Non-trivial Magnetic Phase induced by Magnetic Field in Ca2CoSi2O7

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Novel relationships between magnetism and dielectricity, multiferroics, are attracting great interest of researchers. In some multiferroics, the magnetization appears in response to an electric field, and the application of a magnetic field causes a change in electric polarization. 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 having the collinear magnetic structure[1,2]. In order to clarify the essences of multiferroics and the electromagnon, we would like to have the comparative study on a similar compound having the different energy scale, Ca2CoSi2O7. Both Ca2CoSi2O7 and Ba2CoGe2O7 have the square lattice of Co ions. However, the magnetic structure of Ca2CoSi2O7 is not clear. Furthermore, non-trivial magnetic plateau was observed for the magnetization measurement with applying the magnetic field along the c-axis.[3] We have carried out the neutron diffraction study on single crystal sample to clarify the magnetic structure in Ca2CoSi2O7 without the magnetic field and the change of the magnetic structure with the low-magnetic field.

In order to study the magnetic structure in Ca2CoSi2O7 having the multiferroic property, the neutron diffraction has been carried out using the single-crystal neutron diffractometer TriCS installed at SINQ in PSI Switzerland.

We observed the magnetic reflections with (1,0,0) propagation vector below 6 K. By analysing the magnetic reflections, we found that Ca2CoSi2O7 has the collinear antiferromagnetic structure. Furthermore, we estimate the direction of the magnetic moment and the ratio of the magnetic domain simultaneously from the angle dependence of the magnetic intensities at the equivalent Q-points in the c-plane. In Ca2CoSi2O7, the magnetic structure with the easy axis along <100> relates to the antiferroelectric state, as shown in Fig. 1(a). The magnetic structure with the easy axis along <110> relates to the ferroelectric state, as shown in Fig. 1(b). The angle dependence of the magnetic intensities suggests that Ca2CoSi2O7 has the structure shown in Fig. 1(a).

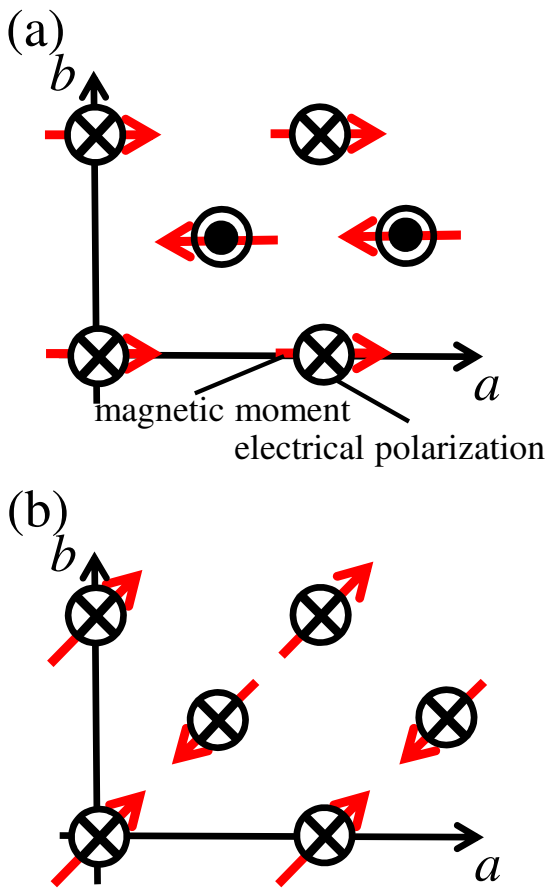

Fig. 1. Directions of the electrical polarization of each CoO4 tetrahedron along c-axis for (a) S//<100> and (b) S//<110>.