Polarization Analyses of Electromagnon in Multiferroics Ba2CoGe2O7

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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 the magnetic field.[1] In Ba2CoGe2O7, Murakawa and co-workers 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. We found one acoustic and two optical modes.[2] All the excitations in zero field are reasonably reproduced by the extended spin wave theory without considering magnetoelectric effects. In the extended spin wave theory, the lowest- and second lowest-lying modes are basically connected to the interacting lowest-lying doublets of the Sz = $\pm$ 1/2. The former is the transverse fluctuation in the a-b plane, T1-mode and the latter are those in the c-direction, T2-mode, as shown in Fig. 1(a). The mode around 4 meV, which corresponds to the electromagnon, comes from the longitudinal fluctuations of the ordered moment, L-mode. These L, T1, and T2 modes are consistent with those identified in the previous ESR studies.[3]

We have carried out the mode analyses of the magnetic excitations in Ba2CoGe2O7 using polarized- and cold-neutron triple-axis spectrometer TASP installed at SINQ in PSI Switzerland. We clarified the L, T1, and T2 modes by measuring the non-spin flip (NSF) and the spin-flip (SF) cross section of neutron//Z.

Figure 1(b) shows the NSF and SF neutron intensities at Q=(1.25,0,0) against the transfer neutron energy. Three magnetic excitations at E=1.2, 2.2, and 4 meV were observed as reported in a previous neutron scattering study.[2] The NSF neutron scattering has the intensities at E=1.2 and 4 meV, and the SF neutron scattering has the intensities at E=2.2 meV The NSF and SF neutron intensities correspond to the fluctuation component of the magnetic excitation. The relationships between the NSF and SF neutron intensities at E=1.2, 2.2, and 4 meV are consistent with T1, T2, and L modes, respectively, calculated by the extended spin wave theory.

References

[1] H. Murakawa et al., PRL 105 137202 (2010).
[2] M. Soda et al., PRL 112 127205 (2014).
[3] K. Penc et al., PRL 108 257203 (2012).

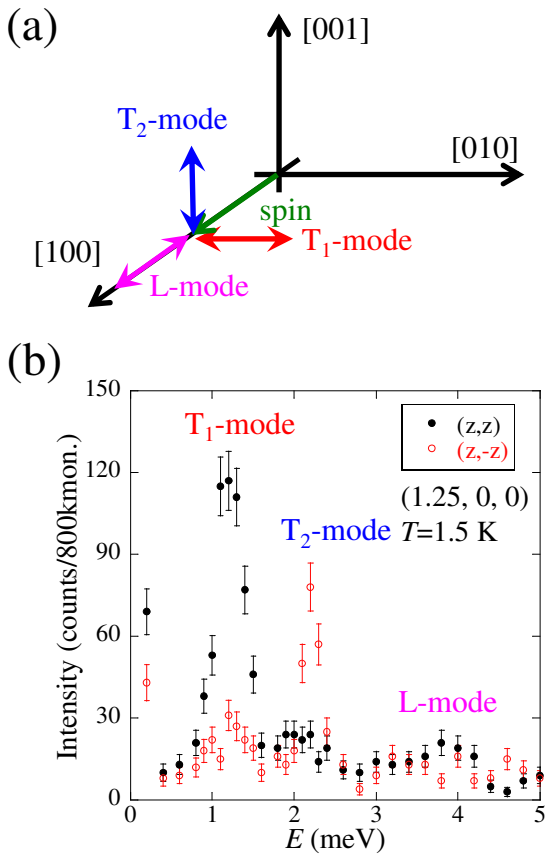

Fig. 1. (a) Schematics of spin fluctuation for each mode. Transverse fluctuation in the a-b plane is the T1 mode, those along the c direction is the T2 mode, and longitudinal fluctuation is the L mode. (b) NSF and SF neutron scattering spectra.