Magnetic Excitation Spectra of Honeycomb System Na3T2SbO6 (T=Cu, Ni, Co)

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Na3Cu2SbO6 is composed of Cu2SbO6 layers with Na layers between them. The former layers consist of edge-sharing CuO6 octahedra, which form the distorted honeycomb lattice with SbO6 octahedron at the center of each hexagon of the CuO6 octahedra (left figure). The Cu valence is +2 and the spin S=1/2. The temperature (T) dependences of the spin component of the magnetic susceptibility chi-spin and the specific heat C-spin indicate that a spin gap exists in the system. The superexchange interactions between two Cu spins, J1 and J1′ via Cu-O-Cu paths and that of the Cu-O-O-Cu path J2 are defined as shown in the left figure. Taking into account of both the large Jahn-Teller distortion and the characteristics of the shape of the electron orbits in which the spins exist, we expect that J2 is the largest and J1′ is much smaller than the other two, rationalizing that a model of the alternating chains along b is a proper one to describe the present spin system. We carried out detailed analyses of the spin-gap behavior using the (chi-spin)-T and (C-spin)-T data, and found, as described in ref. 1, that the antiferromagnetic (AF)-ferromagnetic (F) alternating chain model successfully describes it.

Inelastic neutron scattering experiments have been performed on aligned single crystals of Na3Cu2SbO6 to directly observe the spin-gap in the magnetic excitation spectra. The measurements were carried out on the triplet-axis-spectrometer ISSP-PONTA at JRR-3 in Tokai. Pyrolytic graphites (PG) were used as the monochromator and the analyzer. A PG filter after the sample was used to suppress the higher order contaminations. Horizontal collimations were effectively 40′-40′-80′-80′. The aligned crystals were oriented with the [100] and [010] axes in the scattering plane. The condition of the fixed final neutron energy Ef=14.7 meV was adopted.

Scattering intensities were collected at 10 K by the k-scans along (h, k, 0) with the transfer energy (E) of 9 meV. Peaks of the singlet-triplet excitaions were found at the k points of 0.5, 2.5 and 3.5 in the region of k<4.0 (see the right figure shown below for h=1). We also carried out similar scans at several different values of h and found that these peaks extend along h, having the one-dimensional character of the spin system, which is consistent with the above description that the system can be understood by the AF-F alternating chain model. Then, the E-scan profiles were obtained at Q=(1, 2.5, 0) at several fixed temperatures in the region of 10<T<200 K, where the gap energy were found to be 9 meV, which also agreed with the results obtained by our previous studies of chi-spin and C-spin.

The dispersion curve was also measured by the E-scans at various Q points. Analyses to estimate the J1 and J2 values from the dispersion curves are underway.

[1]Y. Miura et al.: J. Phys. Soc. Jpn. 75 (2006) 084707.

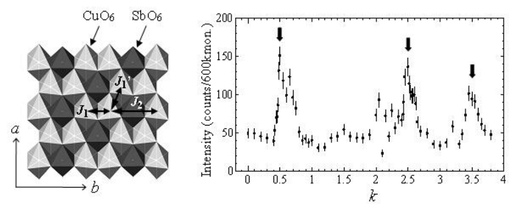

Fig. 1. (Left) Schematic figure of the honeycomb layer. At the corners of the octahedra, O atoms exist, and a Cu or Sb atom is within each octahedron. (Right) The Q-scan profile of (1, k, 0) at 10 K for E=9 meV.