Collective magnetic excitations of $Nd_3Co_4Sn_{13}$

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The $R_3Co_4Sn_{13}$ class of materials show various electronic states accompanied with structural transformations [1, 2]. The R = Ce compound shows a heavy-fermion semimetal behavior, and the R = La compound is a superconductor below 2.7 K. These properties are expected to be associated with the topological electrons under the chiral crystal structure. In present study, we investigated collective magnetic excitations in $Nd_3Co_4Sn_{13}$, which was reported to show a structural superlattice below 124 K and antiferromagnetic ordering at 2.1 K [3, 4].

Inelastic neutron scattering (INS) experiments for the coaligned single-crystal samples of $Nd_3Co_4Sn_{13}$ synthesized using the molten Sn-flux method were performed at the cold-neutron triple-axis spectrometer HER (C1-1). Measurements were conducted with final neutron energy at 3.636 meV chosen by the focusing PG analyzer. Sample temperature was controlled using a ^{3}He cryostat.

Figure 1 shows INS spectra measured at the scattering vector $\boldsymbol{Q}$ = (1, 1, L) with L = 0.0–1.0 r.l.u. of $Nd_3Co_4Sn_{13}$ at 0.3 K. Near L = 0.0 and 1.0, the spectra are composed of a large peak located at 0.2 meV, which shifts to 0.35 meV with varying $\boldsymbol{Q}$ to L = 0.5. This feature seems to be spin wave excitation. In addition, near L = 0.0 and 1.0, higher energy excitation peaks located near 0.4 and 0.8 meV are also observed. In particular, the higher energy excitation at L = 0.5 becomes a continuum between 0.4 and 0.8 meV above the spin-wave-like peak at 0.35 meV.

The measured collective excitation is attributed to magnetic-moment motion within the Kramers doublet ground state of the crystalline-electric-field split levels of Nd^{3+} $4f^3$ configuration. The doublet state can be mapped to an effective spin-1/2 quantum state. The crystal structure of $Nd_3Co_4Sn_{13}$ is characterized by one-dimensional (1D) arrays of the nearest-neighbor Nd ions, which direct along the principal axes of the cubic unit cell. The 1D quantum spin excitation causes the continuum spectra with the lower-boundary dispersion relationship between 0.2 and 0.35 meV, as observed near L = 0.5. Because of inter-array magnetic interactions, the spectra of multi peak components appear at other $\boldsymbol{Q}$, as discussed in terms of spinon bound state investigated for $BaCu_2Si_2O_7$ [5] and $SrCo_2V_2O_8$ [6].

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[1] Y. Otomo et al., PRB **94**, 075109 (2016). [2] J. Welsch et al., PRM **3**, 2 (2019). [3] C. W. Wang et al., J. Phys.: Condens. Matter **29**, 435801 (2017). [4] C. W. Wang et al., Physica B **551**, 12 (2018). [5] A. Zheludev et al., PRB **65**, 014402 (2001). [6] A. K. Bera et al., PRB **96**, 054423 (2017).

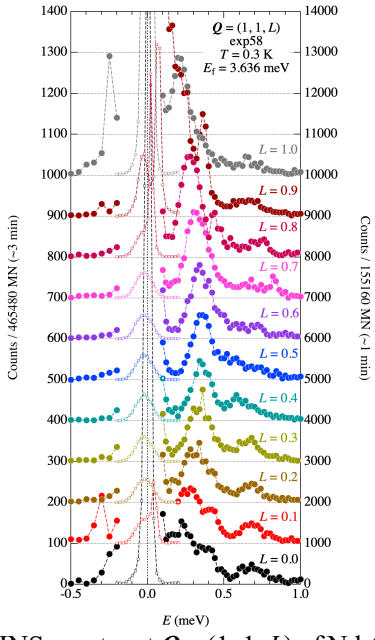

Fig. 1. INS spectra at $\boldsymbol{Q}$ = (1, 1, L) of $Nd_3Co_4Sn_{13}$ at 0.3 K. Left and right ordinates are for inelastic and elastic parts, respectively.