Fermi Surface of Flat-Band Intermetallic APd_3 (A= Pb, Sn)

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Introduction

Recently, APd_3 (A = Pb, Sn) have been shown to be unusual dual topological Dirac semimetals. [1] There is a dispersionless band along the Γ−X line lying remarkably close to the Fermi level, E_F. A dramatic change in density of states (DOS) occurs in the vicinity of E_F, implying exotic transport properties. In addition, a few linear bands appear along the X−Γ−R−M lines near the E_F, suggesting topological states. We have synthesized large single crystals of $PbPd_3$, through both molten metal flux growth and Czochralski growth, and $SnPd_3$ by Czochralski growth method in order to reveal the Fermi surface experimentally through quantum oscillation under high field.

Experimental

Magnetoresistance and torque magnetometry measurements between 0.3 K and 70 K were performed at the NHMFL DC Field Facility using a He3 cryostat and the Hybrid 45 T magnet.

Results and Discussion

The geometry of the Fermi surfaces is revealed through the de Haas-van Alphen (dHvA) effect. [2] As shown in Fig.1, the α orbit can be associated to an “egg" like hole pocket and γ orbit for the large spherical electron pockets. The cubic β pocket near the Γ point only appears in $PbPd_3$. The cyclotron frequencies F, the background subtracted torque $\Delta\tau$ and the fast Fourier transform (FFT) amplitude for $\Delta\tau$ at different temperatures are shown in Figs. 1c-h.

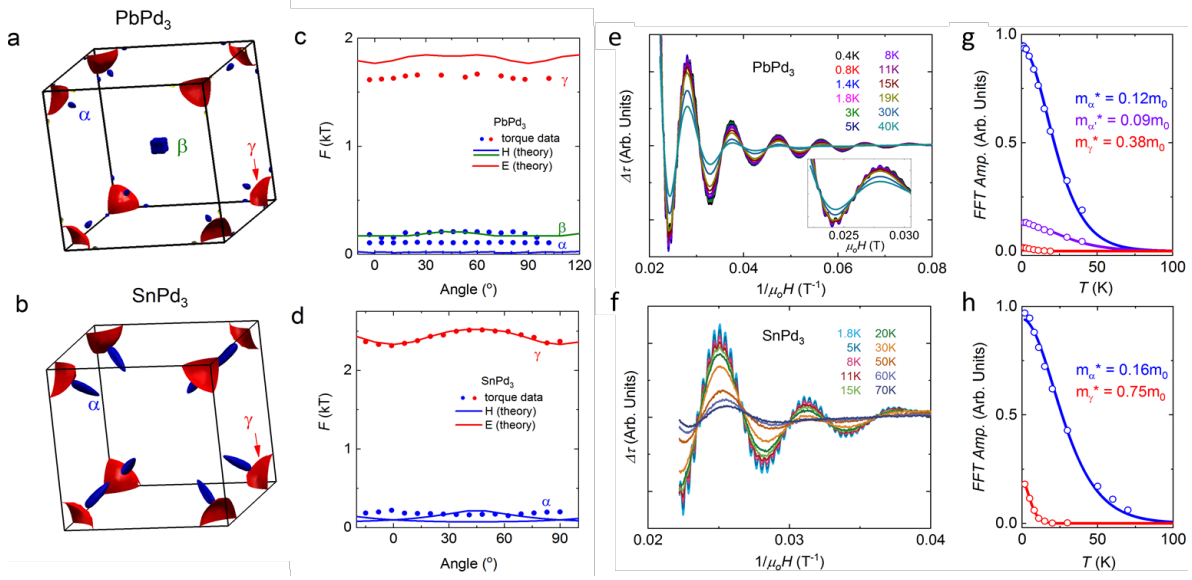

Fig.1 (a) and (b): Fermi surfaces of $PbPd_3$ and $SnPd_3$. Hole-like and electron-like pockets are depicted in blue and red, respectively. (c) and (d): the cyclotron frequencies F as functions of the angle θ relative to the crystallographic c axis. The solid dots represent the dHvA data and the lines are the theoretical prediction. (e) and (f): background subtracted torque $\Delta\tau$. (g) and (h): FFT for $\Delta\tau$ at different temperatures.

Conclusions

Through quantum oscillations in high fields we mapped the 3-D Fermi surface of APd3 and compared the electronic configurations they revealed experimentally with that from theoretical calculations. The E_F measured by dHvA oscillations is higher than the values predicted by DFT, 54 meV higher for $PbPd_3$ and 68 meV higher for $SnPd_3$, respectively. This result is of key importance to guide future studies focusing on accessing the surface states or the flat bands of these compounds through E_F manipulation.

Acknowledgements

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References

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[2] Wei, K., *et al.*, Phys. Rev. Lett., to be submitted.