Effective random-field domain-state in a diluted frustrated magnet $CuFe_{1-x}Al_xO_2$

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Geometrically frustrated spin systems have been extensively investigated, because they exhibit a variety of exotic magnetic orderings, which spans from a complex noncollinear magnetic state to a spin-glass like disordered state. One of the unusual magnetic state in this system is the Partially-Disordered (PD) state, in which magnetically disordered sublattices exist. Recent studies on diluted triangular lattice antiferromangets such as $CsCo_{1-x}Mg_xBr_3$[1] and $CuFe_{1-x}Al_xO_2$ $(x = 0.10)$[2], which exhibit the PD magnetic orderings, revealed that a combination of the PD magnetic ordering and site-random magnetic vacancies can generate effective random-field even in the absence of external magnetic field.

For the systematic study on this effective random-field effect in the diluted frustrated magnet, we performed neutron diffraction measurements on $CuFe_{1-x}Al_xO_2$ samples with $x = 0.15$ and 0.20, 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 2.44Å. The single crystal of $CuFe_{1-x}Al_xO_2$ samples were mounted in a ^{4}He-pumped cryostat with a hexagonal (hhl)-scattering plane. In order to evaluate the magnetic correlation length quantitatively, we analyzed the scattering profile, using Multi-Profile-Deconvolution method presented in Ref. [2].

Figs. 1(a) and (b) show the scattering profiles of the $x = 0.15$ and 0.20 sample at $T = 2$K and the results of MPD-analysis for these profiles. For both samples, the scattering function of the magnetic reflections are well described by the sum of a Lorentzian term and a Lorentzian-squared term with anisotropic width (see Fig. 1(d)). In particular, the existence of a Lorentzian-squared term indicates that the system breaks into a large number of small magnetic domains. We found that the width of the S(q), κ, increases with increasing Al^{3+}-concentration x (see Fig. 1(c)). This indicates that the average size of magnetic domains decreases with increasing x. We also found the contribution of the Lorentzian term in $S(q)$ increases with increasing x, as shown in Fig. 1(c). This implies that the system gradually changes from a random-field domain state to a spin-glass like disordered state, as the substitution increases. The further detailed analysis is now in progress.

References

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

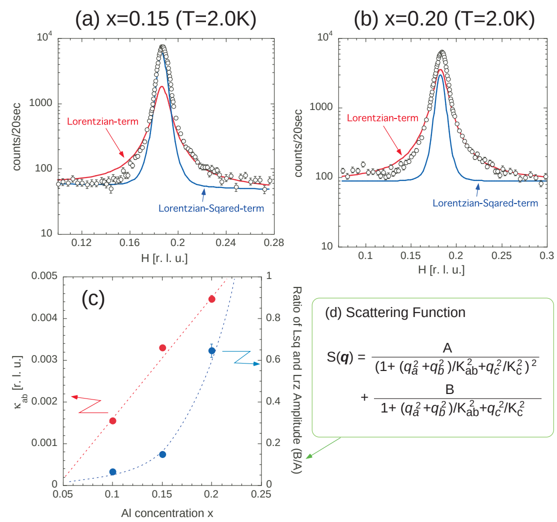

Fig. 1. Typical scattering profiles of (a) $x = 0.15$ and (b) $x = 0.20$ samples at $T = 2.0$K. (c) x dependence of the width of $S(q)$ and the ratio of amplitude of Lrz and Lsq term at $T = 2$K. The data of $x = 0.10$ is taken from Ref. [2] (d) Definition of the $S(q)$.