Electric Control of Magnetic Anisotropy in Multiferroics Ba2CoGe2O7

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Recently, novel relationships between magnetism and electricity, multiferroics, are attracting great interest of researchers in the fields of materials science and condensed matter physics. In the typical multiferroic system, the ferroelectricity is induced by a cycloidal magnetic ordering and a proper-screw magnetic ordering. The magnetization appears in response to an electric field, and the application of a magnetic field H causes a change in electric polarization P. These couplings of the magnetic and polarization orders are known as dc magnetoelectric (ME) effects. In the low energy excitations, on the other hand, the oscillating magnetization and polarization can be also induced by the electric and magnetic component of light, respectively, The hybridization of the spin and the polarization waves is known as electromagnon, as discussed in TbMnO3 and TbMn2O5. Recently, new type of multiferroics and electromagnon of which the origin is d-p hybridization mechanism are reported in tetragonal Ba2CoGe2O7 [1,2].
Ba2CoGe2O7 having the noncentrosymmetric crystal structure shows a staggered antiferromagnetic structure in the (001) plane below TN=6.7 K. Below TN, a ferroelectric polarization is observed under H. In Ba2CoGe2O7, Murakawa and coworkers have shown that the ferroelectricity is induced by the spin-dependent d-p hybridization mechanism. Previously, we have performed inelastic neutron scattering to identify the electromagnon observed by light scattering experiment. All the excitations in zero field are reasonably reproduced by the extended spin wave theory without considering magnetoelectric effects. On the other hand, we have also clarified that the anisotropy of the magnetic moments connects with the multiferroic property of Ba2CoGe2O7. Figure 1(a) and 1(b) show the directions of the electrical polarization of each CoO4 tetrahedron for the S//<100> and S//<110>, respectively. The ferroelectricity is realized in the S//<110>, while the S//<100> induces the antiferroelectricity. In the previous inelastic neutron study, we have found the existence of ˜0.1 meV anisotropy gap between (a) and (b) states.
In order to clarify the unique magnetic anisotropy with the multiferroic property, we have carried out the polarized neutron scattering study (TASP) with the electrical field. In the zero field experiment, we have found that the system has the ground state which has the S//<100> and S//<010> domains. By applying the electric field along $\pm$ c-axis, on the other hand, the direction of the magnetic moment would be rotated. The results of the polarized neutron experiment indicate that the rotation angle of the magnetic moments increases gradually with increasing the electrical field. This is the first result of electrical control of the magnetic anisotropy.

References
[1] H. Murakawa et al., PRL 105 137202 (2010).
[2] I. Kezsmarki et al., PRL 106 057403 (2011).