Anomalous Weak ferromagnetism of LaCo1-xRhxO3 between Two Non-magnetic Phases

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The perovskite cobalt oxides have been investigated for their rich physical properties. Co3+ ions in cobalt oxides have some spin states due to the crystal field splitting, which significantly affects the transport and magnetic properties. The perovskite oxides LaCoO3 and LaRhO3 are nonmagnetic at low temperature because the d electrons in Co3+ (3d6) and Rh3+ (4d6) fully occupy the lower t2g orbitals (t2g6, S=0). However, the solid-solution LaCo1-xRhxO3 has a Curie-Weiss like susceptibility at low temperature [1].

We have measured the X-ray diffraction and magnetization of LaCo1-xRhxO3 in the range of 0?x?0.9 in order to investigate a mechanism of the anomalous magnetism of LaCo1-xRhxO3 [2].The anomalous magnetism induced in the solid solution of the two nonmagnetic phases is developed in the range of x from 0.1 to 0.9. The effective Bohr magnetic moment evaluated from the temperature dependence of the magnetic susceptibility at room temperature is independent of x for 0<x<0.5, and rapidly decreases above x=0.5. Furthermore, we have found the weak ferromagnetic ordering in the x range of 0.1~0.4. The ferromagnetic ordering induced by Rh3+ substitution is newly discovered, and is distinguished from the metallic ferromagnetic state driven by the double exchange mechanism. We also have found that the applied field dependence of the Magnetization for LaCo0.8Rh0.2O3 is not saturated and increases linearly with the applied field increasing above 6 T. It indicates that this magnetic ordering is not a simple ferromagnetic order.

We have carried out the neutron diffraction measurements on the single crystal of LaCo0.8Rh0.2O3 using the triple axis spectrometer 5G installed at JRR-3 in order to understand the magnetic structure. Figure 1 shows the profiles of the ω-scan (sample-angle scan) of LaCo0.8Rh0.2O3 through Q=(0,0,1) point in the reciprocal space at T =7 and 50 K. The intensity of 001 reflection increases with decreasing T. It indicates that the ferromagnetic diffraction is developed at low temperature. Figure 2 shows the T dependence of the diffraction intensity of 001 reflection for LaCo0.8Rh0.2O3 in the region 7<T<50 K. The intensity increases below T~18 K with decreasing T. It is consistent with the transiton temperature evaluated by the temperature dependence of the magnetic susceptibility, TC ~ 15 K. Figure 3 shows the ω-scan profile of 001 ferromagnetic reflection for LaCo0.8Rh0.2O3 by subtracting the profile at T=50 K from that at T=7 K. We evaluate the intensity and FWHM of the ferromagnetic reflection by fitting the profile with the Lorenz distribution (shown in solid line) to the data, and we obtained the ordered moment is 0.4 μ B/f.u. and the correlation length is 5.48 . The value of the ordered moment is consistent with the ferromagnetic moment evaluated from the magnetization curve [2]. The finite correlation length indicates that the weak ferromagnetism of LaCo0.8Rh0.2O3 is originated from the short-range ferromagnetic ordering of (high spin state) Co3+ spins separated by nonmagnetic Rh3+ ions.

References

[1] T. Kyomen, Y. Asaka, and M. Itoh: Phys. Rev. B 67 (2003) 144424.
[2] S. Asai, N. Furuta, Y. Yasui, I. Terasaki: J. Phys. Soc. Jpn 80 (2011) 104705.

Figure captions.

Fig. 1: The profiles of ω-scan (sample-angle scan) of LaCo0.8Rh0.2O3 through the

Q =(0,0,1) point at T = 7 and 50 K.
Fig. 2: The T dependence of the diffraction intensity of 001 reflection for LaCo0.8Rh0.2O3.
Fig. 3: The profile of the ω - scan of 001 magnetic diffraction. The solid line shows the fitted Lorenz distribution.

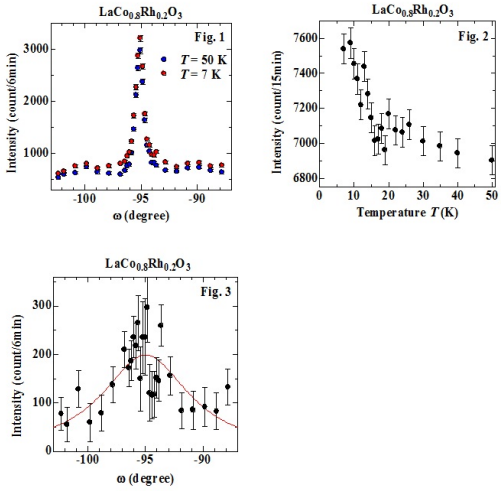

Fig. 1.