MLF Experimental Report	提出日 Date of Report Dec. 11, 2014
課題番号 Project No. 2014B0023 実験課題名 Title of experiment Determination of dispersion relation of magnetic excitations in the antiferromagnetic spin-1/2 chain substance $CuSb_2O_6$ 実験責任者名 Name of principal investigator Masashi Hase 所属 Affiliation National Institute for Materials Science	装置責任者 Name of responsible person Shin-ichi Itoh 装置名 Name of Instrument/(BL No.) BL12 HRC 実施日 Date of Experiment Dec. 7 to 10, 2014

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Copper diantimonate, $CuSb_2O_6$, powders.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

We describe magnetism of $CuSb_2O_6$. The space group is monoclinic $P2_1/c$ (No. 14). Antiferromagnetic (AF) order appears below $T_N = 8.7$ K [1,2]. The magnetic susceptibility above T_N agrees well with the susceptibility of the one-dimensional AF Heisenberg model with the intrachain exchange interaction of $J = 8.3$ meV [1,3]. The susceptibility above T_N is nearly isotropic [2]. The spin-flip transition appears around 1.3 T when the magnetic field H is applied parallel to the a or b axis. The symmetry of crystal fields affecting Cu^{2+} ions is nearly cubic. Consequently, magnetic anisotropy is small. Gibson et al. reported the magnetic structure in which the ordered moments lie in the $a-b$ plane with the major component along the b axis [4]. The magnetic structure is consistent with the appearance of the spin-flip transition both $H \parallel a$ and b. The magnetic specific heat below T_N is well fit to $A\exp(-\Delta_G/T)$ with $\Delta_G = 1.51$ meV, indicating the existence of a gap.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

To confirm whether the gap exists or not, we performed inelastic neutron scattering (INS) experiments on $CuSb_2O_6$ powders using the HRC spectrometer at BL12. The typical incident neutron energy E_i is 11.4 or 51.0 meV. Figure 1 shows INS results at 2.5 K. We observed magnetic excitations between 1.8 and 13 meV. No excitation is seen below 1.8 meV, indicating the existence of an excitation gap. Weak excitations seem to exist around 1 meV. However, these excitations were not observed in the INS result using $E_i = 8.83$ meV. Therefore, no excitation exists around 1 meV. The highest excitation energy in the lowest branch of magnetic excitations is expected to be $\pi J/2 = 13$ meV and is consistent with the experimental result. The 1.8 meV excitation has a maximum in intensity around $Q_{\mathrm{AF}} = 0.48$ Å^{-1}. The Q value corresponds to a Cu-Cu length of 6.6 Å. The length is consistent with that of the Cu-Cu bond having the intrachain exchange interaction. The intensity of the 1.8 meV excitation is also strong around $3Q_{\mathrm{AF}} = 1.44$ Å^{-1}.

Figure 2 shows INS results at 12.5 K above $T_{\mathrm{N}} = 8.7$ K. We observed magnetic excitations below 13 meV. The excitation gap does not exist. Probably, the excitation gap appears only in the ordered state. We will consider the origin of the excitation gap.

[1] A. M. Nakua et al., J. Solid State Chem. 91, 105 (1990).

[2] A. Rebello et al., Phys. Rev. B 87, 224427 (2013).

[3] M. Kato et al., J. Phys. Soc. Jpn. Suppl. 71, 187 (2002).

[4] B. J. Gibson et al., J. Magn. Magn. Mater. 272-276, 927 (2004).

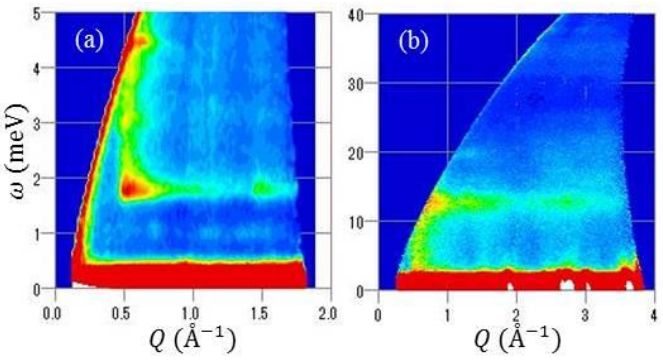

Fig. 1 The intensity map in the $Q-\omega$ plane of $CuSb_2O_6$ at 2.5 K obtained using $E_i = 11.4$ meV (a) and 51.0 meV.

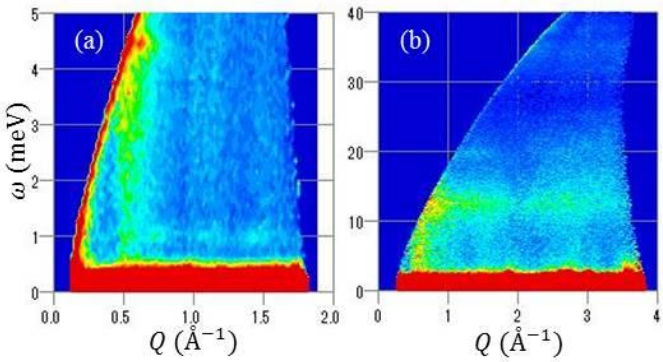

Fig. 1 The intensity map in the $Q-\omega$ plane of $CuSb_2O_6$ at 12.5 K obtained using $E_i = 11.4$ meV (a) and 51.0 meV.