Magnetotransport of the type-II Weyl semimetal $NbIrTe_4$

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Introduction

Weyl fermions in condensed-matter have attracted considerable interest. Type-I Weyl semimetal hosts an ideal Weyl cone with a closed point-like Fermi surface, whereas type-II Weyl points appear at the topologically protected touching points between electron and hole pockets with titled Weyl cones [1]. $TaIrTe_4$ is predicted to host only four well-separated Weyl points, the minimum imposed by symmetry, and the Fermi arcs connecting Weyl nodes extend to about 1/3 of the surface Brillouin zone, which was confirmed by ARPES measurements [2, 3]. However, the Weyl points locate above the Fermi surface, and barely affect the transport properties [4]. In contrast $NbIrTe_4$ is predicted to have 16 Weyl points with possible larger influence on electronic transport [5].

Experimental

Single crystals of $NbIrTe_4$ were grown by self-flux method, Magnetotransport and de Haas van Alphen (dHvA) cantilever measurements at high magnetic fields up to 35 T were conducted at the National High Magnetic Field Laboratory in Tallahassee.

Results and Discussion

Quantum oscillations were observed above 9 T. The beat patterns indicate multiple frequencies exist in $NbIrTe_4$, as shown in Fig. 1. The fast Fourier transform (FFT) spectra shows 6 frequencies which cluster into 3 groups. When compared to calculated Fermi surface, F_{E4} and F_{E5} can be attributed to hole-like pockets, and F_{H1} and F_{H2} can be attributed to electron-like pockets. From Onsager relations $F=(\Phi_0/2\pi^2)A_F$, where Φ_0 is the flux quantum and A_F is the orthogonal cross-sectional area of the Fermi surface, the Fermi surface parts detected by quantum oscillations are estimated to be 1.37 nm^{-2}, 2.74 nm^{-2}, and 3.97 nm^{-2}, corresponding to 1.6%, 3.2%, and 4.6% of the total area of the Brillouin zone in the ab plane. The effective mass and mobility of carriers in $NbIrTe_4$ suggest that the Fermi surfaces detected by quantum oscillation are not under significant influence of the Weyl points. The well-separated frequencies between F_{E4} and F_{E5}, F_{H1} and F_{H2} suggest that the spin-orbit coupling (SOC) is relatively strong in $NbIrTe_4$. Chemical substitution and shift of Fermi level is required to bring the Weyl nodes to the Fermi surface [6].

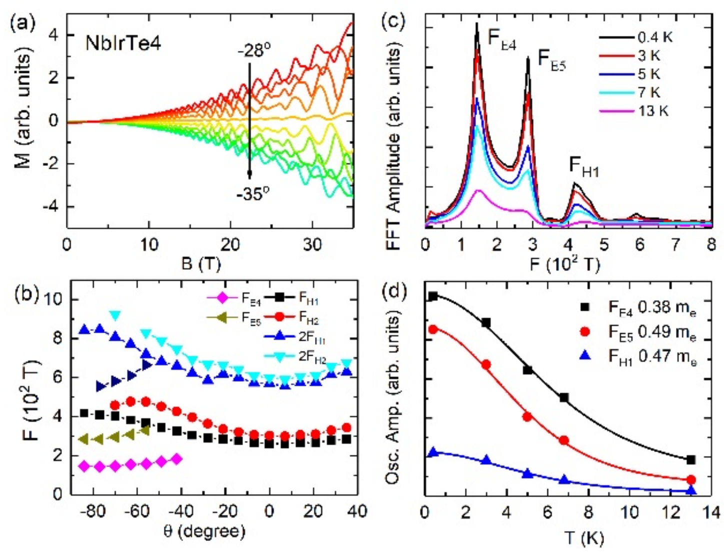

Fig.1 (a) Cantilever magnetization at various angles. (b) Angular dependence of the oscillation frequency. (c) Temperature dependence of the oscillation frequency. (d) Temperature dependence of oscillating amplitude.

Conclusions

Multiple bands are detected by dHvA measurement in $NbIrTe_4$. The effective mass and mobility detected by quantum oscillations are not under significant influence of Weyl points. Strong spin-orbit coupling effect was observed in dHvA measurements, whereas the temperature and angle dependence of quantum oscillation measurements reveal anisotropic multiband characteristics.

Acknowledgements

Work at Brookhaven was supported by the U.S. DOE under Contract No. DESC00112704. The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

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