Electric Control of Helimagnetic Chirality in CoCr2O4

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Ferroelectricity driven by magnetic order is paid a large attention in the recent study of multiferroics. A cubic spinel CoCr2O4, in which magnetic Co2+ ions occupy the A site and Cr3+ ions occupy the B site, shows ferrimagnetic ordering below TC = 93 K and conical-spiral magnetic ordering below TS = 26 K. [1] As the spiral magnetic ordering induces electric polarization,[2, 3] the right-handed or left-handed spiral magnetic structure can be controlled by the electric polarization.[4] To detect the chiral helimagnetic structure, polarized neutron diffraction is powerful method by comparing magnetic satellite intensity of up-spin and down-spin incident neutron beams.

To detect the helimagnetic chirality, we performed polarized neutron diffraction experiments on a triple-axis spectrometer 5G (PONTA), JRR-3M, Tokai, Japan. The energy of incident neutron beam was 13.7 meV. To make single chiral helimagnetic domains, we cooled the sample with applying a magnetic field of 0.5 T along <0, 0, 1> and electric field of 0 to 0.9 kV/mm along <-1, 1, 0>. After cooling, the magnetic and electric field was turned off and the sample was set on a goniometer. The data was collected at 10 K. By observing nuclear Bragg reflection of (2, 2, 0), the neutron polarization of incident beam was determined to be 95.4 %. As shown in Fig. 1, we observed magnetic satellite peak at (2-q, 2-q, 0), where the magnetic propagation vector kmag was (q, q, 0) (q = 0.616). To investigate the helimagnetic chirality, intensity comparison at (± q, ± q, 2) is necessary. As the peaktop intensity of (± q, ± q, 2) was too weak (0.1 cps), we estimated the intensity by subtracting the background intensity from the peaktop intensity. In any electric field amplitude, the obtained neutron polarization in (q, q, 2) was nearly zero, which indicates the right- and left-handed magnetic screw domains coexist in equal ratio. The magnetic domains might be destroyed in the process of turning off the magnetic field. Therefore, the additional polarized neutron diffraction experiments under an applied magnetic field are now in progress.

[1] K. Tomiyasu et al.: Phys. Rev. B 70 (2004) 214434.
[2] Y. Yamasaki et al.: Phys. Rev. Lett. 96 (2006) 207204.
[3] Y. J. Choi et al.: Phys. Rev. Lett. 102 (2009) 067601.
[4] H. Katsura et al.: Phys. Rev. Lett. 95 (2005) 057205.

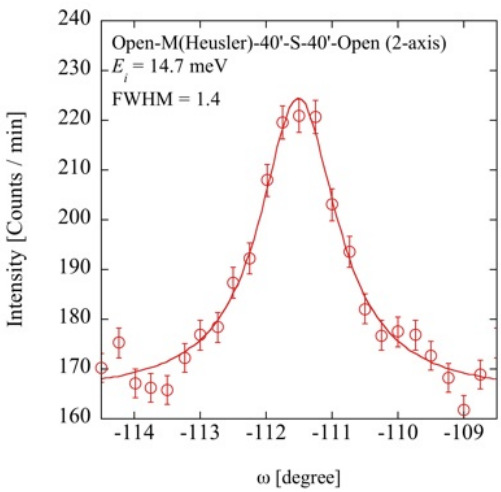

Fig. 1. Omega scan profile in (2-q, 2-q, 0)