Nuclear and Magnetic Diffuse Scatterings in Relaxor Magnet $YbFeCoO_4$

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In relaxor systems, temperature dependence of the dielectric permittivity shows a broad maximum and a characteristic frequency-dependence. To explain physical behaviors of relaxors, randomly oriented, very local polar regions, i.e., “Polar Nanoregions” (PNRs) are proposed. Physical properties of many relaxor ferroelectrics have been understood based on the behavior of PNRs. Because the typical relaxor systems have no magnetic ions, the relationships between relaxor property and magnetism have been reported rarely. Previously we studied one of the relaxor ferroelectrics having the magnetic ions, $BiFeO_3$-1/3$BaTiO_3$.[1] From the neutron results in $BiFeO_3$-1/3$BaTiO_3$, the PNR was found to affect the magnetic ordering significantly, and the resulting magnetic nanodomains are the new origin of superparamagnetism. Superparamagnetism is very unique because of its inherent connection between dielectric and magnetic properties. As a new variation of such relaxor systems having the magnetic ions, we have focused our attention on triangular lattice systems LuFeCoO4 having relaxor properties.[2] Then, we found the interaction between the PNR and magnetism through both macroscopic property measurements and microscopic neutron-scattering measurements. Our results indicate that LuFeCoO4 has nano-length magnetic correlation and superparamagnetism induced by PNRs. In the present study, we studied another relaxor magnet $YbFeCoO_4$ in order to clarify the essence of the relaxor magnet.

The neutron measurement on $YbFeCoO_4$ single crystal was performed by using the triple-axis spectrometer GPTAS (4G) installed at JRR-3 in JAEA Japan. The final neutron energy was set at E_f=30.5 meV. The single crystal was oriented with the [110] and [001] axes with the trigonal unit cell in the horizontal plane.

In the neutron studies of $YbFeCoO_4$, rod-shaped magnetic reflection at (1/3,1/3,L) was observed below 200 K. In the magnetization measurement, on the other hand, the hysteresis behavior was observed below 80 K. In the temperature region 80 K < T < 200 K, the magnetic correlation is expected to be short-ranged. This is consistent with the T-dependences of the magnetic profile width. The strong nuclear diffuse scattering around a nuclear Bragg reflection was also observed. We concluded that the nuclear diffuse scattering is given by the PNR. We are analyzing the correlation length of both nuclear and magnetic scatterings. The obtained results give us the coupling between nuclear and magnetic scatterings.

[1] M. Soda *et al.*, J. Phys. Soc. Jpn. **80** 043705 (2011).

[2] M. Soda *et al.*, J. Phys. Soc. Jpn. **85**, 034713 043705 (2016).