07/11/2014

Abstract:

This proposal is focused on the relatively unstudied compound CuSb2O4. It has a superficial resemblance to the chemistry of CuSb2O6, -a compound in which our understanding of its magnetic phenomena benefitted in a substantial manner from neutron studies. Our physical properties studies suggest that CuSb2O4 is an equally interesting case study of low-dimensional magnetism deriving from Cu2+ ions. Magnetic order, presumably of antiferromagnetic nature takes place below 1.8K. CuSb2O4 crystallizes in tetragonal symmetry with space group P42bc. Concerning Cu bonding, the CuO6 polyhedra are strongly elongated due to Jahn-Teller distortion. The results of analysis of our x-ray diffraction data are supported by Raman spectroscopy, and with computation of the vibrational behaviour of the contents of the unit cell. Here we propose to perform an inelastic neutron study on IN6 in order to survey the magnetic excitations. A major part of the study will be devoted to investigating the spin gap state in CuSb2O4 with which to connect to the dimensional nature of the magnetism.

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Inelastic neutron scattering experiments were performed on the cold time-of-flight neutron spectrometer IN6 at the Institute Laue-Langevin in Grenoble. The spectrometer was used with an incident wavelength of 5.92 Å in the high-resolution time focusing mode. In this mode, at the expense of the neutron flux, the resolution is improved drastically in the energy range of interest. Inelastic focusing was set to 7 meV. This way we were able to obtain the multiphonon corrected generalized densities of states for all sample. To subtract the background the empty sample holder was measured as well.

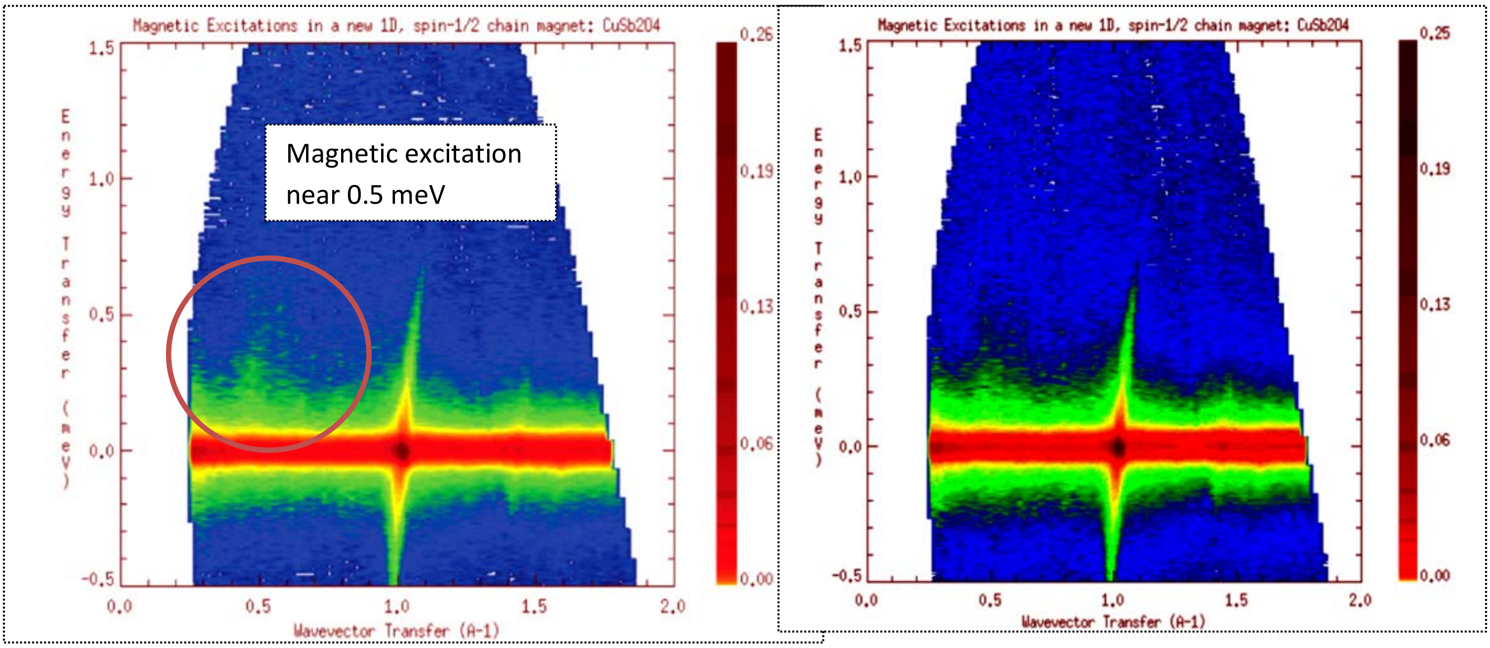

Fig. 1. Inelastic neutron-scattering intensity of $CuSb_2O_4$ at 0.4 K (left panel) and 4 K (right panel) measured with Lambda = 5.92 Å on the IN6 spectrometer.

In order to fully understand the nature of magnetic ground state we did an inelastic neutron scattering on IN6 spectrometer on the new 1D, spin-1/2 chain magnet $CuSb_2O_4$ between 0.4 K and 30 K to investigate the nature of spin excitations in a S=1/2 chain. From this study we would like to estimate both nearest- (NN) and next-nearest-neighbor (NNN) magnetic exchange interactions which would then reveal the true 1D nature of the magnetic interactions in this compound. For an ideal 1D system we would expect gapless spin excitations. Low-energy inelastic neutron-scattering measurements on the IN6 spectrometer have been carried out to further confirm whether there is any sign of quasielastic scattering present in $CuSb_2O_4$ below and above magnetic ordering. It is interesting that the temperature dependence of the Q-integrated energy versus intensity data exhibits sign of magnetic excitations (Figure 1 and 2).

Temperature dependence of elastic peaks (Fig. 3) at different temperatures does show the evidence of magnetic Bragg peak which agrees with our magnetization and heat capacity data. Our x-ray study on $CuSb_2O_4$ reveals that it crystallizes in tetragonal symmetry, space group $P4_2bc$ (106); unit cell parameters $a = b = 8.76033$ (5) Å, $c = 5.79786$ (4) Å^3. Concerning Cu bonding, the CuO_6 polyhedra are strongly elongated due to Jahn-Teller distortion in a [2+2+2] coordination arrangement, i.e. there are two long axial Cu-O1 bonds of 2.447(13) Å, in the equatorial plane there are two intermediate Cu-O2 bonds of 2.07(3) Å and two short Cu-O2 bonds of 1.88(2) Å.

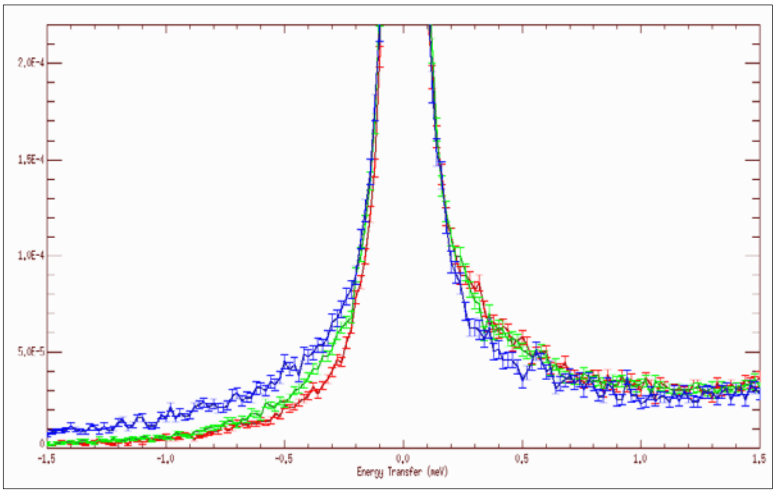

Fig. 2. Q-integrated intensity vs. energy transfer of $CuSb_2O_4$ for Lambda = 5.92 Å at 0.4 K (red) , 4 K (green) and 30 K (blue).

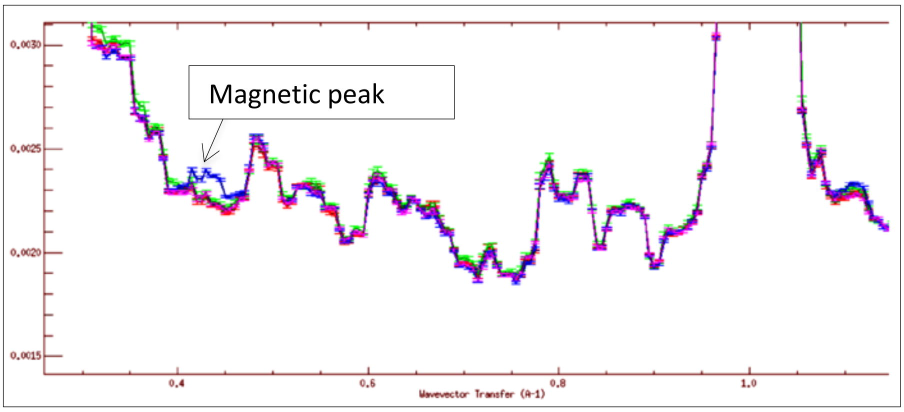

Fig.3. Elastic cuts for Lambda = 5.92 Å at 0.4 K (red) ,, 4 K (purple), 10 K (green) and 30 K (blue).