Experimental report

14/02/2017

Proposal: **5-42-439** **Council:** 10/2016

Title: Search for the magnetic skyrmion in non-centrosymmetric Ca3Ru2O7

Research area: Physics

This proposal is a new proposal

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Experimental team: Dmitry SOKOLOV

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Samples: Ca3Ru2O7

Instrument	Requested days	Allocated days	From	To
D33	4	3	23/01/2017	26/01/2017

Abstract:

We propose to search for the magnetic skyrmion in non-centrosymmetric Ca3Ru2O7. The lack of space inversion symmetry along the b-axis in the crystal structure leads to chiral interactions in this compound. Such chiral interactions are known to stabilise topologically protected spin textures also known as skyrmion states akin to blue phases in liquid crystals. If found, the magnetic skyrmion in Ca3Ru2O7 will be the first example of the skyrmion in the material with the crystal structure other than B20 type signifying the general nature of the phenomenon.

Search for the magnetic skyrmion in non-centrosymmetric $Ca_3Ru_2O_7$.

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We report the Small-Angle Neutron Scattering measurements on single crystal of noncentrosymmetric antiferromagnet $Ca_3Ru_2O_7$ performed on D33 instrument at ILL. Experiment 5-42-439.

PACS numbers:

I. EXPERIMENT

We have carried out our SANS measurements in a horizontal magnetic field of 4 T and at temperatures between 10 K and 61 K. The magnet was oriented parallel to the neutrons incident momentum. The measurements were mostly performed at the wavelength of 4.8 $\AA$ and for a very limited set of temperatures at 6 and 12.8$\AA$. The distance between the sample and the detector was 2.8 m and the collimation was set at 2.8 m for 4.8 $\AA$ configuration. Our sample was a 238 mg single crystal cut from the D.A.S. growth #8, mounted on Al sample holder with the c-axis vertical and the b-axis parallel to the field and the neutron incident momentum. The sample was oriented with the backscattering X-ray Laue instrument in Dresden and checked with the neutron Laue using the ORIENT EXPRESS instrument at ILL, which confirmed its orientation and good crystallinity.

II. MEASUREMENTS IN 0 AND 4 T.

Typically, each scan was collected over 30 minutes to obtain a good statistics. To obtain the scattering as a function of the wavevector, a reduction protocol was built and applied to the data. A sector average was chosen to isolate the signal at the top and the bottom sides only with the width $\Delta\phi$=120 degrees and with the radius of up to 0.4 $\AA^{-1}$. For the empty cell we have used the scans collected at T=10 K, which showed a featureless map. The default mask was used to mask the direct beam.The measurements in the zero filed showed that the scattering appeared close to the Neel temperature, T_{Neel}=56 K and fell sharply at temperatures above and just below T_{Neel}, FIG 1. The scattering intensity obtained by integrating the counts within the red sectors showed the temperature dependence similar to the bulk magnetisation measurements (not shown). The data collected at 6 and 12.8$\AA$ did not show a substantial temperature dependence as the main detector was positioned further away from the sample and did not register the scattering from (0 0 1) reflections. We have also performed the measurements in magnetic field of 4T. In addition to the broad features at the top and the bottom of the detector we have observed 2 sharp reflections at Q_x=±0.075 $\AA^{-1}$, which corresponds a magnetic modulation with a repeat distance of 13$\AA$, FIG 2. The rocking scan through the reflections provided an estimate of the lengthscale ∼900nm. The precise field and temperature dependence of the reflections will be a subject of a future research. We have also observed a new feature with the hexagonal symmetry at smaller wavevectors, Q_x<±0.05$\AA^{-1}$, which also has a strong field and temperature dependence unlike the one of the reflections at Q_x=±0.075 $\AA^{-1}$. More measurements at smaller wavevectors are needed to properly characterize this feature. To our knowledge, this is the first observation of the field driven magnetic spiral in the bulk antiferromagnet, which clearly deserves a further study.

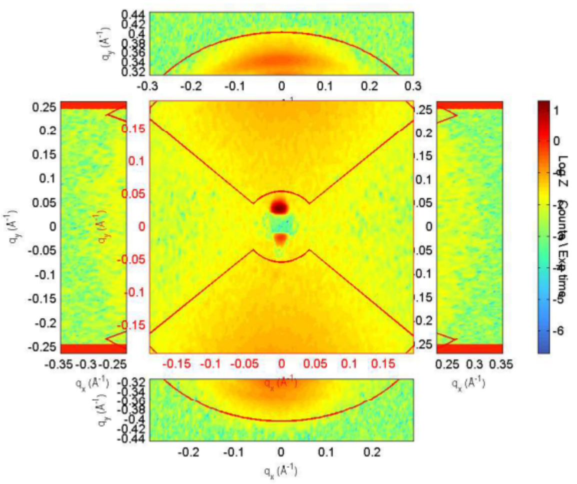

FIG. 1: Zero field SANS data taken at 55 K with 10 K data subtracted as a background. The increased scattering at the top and the bottom figure corresponds to the critical scattering and originates from $Q_{1,2}$=(0 0 ±1) AF reflections.

III. CONCLUSION

This findings suggest that the magnetic structure of $Ca_3Ru_2O_7$ in the presence of the magnetic field is far more complex than had previously been reported[1].

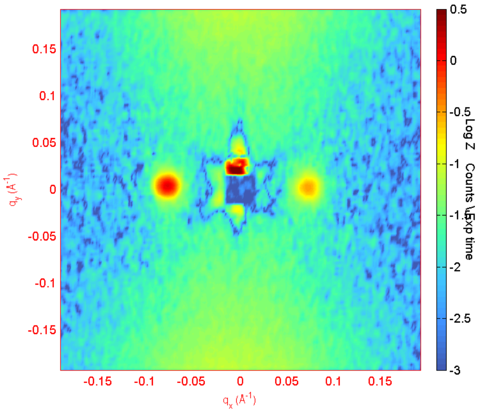

FIG. 2: 4T SANS data taken at 49 K with 39 K data subtracted as a background. The sharp reflections at $Q_x=\pm 0.075\ \mathring{A}^{-1}$ correspond to a magnetic spiral. The hexagonal feature at $Q_x<\pm 0.05 \mathring{A}^{-1}$ is of unknown origin.

[1] W. Bao, Phys. Rev. Lett., **100**, 243207 (2008).