Annual Report for High Field Studies of Magnetic Weyl Semimetals

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Introduction

Weyl semimetals possess crossing points of nondegenerate linearly dispersing bands in momentum space; the band structure near the crossing points can be described effectively by Weyl equation. Owing to the chirality of the emergent Weyl fermions, Weyl semimetals have a potential to show various nontrivial properties including the presence of surface Fermi arc state and magnetotransport related to the chiral anomaly [1]. The crossing of nondegenerate linear dispersion bands requires either inversion or time-reversal symmetry of the material to be broken. The Weyl semimetal of the former type including TaAs [2] and WTe_2 [3] are well studied by spectroscopy and transport techniques, while less for the latter candidates. Among them, *R*AlGe (*R* is rare-earth) offers a unique opportunity to investigate the effect of time-reversal symmetry breaking on these properties: this series of compounds have an inversion symmetry broken crystal structure (space group $I4_1md$) and possess Weyl nodes near the Fermi level as observed by recent angle resolved photoemission spectroscopy (ARPES) for the La compound [4]. In addition, it is predicted for the magnetic counterparts CeAlGe and PrAlGe that the magnetic ordering of rare-earth moments breaks the time-reversal symmetry of the system while possessing the nodal band structure [5]. The detailed studies of fermiology and magnetotransport in *R*AlGe would provide the insight into the role of magnetic ordering in topological semimetal, the effect of time-reversal symmetry breaking and beyond. Here, we explore the fermiology of the nonmagnetic LaAlGe with torque magnetometry technique.

Experimental

Single crystals of *R*AlGe (*R* is rare-earth) were grown by a flux method. Torque magnetometry measurement was performed at NHMFL Pulsed Field Facility in ^{3}He cryostat with a rotation probe.

Results and Discussion

LaAlGe shows clear de Haas-van Alphen (dHvA) oscillation above $\mu_0 H \approx 20$ T at temperature T = 0.5 K. The observed frequency corresponds to 120 T (corresponding to Fermi wave vector $k_F \approx 0.065$ Å^{-1} assuming an isotropic Fermi surface in the tetragonal (001) plane) is consistent with the previous ARPES study [4]. Figure 1 shows the T dependence of oscillatory part of the torque signal at the fixed field direction, where the oscillatory part was obtained by fitting the non-oscillatory part to the polynomial function of magnetic field H. The Lifshitz-Kosevich analysis of the T dependence of the amplitude at fixed H gives the effective mass of $0.13m_0$ (m_0 is the electron mass). Further studies of fermiology of magnetic CeAlGe and PrAlGe, where we have observed unusual magnetotransport and anomalous Hall effect, and the detailed comparison to the observation here would reveal the coupling of the magnetic ordering and topological electronic state, which is the subject of the future study.

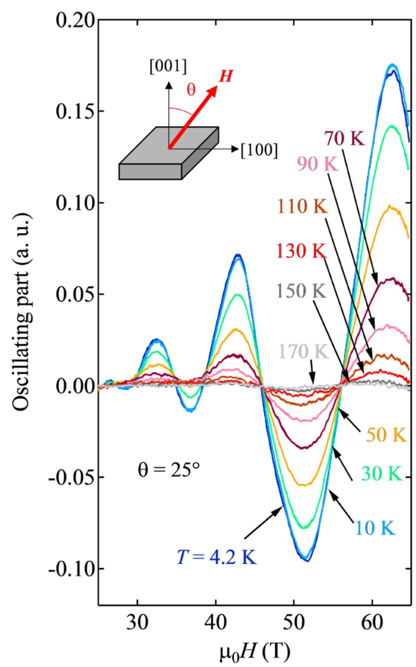

Fig.1 Oscillating part of torque signal of LaAlGe at various temperature. Magnetic field was applied along the direction 25º tilted from the [001] to [100]. The inset is a schematic showing the field direction and crystallographic axes.

Conclusions

We have measured the Fermi surface of Weyl semimetal LaAlGe by torque magnetometry technique. Further studies in magnetic *R*AlGe would provide the insight into the coupling of magnetism and topology in magnetic Weyl semimetals.

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References

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