Mechanism of Spontaneous Electric Polarization Flop in TbMnO3

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Orthorhombic perovskite TbMnO3 is one of the typical multiferroic systems. Spontaneous electric polarization (P) along the c-axis appears below TC (~27K) [1]. It originates from the spiral configuration of Mn3+ spins rotating in the bc-plane with propagating vector (0 q 1) (q~0.27) through an inverse effect of the DM interaction [2,3]. Interestingly, the P//c is turned to the a-axis direction by applying a magnetic field along the a- or b-axis. Magnetic structure analysis and a spin-polarized neutron diffraction study of 160Gd0.7Tb0.3MnO3 strongly suggest that P//a also originates from helical spin structure rotating in the ab-plane [4]. It has been pointed out that anisotropic magnetic moments of Tb3+ play an important role for the complicated electric polarization flop [5].

To clarify mechanism of the electric polarization flop, we have performed a spin-polarized-neutron diffraction measurement using the TOPAN installed at JRR-3. Heusler(111)-Heusler(111) monochromator-analyser configuration was used. The incident neutron energy Ei was 80 meV. Collimators were set as open-80-100-open. A single crystal sample was mounted in a superconducting magnet with the a- and c-axis in the scattering plane. The magnetic field was applied along the b-axis up to 5.5 T.

We observed magnetic field dependences of spin-flip and non-spin-flip scattering at (0, q, 7) and (4, q, 1) at 8 K. These results indicate the basal plane change of spin helix from the bc- to ab- plane. In addition, we observed increasing of (1 0 6) reflection corresponding to the C-type antiferromagnetic structure with increasing magnetic field. It might be caused by the local anisotropy of Tb magnetic moments lying in the ab plane. Based on the experimental results, we considered coupling between Mn3+ spins and anisotropic Tb3+ magnetic moments. We calculated magnetic field dependence of the energy gain of the coupling and succeeded in reproducing the electromagnetic diagram of TbMnO3 [5].

Reference

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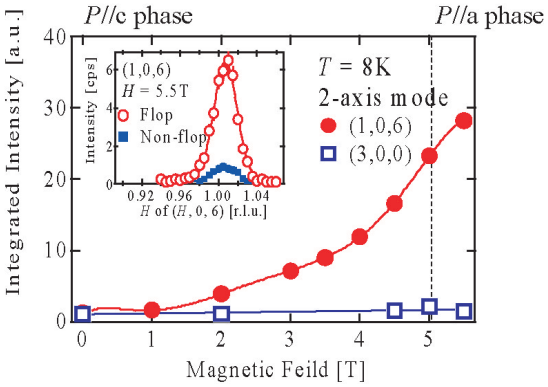

Fig. 1. Magnetic field dependences of integrated intensities of (1 0 6) and (3 0 0) refrection. The inset shows reflection profiles of spin frop and non-spin flop scattering at (1 0 6).