Short-range correlations in the new quantum kagome-lattice compound $Yb_3Ni_{11}Ge_4$

M. Takahashi(A), K. Nawa(A), M. Frontzek(B) and T. J Sato(A)
IMRAM Tohoku University(A), ORNL(B)

Quest for quantum spin liquid state in two dimensional frustrated lattice has been at the heart of the condensed matter physics for decades. To detect such a exotic state, experimental research has been primarily conducted on insulating compounds where the quantum spin $S = 1/2$ is realized by the $3d^1$ or $3d^9$ state of the transition metal ions, such as Cu^{2+} or Ti^{3+}. Recently, Yb^{3+} based magnetic compounds attract growing attentions as a quantum frustrated system, because the ground-state Kramers doublets of Yb^{3+} may be regarded as pseudo spin $S = 1/2$.

In this work, we study the ternary intermetallic compound $Yb_3Ni_{11}Ge_4$, which has a breathing kagome-lattice structure where the quantum spin liquid state has been proposed theoretically[1]. First, we performed the magnetization and specific heat measurements. In both the experiments, anomaly due to a phase transition has not been observed down to 0.5 K. Instead, the C/T showed log-T increasing behavior below 2 K, and concomitantly magnetization curves indicated the development of in-plane antiferromagnetic correlations at low temperatures. To elucidate the log-T behavior and concomitant antiferromagnetic short range order, we performed powder neutron diffraction experiments using Wide-Angle Neutron Diffractometer (WAND) at ORNL. Neutrons with wavelength $\lambda = 1.488$ Å were selected by a monochromator using Ge 113 reflections. The powdered sample loaded in a copper can was set in the dilution refrigerator.

We measured powder diffraction patterns at the base temperature ($\sim$50 mK) and two higher temperatures (0.8 and 4.5 K) between $2\theta = 1.4^\circ$ and 122°. Figure 1 shows Q-dependence of the intensities at $T = 50$ mK and 0.8 K from which the high temperature (4.5 K) data were subtracted. Magnetic bragg peaks were not detected down to the lowest temperature. On the other hand, we can see the development of broad peaks due to antiferromagnetic short range order at the Q-position near 0 Å^{-1} and 0.88 Å^{-1}, which correspond to the scattering vectors $Q = (0, 0, 0)$ and $Q = (1, 0, 0)$. It is likely that these fluctuations would be related to the $q = 0$ structure; the lattice in a crystal unit cell is divided into three sublattices where the direction of spins on one sublattice differs by 120° from that on other sublattices. The increase of intensity near $Q = (0, 0, 0)$ indicates the existence of ferromagnetic spin fluctuations. To detect the spin excitation spectra due to those spin fluctuations, and to confirm the exact Q-position of the diffuse scattering, we are planning to perform further neutron inelastic scattering experiment using a single crystal.

[1] R. Schaffer, Y. Huh, K. Hwang and Y. B. Kim, Phys. Rev. B 95, 054410 (2017).

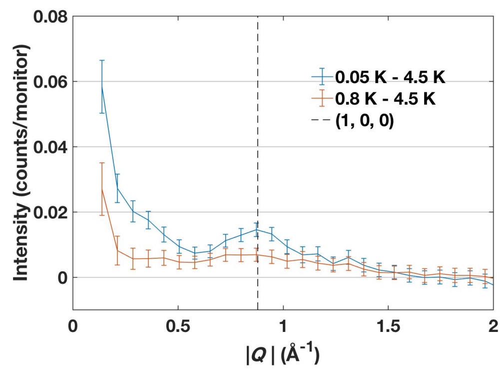

Fig. 1. Magnetic neutron-scattering patterns at T = 50 mK and 0.8 K obtained by subtracting a high temperature (4.5 K) data. The dashed line indicates the Q-position corresponding to the scattering vector Q = (1, 0, 0).