Magnetic excitations in a hexagonal La_3FeGaS_7 with quasi-one-dimensional and chiral crystal structure

Y. Yamane[A], T. Taniguchi[B], A. Yamaguchi[A], A. Sumiyama[A], M. Fujita[B]

[A]*School of Science, University of Hyogo*, [B]*Institute for Materials Research, Tohoku University*

Magnetic systems in which small spin angular momenta S = 1/2 or 1 form a one-dimensional chain show quantum nonmagnetic ground states due to large quantum fluctuations. Particularly, in the case of S = 1, valence-bond-solid accompanied by Haldane gap realizes as a ground state. For larger spin systems with S = 3/2, 2 …, on the other hand, classical Neel order manifests itself as the ground state since the quantum fluctuations become small.

Recently, we proposed the one-dimensional magnetic states in hexagonal compounds $La_3\mathit{Tr}GaS_7$ (Tr = Fe, Co, Ni). The temperature dependences of magnetic susceptibility χ for the Tr = Fe, Co, Ni systems exhibit a maximum at T_{max} = 210, 190, 260 K, respectively. The maximum suggests developed short-range correlations in the one-dimensional chain. Moreover, the $\chi(T)$ for the Tr = Fe system shows an additional maximum and sudden decrease at T = 20 and 13 K, respectively, implying long-range magnetic order arising from the finite inter-chain magnetic interaction. On the other hand, the $\chi(T)$ for Tr = Ni in 1.8 – 300 K can be reproduced by the calculation of finite Haldane chain system. In this study, we performed powder neutron diffraction and inelastic neutron scattering experiments for $La_3\mathit{Tr}GaS_7$ (Tr= Fe, Ni) in 8 – 200 K at zero magnetic field to extract the magnetic order suggested from the $\chi(T)$ for Tr = Fe.

Figure 1 shows the powder neutron diffraction patterns for Tr = Fe in 8 – 200 K. The pattern at T = 200 K can be reproduced well by the simulated pattern with the $La_3\mathit{Tr}GaS_7$ crystal structure as shown with grey solid line. This pattern is retained from 200 K to 8 K, thus, no additional peak was observed within the measurement accuracy. This result suggests that the Tr = Fe system doesn't show neither structural phase transition nor long-range magnetic order. Therefore, the maximum and sudden decrease observed in $\chi(T)$ at B = 1 T is possibly attributed to magnetic field induced phase transition.

Figure 2 shows the inelastic neutron scattering spectra for the Tr= Fe, Ni systems at q = 2.1. In the spectra for Tr= Ni system, a broad peak was observed around 10 meV, suggesting novel excitation. This excitation energy is comparable to the Haldane gap of 9.2 meV which is estimated from the $\chi(T)$ data. However, similar peak was observed in the Tr = Fe system as well. Thus, to confirm whether the excitation in the Tr= Ni system is attributed to the Haldane gap or not, it is highly desirable to measure the inelastic neutron scattering spectra for the single-crystalline samples of the Tr= Ni system.

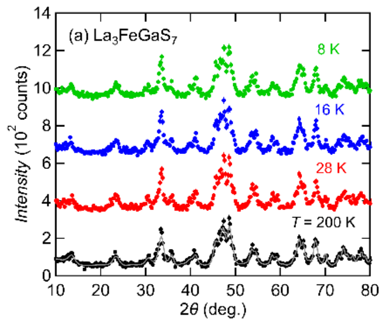

Figure 1. Powder neutron diffraction patterns of $La_3\mathit{Tr}GaS_7$ Tr = Fe.

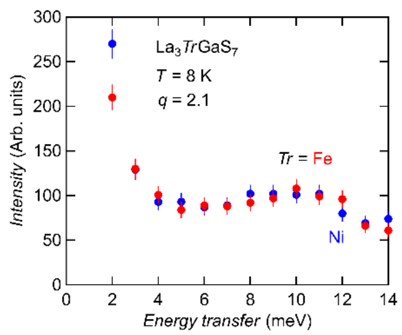

Figure 2. Inelastic neutron scattering spectra for Tr = Fe, Ni at q = 2.1 in T = 8 K.