Experimental report

13/10/2016

Proposal: 4-01-1459 **Council:** 4/2015

Title: Low-energy magnetic modes in SeCuO3

Research area: Physics

This proposal is a new proposal

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Local contacts: Paul STEFFENS

Samples: SeCuO3

Instrument	Requested days	Allocated days	From	To
THALES	9	6	23/10/2015	29/10/2015

Abstract:

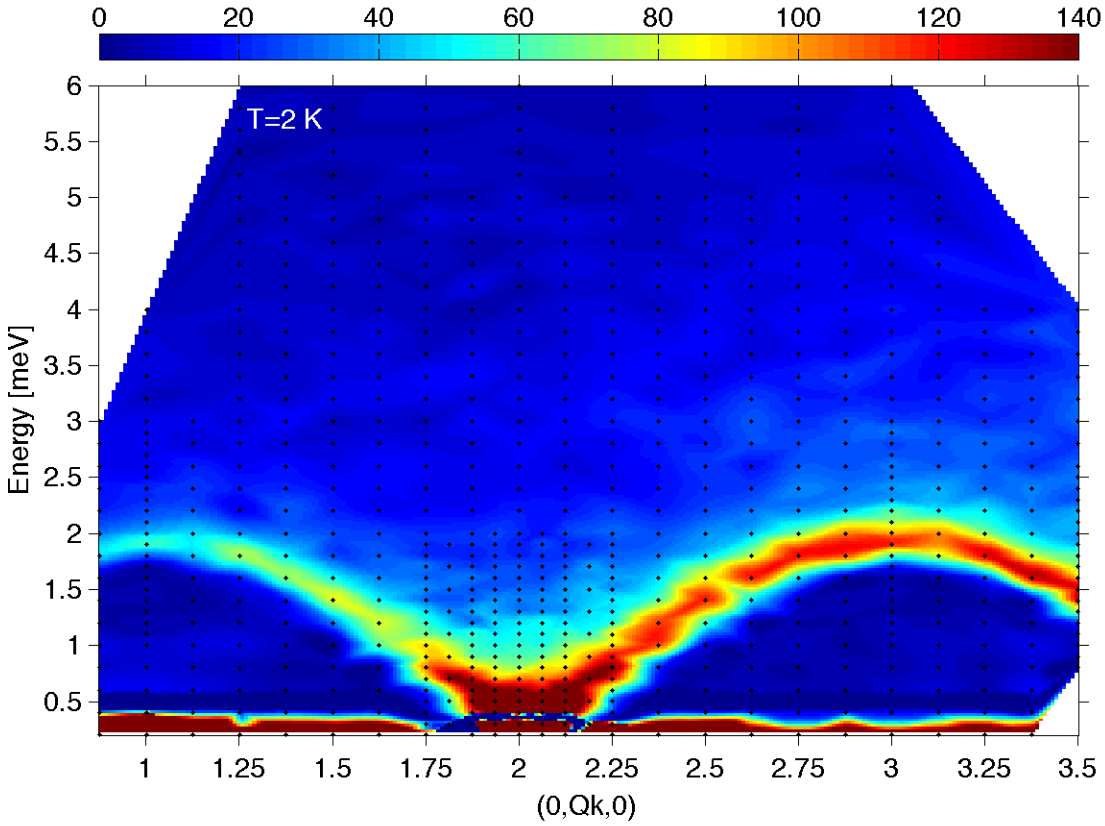
One of the questions in solid state physics is how local quantum states evolve into collective states. An intriguing scenario occurs when the basic magnetic unit consists of several spins, i.e. clusters, ordered in such a way that when isolated exhibit a nonmagnetic singlet ground state. Such systems should intrinsically oppose long-ranged magnetic order and, when ordered, retain quantum behavior. SeCuO3 is a candidate where such behavior should be visible. It consists of two distinct Cu sites, and its magnetic structure can be visualized as a 3D web built of weakly-coupled spin tetramers. The system orders as AFM at 8K, but quantum correlations can be seen even at room temperature. Here we propose to investigate low-energy acoustical magnon excitation, which should correspond to one of the inter-tetramer interactions.

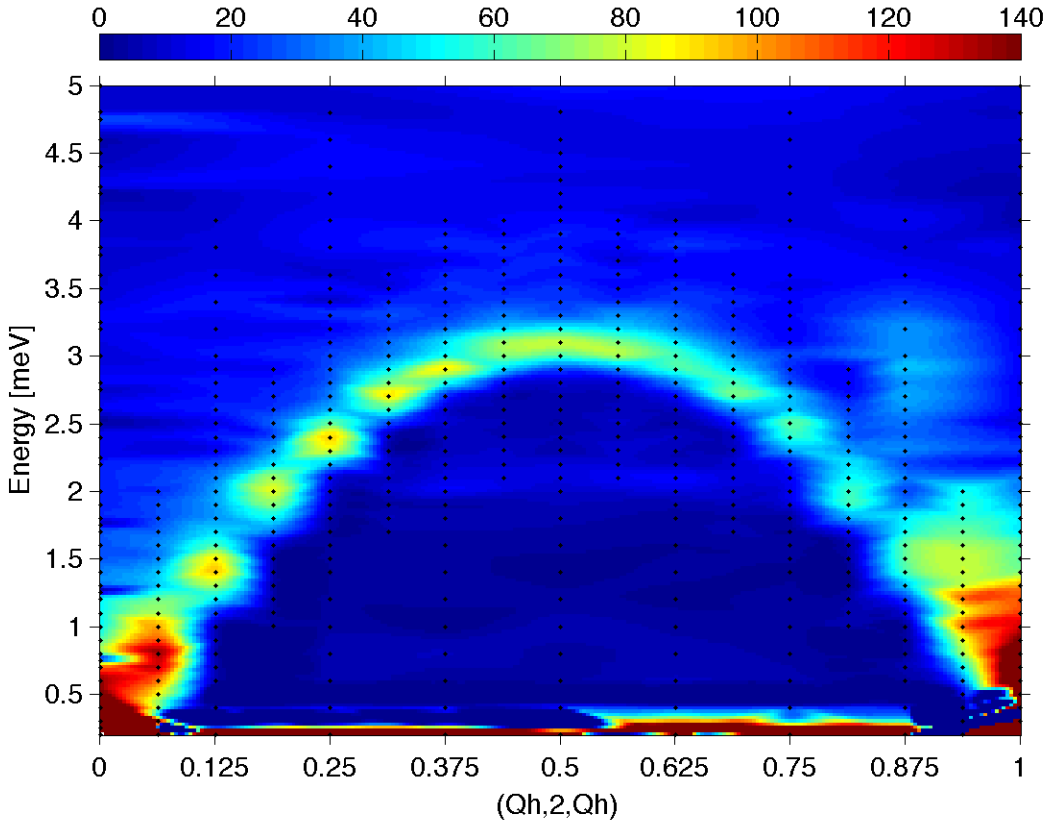
An intriguing scenario occurs when the basic magnetic units consist themselves of several spins – clusters - which when isolated exhibit a nonmagnetic singlet ground state. Such systems intrinsically oppose long-ranged magnetic order and, even when ordered, retain features of their quantum ancestry [1]. A candidate of a system where such behavior should be visible is SeCuO3. There are two distinct copper sites Cu1 and Cu2 in the unit cell. The crystalline structure and our previous experiments [2] suggest that the magnetic network of the system can be visualized as a 3D web built out of weakly-connected spin tetramers S1-S2-S3-S4 (Cu2-Cu1-Cu1-Cu2) with two dominant interactions: J1 (in between central spins S2 and S3 of the spin tetramer) and J2 (at the sides of the tetramers, i.e. between S1 and S2 and between S3 and S4). The system orders in long range AFM order at 8 K (<<J1~200-300 K), signaling weaker interactions between the tetramer units: we believe that this compound lies close to criticality in the intra/inter-tetramer interactions phase diagram.

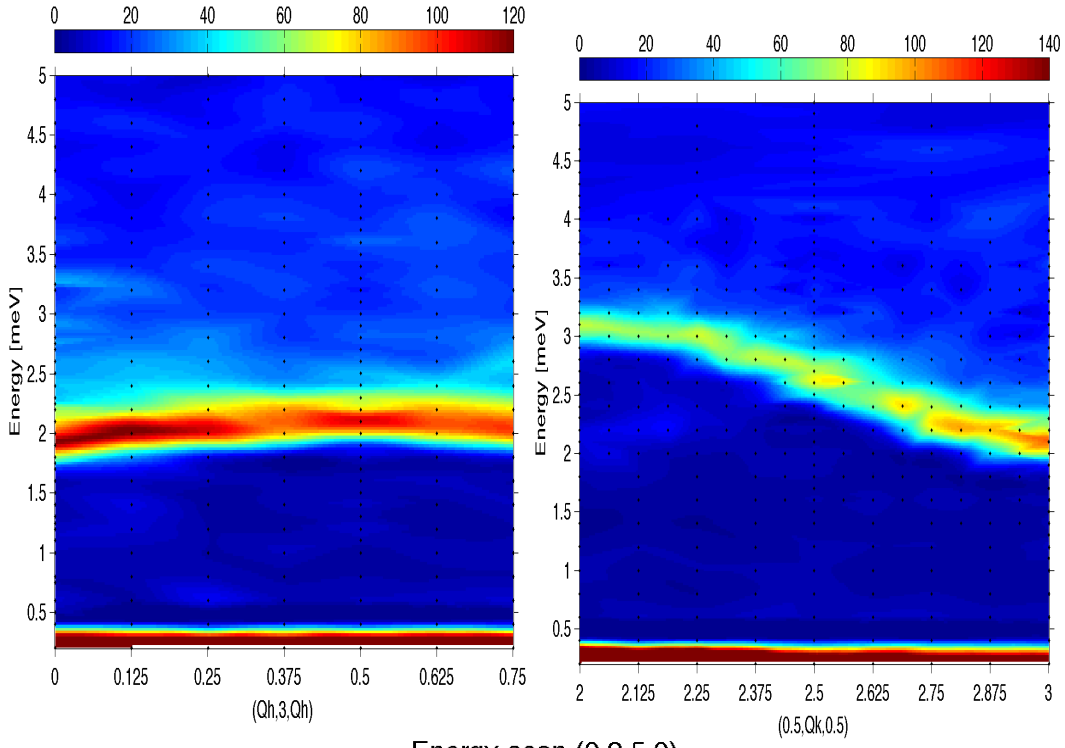
The aim of this experiment was to map the dispersion of the LRO mode and to find its minimum and dispersion along principal symmetry axes. From our previous measurements we had indication that this mode could be around (030) plane at 2 meV and should be acoustic, but due to lack of measured points we couldn't make any conclusions.

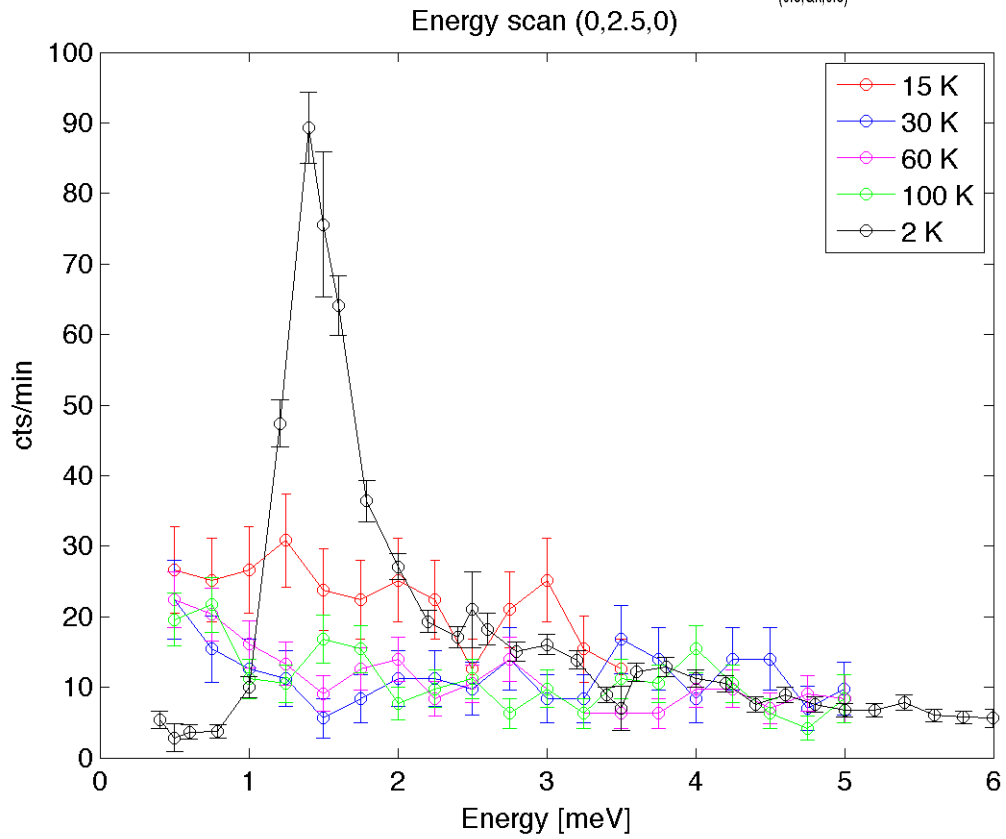
To this end we have performed an inelastic neutron scattering experiment with thermal neutrons at the ThALES instrument. The sample was 15x5x5mm^3 in size, with a mass of around 0.5 g and it has been placed so that the scattering plane has contained vectors [101] and [010]. The monochromator used was PG002 with the kf = 1.55 Å^{-1}.

We were able to observe the acoustic dispersion of LRO mode along (0, Qk, 0) axis with the gapless (up to the instrument resolution) minumum for Qk = 2*k and maximum at 2 meV. We have also observed the dispersion in perpenicular direction, so one can make a conclusion that we observe magnetic Bragg peaks at even *k* and integer *h* for Q=(*h*,*k*,*h*), and that from each magnetic Bragg peak a spin-wave cone comes out. This showes that in the system are at least two dispersive directions, but with the current sample orientation it is not possibile to determine if there is also a third dispersive direction, but given the symetry of the system, there should be.
We have also observed weak short range 1-D correlations between teramers that persist up to 60K.


0 20 40 60 80 100 120 140
T=2 K
Energy [meV]
6 5.5 5 4.5 4 3.5 3 2.5 2 1.5 1 0.5
1 1.25 1.5 1.75 2 2.25 2.5 2.75 3 3.25 3.5
(0,Qk,0)


0 20 40 60 80 100 120 140
Energy [meV]
5 4.5 4 3.5 3 2.5 2 1.5 1 0.5
0 0.125 0.25 0.375 0.5 0.625 0.75 0.875 1
(Qh,2,Qh)





[1] K. Prša *et.al.*, *Phys. Rev. Lett.*, **102**, 177202 (2009).
[2] I. Živković *et. al.*, *Phys. Rev. B*, **86**, 054405 (2012).