(※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。)

MLF Experimental Report

提出日 Date of Report July 10, 2012	
課題番号 Project No. 2012A0113	装置責任者 Name of responsible person Kenji Nakajima
実験課題名 Title of experiment Search for the Z_2-vortex order in the triangular-lattice antiferromagnet $CuCrO_2$	装置名 Name of Instrument/(BL No.) AMATERAS/BL14
実験責任者名 Name of principal investigator Ryoichi Kajimoto	実施日 Date of Experiment June 24–28, 2012 (4 days)
所属 Affiliation Research Center for Neutron Science and Technology, CROSS	

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

$CuCrO_2$

2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。)

Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

$CuCrO_2$ has triangular-lattice layers of magnetic Cr ions, and S = 3/2 Heisenberg spins on the Cr sites form a nearly 120° magnetic structure below the magnetic transition temperature T_N = 24 K. In order to elucidate the magnetic excitations in a single crystal $CuCrO_2$, we performed inelastic neutron scattering measurements using the chopper spectrometer AMATERAS. We aligned the crystal so that the c axis is parallel to the incident neutron beam, and the [110] axis lies on the horizontal plane (ψ = 0°). Then, we rotated the crystal around the vertical axis by 40° (ψ = 40°). By projecting the observed data onto the a^*b^* plane, we could map the two dimensional magnetic excitations in the ab plane. We utilized incident energies (E_i's) of 15, 7.7, 4.7, and 3.1 meV simultaneously taking advantage of the so-called multi-E_i measurement method. With ψ = 0° and E_i = 15 meV, we could observe the almost complete dispersion relation of spin waves around the magnetic zone center $\boldsymbol{Q}$ ~ (1/3,1/3,0). With ψ = 40°, we could access a wider $\boldsymbol{Q}$ region at low energy transfers to observe diffuse quasielastic scattering by sacrificing a higher energy transfer region.

Figure 1 shows an excitation spectrum obtained at $T \sim 6$ K with $\psi = 0°$ and $E_i = 15$ meV. Though we used a quite small crystal (~140 mg), we could observe the spin wave excitations very clearly, which is consistent to a previous study [1]. Furthermore, by investigating this data and a lower E_i data carefully, we confirmed there is continuum like excitation above the spin wave dispersion, and also found there is a second gap at ~1.5 meV at the magnetic zone center.

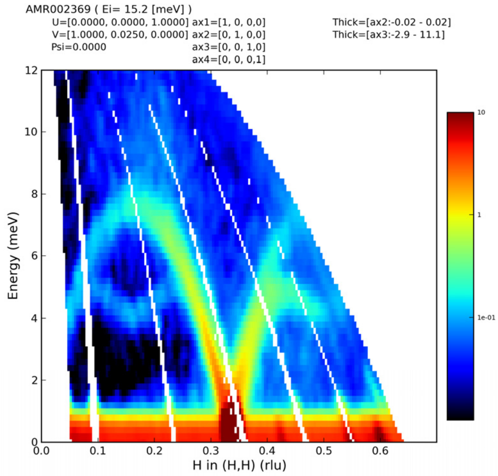

Figure 1. Magnetic excitation spectrum of $CuCrO_2$ along (H,H) at $T \sim 6$ K. The data is integrated along the c^* direction and cut at $K = \pm 0.02$ r.l.u. (reciprocal lattice unit) along (-K,K)

With elevating temperature, we found diffuse quasielastic scattering develops. The diffuse scattering shows a honeycomb pattern on the a^*b^* plane, where intense diffuse scatterings around the magnetic zone centers are connected to each other by weaker diffuse scatterings. This pattern bears a remarkable resemblance to that predicted for the Z_2 vortex [2]. However, we found the diffuse scattering survives far above T_N (at least up to 60 K), though the Z_2 vortices are expected to appear in an only limited temperature region around T_N. Therefore, we should consider several candidates for the origin of the diffuse scattering in addition to the Z_2 vortex, for examples, spin clusters on a triangular lattice unit of Cr or higher order magnetic exchange interactions.

Interestingly, this diffuse scattering appears even below T_N where there exist clear spin wave excitations. This fact suggests that the diffuse scattering originates from spin fluctuations different from spin waves. We speculate this kind of spin fluctuations originates from the two dimensional spin correlations, whereas the spin waves arise from the three dimensional spin ordering. Though the exact origin of the diffuse scattering should be a subject for further experimental and theoretical studies, the present result should give an important clue to understand the true nature of a triangular-lattice Heisenberg antiferromagnet.

[1] M. Frontzek *et al.*, Phys. Rev. B **84**, 094448 (2011).
[2] T. Okubo and H. Kawamura, J. Phys. Soc. Jpn. **79**, 084706 (2010).