MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2012B0009 実験課題名 Title of experiment Confirmation of spin gap excitations in the large-spin substances RCrGeO5 (R = Y or Nd) 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. 1 to 6, 2012

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.

One interesting phenomenon in quantum spin systems is the appearance of a spin-singlet ground state with a spin gap (singlet - triplet excitation). When the spin value is larger than 1, existence of a spin-singlet ground state with a spin gap has not been proved experimentally. We can expect antiferromagnetic (AF) alternating spin-3/2 chains of Cr^{3+} in $RCrGeO_5$ (R = Y or rare earth) and a spin-singlet ground state with a spin gap [1]. Our objective is to confirm the spin gap excitation in RCrGeO5 (R = Y or Nd) powders using inelastic neutron scattering (INS) techniques.

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 performed INS experiments on $YCrGeO_5$ and $NdCrGeO_5$ powders using the HRC spectrometer at BL12. The incident neutron energy Ei is 46.1, 51.1 or 207 meV.

Figure 1 shows INS results of $YCrGeO_5$ powders at 4 K using Ei = 51.1 meV. Excitations are apparent between 5 and 25 meV. Intensities of the excitations are strong in the small Q range. We also measured INS spectra at 200 K. The intensities decrease between 5 and 17 meV. Therefore, most of excitations are magnetic excitations. We could confirm a spin gap in the magnetic excitations.

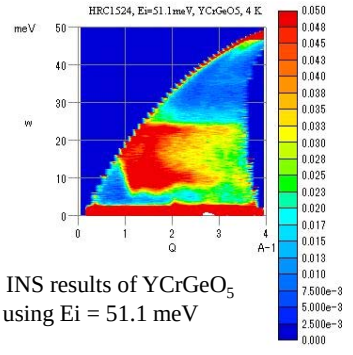

Fig. 1 INS results of $YCrGeO_5$ at 4 K using Ei = 51.1 meV

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

Figure 2 shows the intensity map in the ω – Q_{1D} plane of $YCrGeO_5$ powders at 4 K obtained using the Tomiyasu method [2]. The results correspond to results of a single crystal measured along the spin chain direction. The intensity is the strongest around Q_{1D} = 0.5 (π) as expected in AF spin chains. The spin gap value is evaluated as 8 meV. The dispersion is apparent below Q_{1D} = 1.

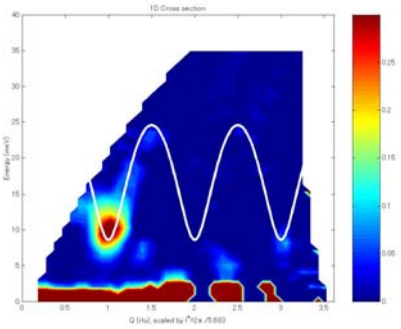

Fig. 2 The intensity map in the ω – Q_{1D} plane of $YCrGeO_5$ at 4 K obtained using the Tomiyasu method [2]. Q_{1D} is Q parallel to the spin chain and is normalized by 2π/d where d is the Cr-Cr distance (0.287 nm). The results correspond to results of a single crystal measured along the spin chain direction. The white line indicates the expected lower edge of magnetic excitations.

Figure 3 shows INS results of $NdCrGeO_5$ powders at 4 K using Ei = 46.1 meV. Excitations are apparent between 18 and 25 meV. Intensities of the excitations are strong in the small Q range. We also measured INS spectra at 100, 200, and 300 K. The intensities decrease with increasing temperature. Therefore, most of excitations are magnetic excitations. We could confirm a spin gap in the magnetic excitations. The magnetic excitations are broad in energy and must have dispersion. We will calculate an intensity map in the ω – Q_{1D} plane. We can see the sharp excitations at 27 meV. The energy position is Q independent (dispersionless) and the intensity decreases with increasing Q. Probably, the excitations originate in 4f orbits split by the crystal field of Nd^{3+} ions.

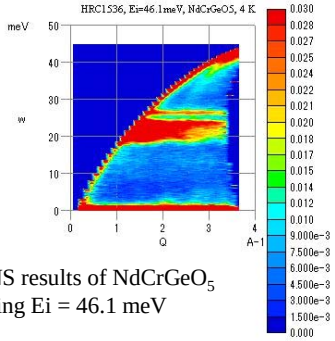

Fig. 3 INS results of $NdCrGeO_5$ at 4 K using Ei = 46.1 meV

In conclusion, we could confirm the spin gap in the magnetic excitations of $YCrGeO_5$ and $NdCrGeO_5$ as expected in AF alternating spin-3/2 chains. To our knowledge, this is the first experimental observation of the spin gap in spin-3/2 substances. We obtained the dispersion relation of the magnetic excitations in $YCrGeO_5$.

[1] R. V. Shpanchenko et al., J. Solid State Chem. 181, 2433 (2008).
[2] K. Tomiyasu et al., Appl. Phys. Lett. 94, 092502 (2009).