Experimental report

12/02/2016

Proposal: **4-03-1722** **Council:** 4/2015

Title: Dirac dispersion of magnons in SrCu2(BO3)2

Research area: Physics

This proposal is a new proposal

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Local contacts: Hannu MUTKA

Samples: SrCu2(BO3)2 with 99% 11B-isotope

Instrument	Requested days	Allocated days	From	To
IN5	5	5	14/10/2015	19/10/2015

Abstract:

Spin-1/2 compound SrCu2(BO3)2 is a good realization of the Shastry-Sutherland model. During last decade this material has drawn considerable attention due to possibilities of experimental investigations of purely quantum effects, such as frustration driven localization of triplet excitations, magnetization plateaus, correlated hopping, and it has been proposed as a realization of the conjectured super-solid quantum state. We propose an experiment on IN5 aiming to demonstrate the spectacular recent theoretical proposal that the magnon spectrum of SrCu2(BO3)2 can be tuned into a Dirac-type dispersion by applying a magnetic field of 2T.

$SrCu_2(BO_3)_2$ is a realization of the Shastry-Sutherland model, which is of particular interest in the context of frustrated quantum magnetism, due to frustration driven localisation of triplet excitations, correlated hopping, and magnetization plateaus. It has been proposed as a physical realization of the theoretically conjectured possibility of a 'super-solid quantum state'. The Shastry-Sutherland model is a heavily studied theoretical model due to its orthogonal exchange geometry (Figure 1, left) which results in an exactly solvable ground state. In $SrCu_2(BO_3)_2$, the S=1/2 moments of the Cu2+ ions are arranged in a 2D lattice of strongly coupled dimers with a strong nearest neighbor coupling J≈85K and a frustrated J'≈56K inter-dimer bound (next nearest neighbor). A small interlayer coupling J'' is also present. From the exact dimer singlet ground state there is a 3meV gap to the excited triplet state. $SrCu_2(BO_3)_2$ is a model quantum magnet that allows to further our understanding of frustrated quantum magnetism and of the properties of field-induced condensate ground states

In particular, inelastic neutron scattering and electron spin resonance measurements have established that the perfect frustration is in fact weakly lifted by an anisotropic Dzyaloshinskii-Moriya (DM) interaction, which creates a weak dispersion even at zero field (see figure 1, right). Recently, it has been that tuning this magnon dispersion with magnetic field can create a Dirac-type dispersion at a field of 2T.

The goal of this experiment was thus to find out whether we observe Dirac dispersion as predicted in the theoretical model by making an map of the dispersion in the (Q,hw) space on IN5 at the critical field.

Our sample was a 3g single crystal with (100) and (010) in the scattering plane. The sample was inserted in the magnet and cooled to 1.5K. The field was applied vertically, i.e. parallel to c. The chosen instrumental set up was Ei=4.6 meV (corresponding to a maximum energy transfer of 3.6meV), a chopper speed of 12000RPM and a 2/3 chopper ratio. The expected energy resolution from this set up was 0.12 meV at the elastic line and 0.07 meV at 3.6meV energy transfer.

Four maps were obtained during this experiment, at applied fields of 0T, 0.7T, 1.4 T and 2.1 T with a rotation of Rot=[99:1:165], with 15-30 min acquisition time per orientation depending on the applied magnetic field.

Figure 1 shows slices of the final dataset along 0K0, for T=1.7K and each of the applied field (0, 0.7, 1.4 and 2.1T). From this, we observe change in the dispersion of the 3meV mode as the field splits the triplet mode. Figure 2 shows constant energy cuts of the data for each applied field at an energy transfer of 3 meV, from which we can see the evolution of the intensity

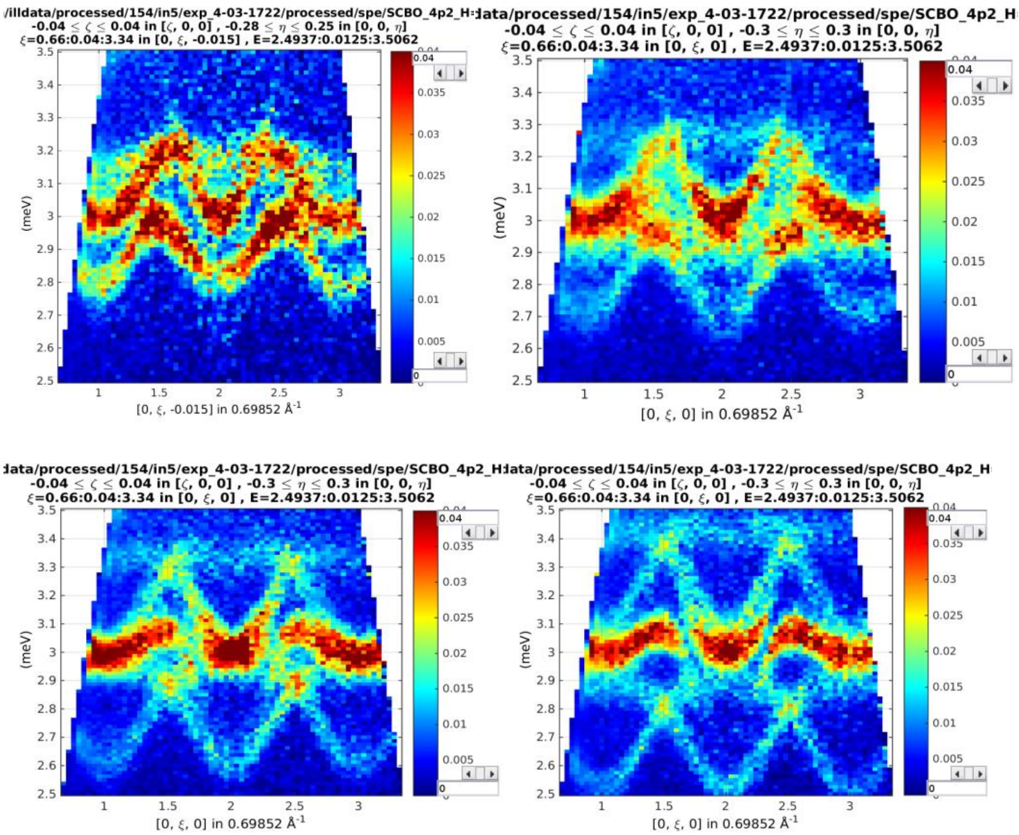

Figure 1 : slice along 0K0 for 0T (top left), 0.7T (top right), 1.4T (bottom left) and 2.1T (bottom right). we go through (0,0) and (0, π).

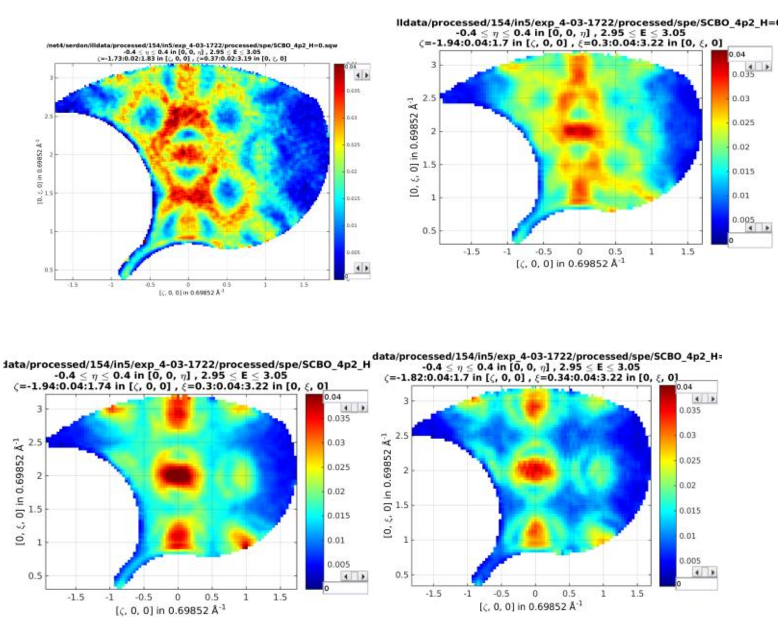

Figure 2 : Constant energy cut arounf deltaE=3meV for 0T (top left), 0.7T (top right), 1.4T (bottom left) and 2.1T (bottom right). we go through (0,0) and (π,π).