Ferromagnetic and antiferromagnetic orders in CaRu$_{1-x}$Mn$_x$O$_3$

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The nature of metal-insulator transition in the transition-metal oxides is one of the intriguing issues in the condensed-matter physics. The distorted perovskite compound CaRuO$_3$ (the GdFeO$_3$-type orthorhombic structure; space group $Pnma$) is considered to be paramagnetic metal, and located in the vicinity of the metal-insulator transition. Recently, it is revealed that the ionic substitutions for the Ru site dramatically enhance the magnetic correlation [1, 2, 3, 4]. In particular, we found that the substitution of Mn for Ru induces both the ferromagnetic and antiferromagnetic (AF) components in magnetization $M$, accompanying the variation of the electrical resistivity from metallic to insulating behavior. These features are expected to be attributed to the variations of the d electronic state, and it is therefore interesting to investigate the microscopic properties of the d electrons in the intermediate Mn concentration range. In the present study, we have performed powder neutron diffraction experiments for CaRu$_{1-x}$Mn$_x$O$_3$.

The polycrystalline samples of CaRu$_{1-x}$Mn$_x$O$_3$ with $x = 0.4, 0.6$ and $0.7$ were prepared by the solid-state method. The neutron diffraction measurements for powdered samples were performed in the temperature ranges between 15 K and 290 K, using the HERMES spectrometer installed at the research reactor JRR-3M of JAEA. The wavelength of the incident neutron was selected to be 1.8264 Å. Figure 1 shows the neutron powder diffraction profiles at 15 K for $x = 0.4, 0.6$ and $0.7$. We have observed the development of Bragg peaks ascribed to the AF order with the G-type structure. These AF Bragg-peak intensities increase with increasing $x$, indicating that the AF structure becomes stable in the Mn-rich concentration range. Furthermore, the intensities of some Bragg-peaks, such as the (101) and (020) peaks, are found to show notable temperature variations. They are roughly in proportional to $M^2(T)$, suggesting that the ferromagnetic order develops in the intermediate $x$ range. These features are roughly consistent with the previous report on the Mn-rich region [5]. The precise analysis on the present neutron diffraction data is now in progress.

References

Fig. 1. Neutron powder diffraction profiles of CaRu$_{1-x}$Mn$_x$O$_3$ with $x = 0.4, 0.6$ and $0.7$ at 15 K. The open and closed arrows indicate the antiferromagnetic and ferromagnetic Bragg peaks positions, respectively.