Antiferromagnetic ordering of $Eu_3Rh_4Sn_{13}$

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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 $R_3Rh_4Sn_{13}$ materials undergo structural transformations to the chiral structures [2]. The R = Ce compounds show a semimetal behavior, and the R = La one is a superconductor below 3 K [3]. 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 $Eu_3Rh_4Sn_{13}$, which was reported to undergo an antiferromagnetic ordering below 11 K based on the magnetization properties [4]. We recently found a structural instability above the magnetic ordering temperature based on a synchrotron X-ray diffraction experiment [5].

In present study, neutron diffraction (ND) experiments for the single-crystal sample of $Eu_3Rh_4Sn_{13}$ (dimensions: $2 \times 3 \times 0.3$ mm^3) synthesized using the molten Sn-flux method was performed at the triple-axis spectrometer HQR (T1-1) equipped with a closed-cycle helium refrigerator.

Figure 1 shows selected rocking curve scan profiles at $\boldsymbol{Q}$ = (3.0, 2.5, 2.5) measured at 2.8 (red circles), 9.1 (blue triangles), and 15 K (black squares). The superlattice emergence was clearly detected, and detailed temperature dependence reveals the magnetic ordering temperature at 11.6 K, which is consistent with the previous study of magnetization measurement [4]. We measured several reflections indexed as $\boldsymbol{Q} = (H, L, L)$ with H = integer and L = half integer. It is noteworthy that the magnetic reflections appear for H = odd, and nothing at H = even. This reflection rule indicates a particular antiferromagnetic ordering. Our synchrotron X-ray fluorescence measurement reveals a trivalent Eu ion [5], which carries a magnetic moment characterized by the total angular moment $J = 7/2$ of the 4*f* electrons; thus, the magnetic ordering should be associated with the Eu sites. As written above, the structural superlattice reflections were detected in the synchrotron X-ray diffraction experiment, which are also represented by the same reduced wave vector (1/2, 1/2, 0) as that for the antiferromagnetic ordering [5]. It is a current issue to determine the combined superlattice structure of crystal lattice and magnetic ordering to examine a topological electronic state.

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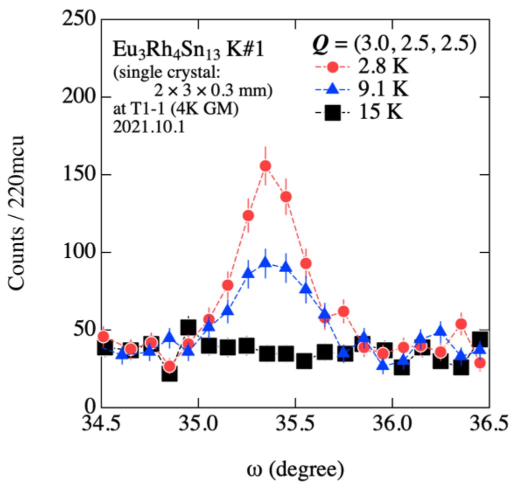

Fig. 1. ND profiles at $\boldsymbol{Q}$ = (3.0, 2.5, 2.5) of $Eu_3Rh_4Sn_{13}$ at 2.8 (red circles) and 9.1 K (blue triangles), and 15 K (black squares).