Zero-Field Random-Field Effect in Diluted Triangular Lattice Antiferromagnet CuFe1-xAlxO2

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Delafossite compound CuFeO2 is one of the model materials of triangular lattice antiferromagnet (TLA), and its magnetic properties were extensively investigated in the last fifteen years. Recent studies on the diluted system CuFe1-xAlxO2 ($x<0.050$) revealed that various magnetically ordered phases are induced in the low-Al3+-concentration region, owing to partial release of spin frustration.[1] In contrast, in the high Al3+-concentration region of $x>0.040$, only the oblique-partially-disordered (OPD) state, whose local spin structure is a sinusoidally amplitude-modulated structure with incommensurate wave number, shows up, and the local magnetic structure does not changes depending on the amount of nonmagnetic impurity.[2] However, our preliminary neutron diffraction measurements revealed that the width of the diffraction profile broadens with increasing Al3+ concentration. We thus investigate how the spin correlation in CuFe1-xAlxO2 is modified depending on amount of nonmagnetic impurity, by high-Q resolution neutron diffraction measurements.

In present experiments, we performed neutron diffraction measurements using the single-crystal CuFe1-xAlxO2(x=0.10) at the triple-axis spectrometer HQR(T1-1) installed at JRR-3M, The incident neutron wavelength is 2.44[A] and collimation open-'40-'40-'60 was employed. We firstly obtained the diffraction profiles of (qOPD,qOPD,1.5) and (qOPD,qOPD,4.5) magnetic reflections with qOPD˜0.19 along six directions illustrated in Fig.1 (e). Next, we numerically calculated the diffraction profiles for these directions by convoluting a functional form of S(q) with the measured resolution function, and fitted them to the measured profiles simultaneously. Trying several functional form of S(q), we found that the scattering function of the magnetic reflection is described as the sum of a Lorentzian term and a Lorentzian-squared term with anisotropic widths. The Lorentzian-squared term dominating at low temperature is indicative of the domain state in the prototypical random-field Ising model. Taking account of the magnetic structure in OPD phase, we conclude that the effective random field arises even at zero-field, owing to the combination of site-random magnetic vacancies and the sinusoidal magnetic structure. The details of the present study will be seen in the coming paper.[3]

[1] N. Terada et al.: JPSJ 74 (2005)2604.
[2] T. Nakajima et al.: ISSP-NSL Activity Report Vol. 13 (2006)
[3] T. Nakajima et al.: JPCM (in press) [a proceeding paper of 'Highly Frustrated Magnetism 2006']

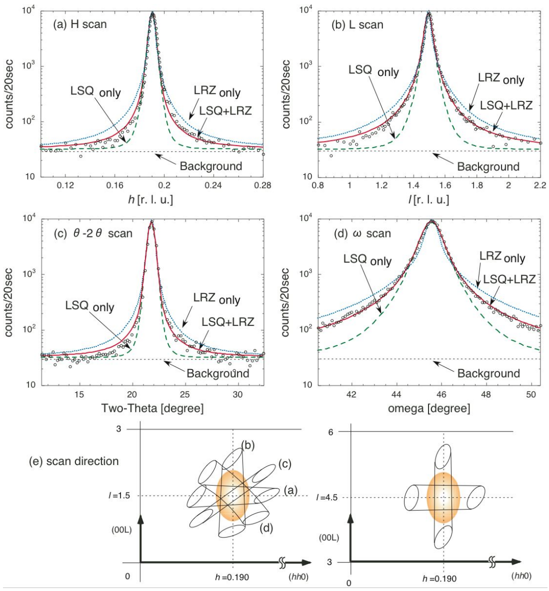

Fig. 1. (a)-(d)Scattering profiles at T=2K. The dotted, dashed and solid lines depict the profiles calculated with Lorentzian-(LRZ), Lorentzian-squared-(LSQ) and LSQ+LRZ-type of S(q), respectively. (e) scan directions corresponding to (a)-(d)