Experimental Report

19/11/2014

Proposal: **4-01-1305** **Council:** 10/2012

Title: Chiral Spin Fluctuations in the Multiferroic Cu2OSeO3

This proposal is a new proposal

Researh Area: Physics

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Samples: Cu2OSeO3

Instrument	Req. Days	All. Days	From	To
IN15 Std+Small echo	10	5	22/05/2013	27/05/2013

Abstract:

In noncentrosymmetric magnetic materials chiral Dzyaloshinskii-Moriya (DM) interactions can stabilize 2D and 3D modulations with a fixed sense of rotation of the magnetization vector. These chiral skyrmions in form of isolated and bound axisymmetric strings have been observed in real space in a number of metallic cubic helimagnets in a small closed pocket, the so called A phase, in the (H,T) phase diagram. In addition the first order phase transition is preceded by strong chiral fluctuations, possibly a skyrmion liquid state. The recent discovery of similar behaviour in the insulator and mutliferroic Cu2OSeO3 shows that these are general features of chiral helimagnets. A direct proof can only be provided by high resolution Neutron Spin Echo spectroscopy and we propose to investigate the chiral fluctuations of Cu2OSeO3 at IN15.

Experimental report on experiment No. 4-01-1305 performed at IN15
Chiral Spin Fluctuations in the Multiferroic Cu_2OSeO_3

The multiferroic insulator Cu_2OSeO_3, together with other B20-type compounds MnSi, FeGe and FeCoSi, crystallizes in the non-centro symmetric space group $P2_13$. The lack of point inversion symmetry in the crystal structure gives rise to a non-zero Dzyaloshinskii-Moriya interaction, which leads to chiral magnetic properties below the magnetic ordering temperature $T_C \sim 58$ K. The magnetic ordered state of Cu_2OSeO_3 is a long period of helix with a pitch of ~ 700 Å along the crystallographic (100) axis below T_C.

The goal of the experiment was to explore the dynamics of the magnetic fluctuations in the very close vicinity of T_C also in conjunction with the magnetic field-temperature (B - T) phase diagram, in particular in the field-stabilized A-phase close to T_C. For these purposes, we performed high-resolution neutron spin echo spectroscopy (NSE) and polarization analysis at low magnetic fields and at 8 Å. These measurements were complemented by polarised SANS under horizontal magnetic fields at 12.5 Å. The high quality single crystal Cu_2OSeO_3 was oriented with the crystallographic (110) axis vertical.

Above T_C diffuse scattering is found, which on the detector appears as a ring around the direct beam, seen in fig 1a, and with a polarized neutron beam reduces to half moons, reflecting the effect of magnetic chirality. Below T_C the diffuse scattering disappears and chiral magnetic Bragg peaks set-in as shown in fig. 1b. When a magnetic field is applied the skyrmion lattice phase is stabilized in a small pocket of the B-T phase diagram [2,3], as revealed by the typical six-fold hexagonal Bragg satellites in the scattering patterns shown in fig. 1c.

The temperature dependence of the intensity at zero magnetic field is given in fig.2. Fig.3 shows the NSE spectra around T_C, revealing a change in the dynamics close to the transition temperature, which has strong similarities with MnSi [1]. Indeed the characteristic relaxation times vary slowly with temperature and the spectra show a coexistence of fluctuations with the helical Bragg peaks that appear as a strong elastic background at long Fourier times.

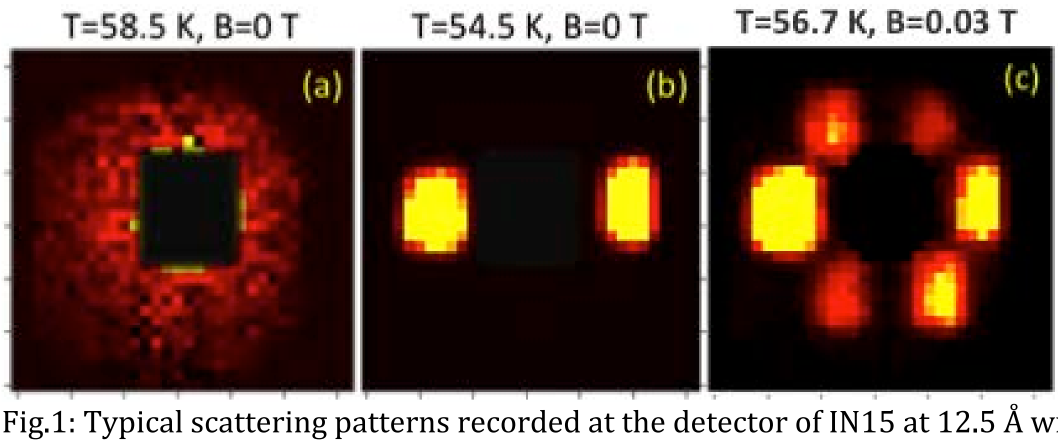

Fig.1: Typical scattering patterns recorded at the detector of IN15 at 12.5 Å with the beam polarization along the neutron propagation vector (i.e. perpendicular to $\vec{Q}$) and for the spin flip channel. The data are corrected from the background determined at T = T_C + 20 K above.

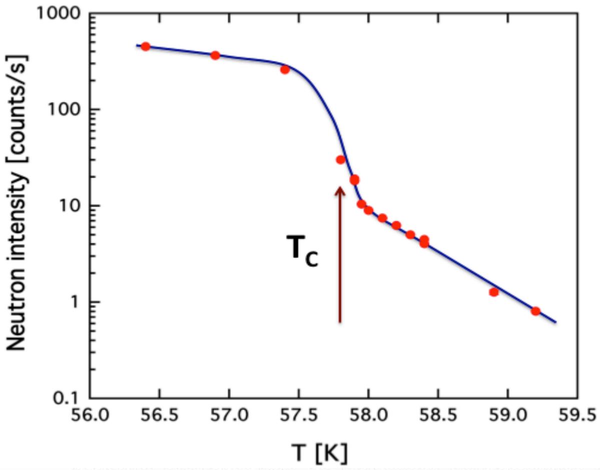

Fig.2: Magnetic intensity as a function of temperature at zero magnetic field. The data are corrected from the background determined at $T=T_C + 20$ K and from xyz polarization analysis measurements.

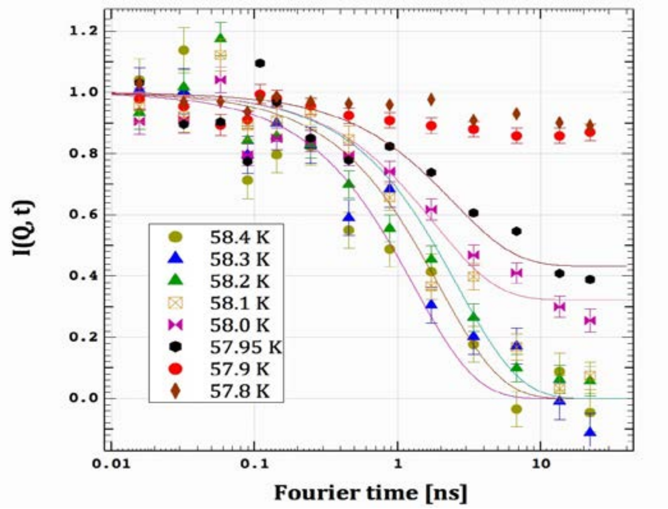

Fig. 3: Neutron spin echo spectra collected at 8 Å as a function of temperature close to $T_C \sim 57.9$ K. Below T_C the spectra become elastic due to the onset of the magnetic (helical) Bragg peaks.

REFERENCES

[1] C. Pappas et al., PRL 102, 197202 (2009)
[2] T. Adams et al., PRL 108, 237204 (2012)
[3] S. Seki et al., PRB 85, 220406(R) (2012)