Spin-Wave Spectrum in 'Single-Domain' Magnetic Ground State of Triangular Lattice Antiferromagnet $CuFeO_2$

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A triangular lattice antiferromagnet (TLA) $CuFeO_2$ exhibits a collinear four-sublattice (4SL) magnetic ordering in the ground state, despite a Heisenberg spin character expected from the electronic state of Fe^{3+} ($S = 5/2$, $L = 0$). As one of approaches to understand the magnetic ordering in this system, Ye *et al.* have performed inelastic neutron scattering measurements to determine the Hamiltonian parameters from the spin-wave spectra [1]. However, in the previous work, there is some ambiguity in the identification of the spin-wave branches because of a problem arising from magnetic domain structures in this system. Specifically, in the 4SL phase, $CuFeO_2$ has three types of magnetic domains whose magnetic propagation wave vectors are described as $(\frac{1}{4}, \frac{1}{4}, \frac{3}{2})$, $(-\frac{1}{2}, \frac{1}{4}, \frac{3}{2})$ and $(\frac{1}{4}, -\frac{1}{2}, \frac{3}{2})$ using a hexagonal basis. These wave vectors are crystallographically equivalent to each other because of the threefold rotational symmetry of the crystal structure. Therefore, the magnetic excitation spectrum reported in the previous study[1] is a mixture of spin-wave spectra from the three magnetic domains having different orientations. Quite recently, we have demonstrated that the application of the uniaxial pressure perpendicular to the c axis results in almost 'single domain' state in the 4SL phase [2, 3]. This is because the formation of the magnetic domains accompanies with anisotropic (monoclinic) lattice distortion in each domain. We have thus performed inelastic neutron scattering measurements using the 'single domain' sample.

We used a cold neutron triple axis spectrometer HER(C1-1) installed at JRR-3. The energy of the scattered neutrons was fixed at $E_f = 3.5$ meV. A horizontal focusing analyzer was employed. Energy resolution at elastic position was 0.13 meV (full width at half maximum).

As shown in Fig. 1, we have identified two distinct spin-wave branches. The dispersion relation of the upper spin-wave branch cannot be explained by the previous theoretical model [4]. This implies the importance of the lattice degree of freedom in the spin-wave excitation in this system, because the previous calculation neglected the effect of the spin-driven lattice distortion in the 4SL phase.

References

[1] F. Ye *et al.*: PRL **99** 157201(2007).
[2] T. Nakajima *et al.*: ISSP-NSL report #1307.
[3] T. Nakajima *et al.*: JPSJ **80** 014714(2011).
[4] R. S. Fishman: J. Appl. Phys. **103** 07B109 (2008).

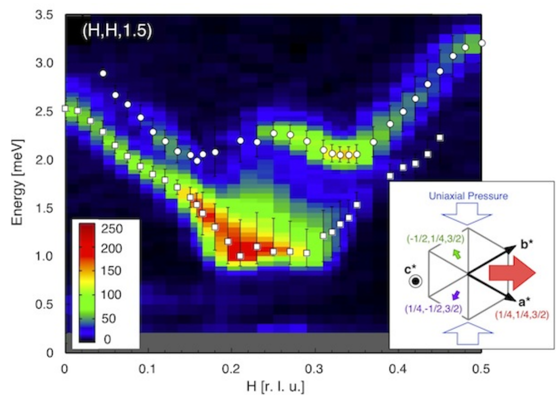

Fig. 1. The spin-wave spectrum in the 'single-domain' 4SL state. (Inset) Directions of the Q-vectors and applied uniaxial pressure.