Antiferromagnetic ordering of $Nd_3Rh_4Sn_{13}$

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Topological electronic states in chiral crystal structure attract attentions in condensed matter physics fields [1]. We have studied materials exhibiting structural phase transitions with chiral symmetry to establish spontaneous formation of the topological electronic state. Further, magnetic ordering is attractive because of breaking time-reversal symmetry in addition to breaking of spatial inversion.

The $R_3Co_4Sn_{13}$ materials undergo structural transformations to the chiral structures [2, 3]. The R = Ce compounds show a semimetal behavior, and the R = La one 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 4*f*-electron state in $Nd_3Rh_4Sn_{13}$, which was recently found to take the chiral structure below approximately 335 K based on a synchrotron X-ray diffraction experiment [4].

In present study, neutron diffraction (ND) experiments for the sample of $Nd_3Rh_4Sn_{13}$ synthesized using the molten Sn-flux method was performed at the powder diffractometer HERMES (T1-3). Measurement was conducted with neutron wavelength 2.2 Å.

Figure 1 shows selected ND patterns measured at 0.7 and 8 K using a 1-K cryostat. Upper and lower panels show the data near the scattering angle 2θ ~ 17.9 degrees of $\boldsymbol{Q}$ = (1, 1, 0) and 2θ ~ 41.8 degrees of (3, 1, 0), respectively. The Miller indices are with respect to the high-temperature cubic crystal structure with the lattice constant of 9.67 Å. Blue squares are data taken at 0.7 K, which is slightly larger than the data shown by red circles measures at 8 K. Such intensity increments are signatures of magnetic ordering in $Nd_3Rh_4Sn_{13}$. The similar low-temperature enhancement of reflections indexed by the integer Miller indices were observed for $Nd_3Co_4Sn_{13}$, which shows an antiferromagnetic ordering state below 2.1 K and the structural transformation at 124 K [5, 6]. Therefore, we expect the same magnetic structure of $Nd_3Rh_4Sn_{13}$ as that of $Nd_3Co_4Sn_{13}$, which is characterized by the alternative coupling of magnetic moments on the nearest-neighbor Nd ions. In contrast, the ratio of magnetic intensities to fundamental nuclear intensities seems to be lower than those comprised of 1.78μ_B/Nd in $Nd_3Co_4Sn_{13}$ at 1.5 K. It is a further issue to determine crystalline-electric-field splitting levels of Nd-ion 4*f*-electron state as well as to obtain higher statistics ND data to discuss a mechanism of magnetic ordering in $Nd_3Rh_4Sn_{13}$.

The present study was performed under the approved proposal No. 21573.

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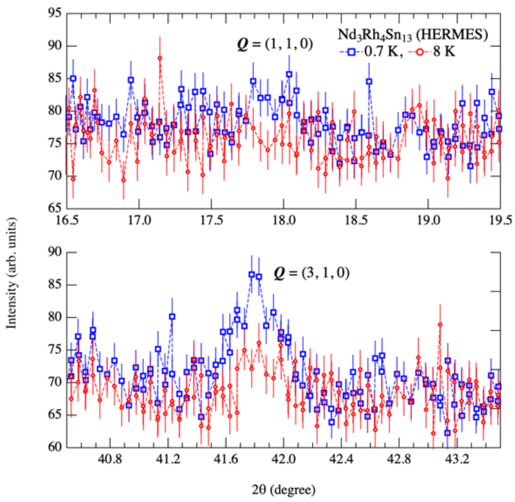

Fig. 1. ND patterns of $Nd_3Rh_4Sn_{13}$ at 0.7 (blue squares) and 8 K (red circles). The scattering-angle regions were chosen for $\boldsymbol{Q}$ = (1, 1, 0) in upper panel and (3, 1, 0) in lower panel.