Zero-field magnetic structures of an orthorhombic Eu intermetallic compound

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Eu-based intermetallic compounds exhibit a wide variety of magnetic states owing to the localized 4f moments of Eu and their coupling mediated by conduction electrons. In low-symmetry crystal structures, competing magnetic interactions can give rise to successive magnetic transitions and complex modulated magnetic structures. The orthorhombic Eu intermetallic compound EuPtIn crystallizes in the space group *Pnma* and exhibits multiple magnetic transitions below approximately 20 K [1], suggesting the emergence of successive magnetic phases. Our previous powder neutron diffraction experiment detected magnetic reflections consistent with a commensurate propagation vector q_1 = (0, 1/2, 0) in the low-temperature phase, while an incommensurate modulation with q_2 = (0, q_{ICM}, 0) was suggested at higher temperatures. However, the detailed temperature evolution of the magnetic modulation could not be unambiguously determined from the powder diffraction data. We therefore performed single-crystal neutron diffraction measurements to clarify the zero-field magnetic phases.

A single crystal was grown by the Bridgman method and polished into a thin plate with dimensions of approximately 5 × 4 × 0.26 mm^3 to reduce neutron absorption by Eu. The crystal was mounted in a GM refrigerator with the (*H*, *K*, 0) plane as the horizontal scattering plane.

At 2 K, a clear magnetic reflection was observed at (1, 1/2, 0), whereas no corresponding peak was detected in the paramagnetic state at 25 K. Line scans confirmed that the low-temperature phase is characterized by the commensurate propagation vector q_1 = (0, 1/2, 0). The temperature dependence of the magnetic modulation vector was investigated by scans along (1, *K*, 0). At low temperatures, the magnetic peak remained at *K* = 0.5. Upon heating above approximately 11–12 K, however, the peak shifted away from the commensurate position, demonstrating a transition to an incommensurate magnetic phase. The incommensurate wave vector evolved continuously with increasing temperature, and the magnetic scattering disappeared near the magnetic ordering temperature of approximately 20 K. These results establish that EuPtIn hosts two distinct zero-field magnetic phases: a commensurate ground state and a temperature-induced incommensurate phase. The P_{zz} polarization analysis suggests that the magnetic moments are predominantly aligned along the *c* axis, with a small component along the *a* axis.

The present single-crystal measurements thus reveal a transition from a commensurate magnetic ground state to an incommensurate phase. These results provide a basis for understanding the multiple magnetic transitions in EuPtIn and for future studies of the field-induced magnetic phases suggested by its anomalous transport properties.

[1] R. Müllmann *et al., J. Solid State Chem*. **137**, 174 (1998).

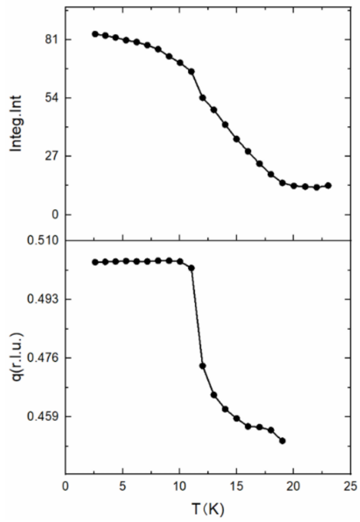

Fig. 1. Temperature dependence of the integrated intensity and the magnetic modulation wave vector *q* obtained from the (1, *K*, 0) scans.