Neutron diffraction study of magnetism and ferroelectricity in $R\mathrm{Mn_2O_5}$ (R = rare-earth, Bi, Y) multiferroics

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$R\mathrm{Mn_2O_5}$ (R = rare-earth, Bi, Y) is one of the most famous and prototypical mutiferroics. In this system, ferroelectricity or magnetism can be controlled by external field such as magnetic field or electric field, which is called as a magnetoelectric effect. Since electric polarization can be induced only in antiferromagnetic phase, magnetic order has been thought to be a primary order parameter for ferroelectricity.

We have carried out neutron diffraction study under magnetic fields for many types of $R\mathrm{Mn_2O_5}$ single crystals to elucidate microscopic mechanism of magnetically induced ferroelectricity. The study have shown that ferroelectric phase transitions simultaneously occur with magnetic phase transitions induced by magnetic field, suggesting that the magnetic structure consisting of R^{3+} spin, $\mathrm{Mn^{3+}}$ spin, and $\mathrm{Mn^{4+}}$ spin induces the electric polarization in this system. Our magnetic structure analysis using neutron diffraction clarified that the arrangement of $\mathrm{Mn^{3+}}$ and $\mathrm{Mn^{4+}}$ spins commonly seen regardless of the type of R^{3+} ions essentially contributes to the electric polarization. On the contrary, the direction of 4*f* magnetic moment on R^{3+} site strongly depends on the type of rare-earth elements (electronic state, single ion anisotropy, and so on), indicating that the 4*f* magnetic moment plays an important role for a rich variety of magnetoelectric effects in this system.

We recently have found in $\mathrm{EuMn_2O_5}$ that magnetic phase transition is induced by applying hydrostatic pressure, where the ferroelectric transition occurs and the electric polarization enhanced. Magnetic structure analysis under pressure have revealed that the suppression of cycloidal magnetic structure increases the electric polarization in this material.

This study has been supported by “KAKENHI” programs of Scientific Research (B) (24340064), Scientific Research (A) (21244051), Challenging Exploratory Research (23654098), and of Scientific Research on Priority Areas “Novel States of Matter Induced by Frustration” (19052001).