Effective random-fied domain-state in Ga-substituted $CuFeO_2$

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The effects of random field on the stability of a long-range magnetic ordering have been extensively studied from 1980s. In the early stage, the random-field effect was experimentally investigated using diluted antiferromagnets under applied magnetic field.[1] The recent experimental studies on $CsCo_{1-x}Mg_xBr_3$ have revealed that a combination of a partially-disordered magnetic structure, which often shows up in some magnetically frustrated systems, and site-random magnetic vacancies can generate 'effective-random-field' without an application of external magnetic field.[2]

In the previous works, we have found that $CuFe_{1-x}Al_xO_2$ ($x > 0.10$) exhibits the effective random-field domain-state, in which the local magnetic structure is a sinusoidally amplitude modulated incommensurate structure.[3] We also found that the scattering function $S(q)$ broadens as the Al-concentration increases. This indicates that the magnetic correlation length is shortened by the Al-substitution. However, the recent studies on $CuFe_{1-x}Ga_xO_2$ have pointed out that the Al-substitution produces not only the magnetic vacancies but also local lattice distortions due to the difference between the ionic radii of Fe^{3+} and Al^{3+}.[4] Although this local distortion might disturb the long-range magnetic ordering, this should be distinguished from the effective random-field effect. In order to purely investigate the effective random-field effect, in the present study, we used Ga-substituted $CuFeO_2$ samples, in which the local lattice distortion is relatively small.

We performed neutron diffraction measurements on $CuFe_{1-x}Ga_xO_2$ samples with $x = 0.20$ and 0.30, using the triple-axis neutron spectrometer HQR(T1-1) installed at JRR-3. The collimation open- '40- '40- '40 was employed. The wavelength of the incident neutron is 2.44 Å. The single crystal of $CuFe_{1-x}Ga_xO_2$ samples were mounted in a ^{4}He-pumped cryostat with a hexagonal (H, H, L)-scattering plane. In order to evaluate the magnetic correlation length quantitatively, we analyzed the scattering profile, using Multi-Profile-Deconvolution (MPD) method presented in Ref. [3].

Figures 1(a) and 1(b) show the $(H, H, 3/2)$ diffraction profiles at $T = 2.0$K and results of the MPD-analysis. For both samples, the functional form of $S(q)$ are well described by the sum of a Lorentzian term and Lorentzian-Squared term shown in Fig. 1(c). The Lorentzian-squared component dominating at low temperature indicates the domain state as seen in the prototypical random-field Ising model.[1] While the ratio between the amplitudes of Lorentzian and Lorentzian-squared terms are comparable to each other ($B/A = 0.02 \sim 0.09$), the widths of $S(q)$ are rather different. The further detailed analysis is now in progress.

References

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[2] J. van Duijn *et al.*: PRL **92** 077202 (2004).
[3] T. Nakajima *et al.*:JPCM **19** 145216 (2007).
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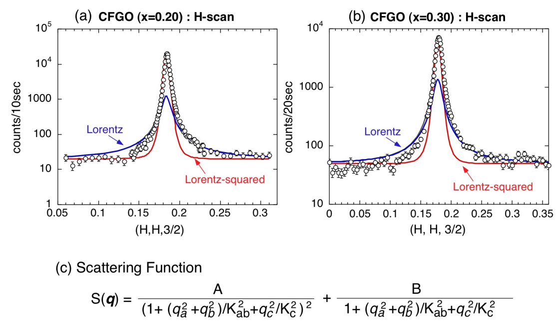

Fig. 1. [(a)-(b)] $(H, H, 3/2)$ diffraction profiles of (a) $x = 0.20$ sample and (b) $x = 0.30$ sample at $T = 2.0$K, and results of the MPD-analysis.(c) The definition of the functional form of the scattering function $S(q)$.