Investigation of the magnetic ground state in a new one-dimensional quantum spin system K2Cu3O(SO4)3

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For discovery of a exotic ground states, we tried to synthesize a new quantum spin system K2Cu3O(SO4)3 and finally succeeded in preparing pure-phase. The magnetic ions of Cu2+ form edge-sharing spin tetrahedral cluster and that are connected each other by SO42- ions along the b-axis direction. The inter-cluster magnetic interactions should be weaker than intra-cluster magnetic interactions because it is next-nearest-neighbor magnetic interaction through the Cu-O-S-O-Cu exchange paths, so we called this system " the edge-sharing tetrahedral cluster chain system ". The competing of the edge-sharing tetrahedral frustration and one-dimensionally weak inter-tetrahedra magnetic couplings are expected in this unique structure of K2Cu3O(SO4)3.

Short-range magnetic correlations were observed to develop in two-stage process at around 100 K and 4 K without long-range ordering. Magnetization datas showed the 1/3 plateau both above and below 4K. We observed only a Schottky-like anomaly at around 5 K and any anomaly indicative of long-range ordering is absent down to at least 0.5 K in the specific heat.

The inelastic neutron scattering (INS) on powder K2Cu3O(SO4)3 was performed on a cold-neutron time-of-flight chopper spectrometer, PELICAN installed at ANSTO. In Fig.1 (a), a data of T = 1.6 K, the dispersive excitation and a gap of Δ ~ 0.8 meV was observed definitely, which shows the characteristic of the one dimensional spin gap system. In Fig.1 (b), a data of T = 20 K, the gapless dispersive excitation is observed, indicating the development of one dimensional short range correlations.

These experimental results is explained theoretically as follows. Three spin-triplet state which formed in a cluster in spite of the antiferromagnetic interactions are dominant, and which can be described the composite Haldane spin chains.

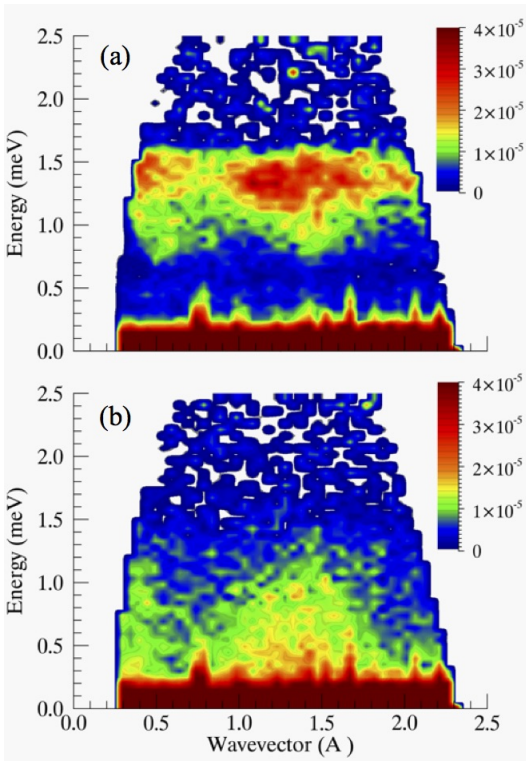

Fig. 1. Inelastic neutron spectra measured at (a) 1.6 K and (b) 20 K. The incident neutron wavelength was 4.75 A.