Quantum Oscillation Evidence of Topological Semimetal Phase in ZrSnTe

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Introduction

The *WHM* - type materials (*W* = Zr, Hf, La; *H* = Si, Ge, Sn, Sb; *M* = O, S, Se, Te) materials represent a large family of topological semimetals, which provides an excellent platform to study the evolution of topological semimetal state with the fine tuning of spin-orbit coupling and structural dimensionality for various combinations of *W*, *H*, and *M* elements. In this work, through high field de Haas–van Alphen (dHvA) quantum oscillation studies, we have found evidence for the predicted topological nontrivial bands in ZrSnTe. Furthermore, from the angular dependence of quantum oscillation frequency, we have revealed the three-dimensional Fermi surface topologies of this layered material owing to strong interlayer coupling.

Experimental

We have synthesized ZrSnTe single crystals using Te-flux method, and carried out the de Haas-van Alphen (dHvA) quantum oscillation studies by using a 31T resistive magnet at NHMFL.

Results and Discussion

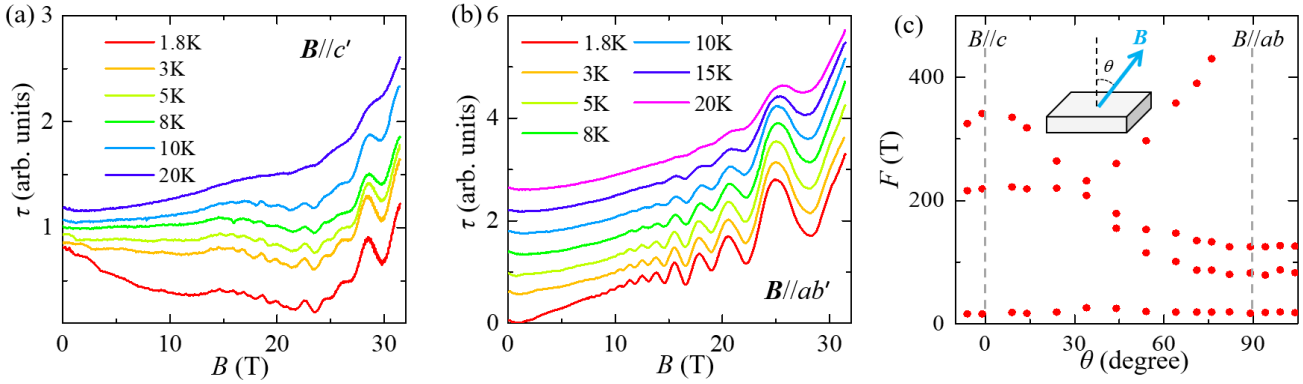

Fig.1 dHvA oscillations at different temperatures probed in magnetic torque measurements for ZrSnTe for magnetic field (a) nearly parallel to c-axis (B//c'), and (b) nearly in-plane (B//ab'). (c) Angular dependence of oscillation frequencies. Inset: schematic of measurement setup.

We have observed dHvA (Figs. 1a-1b) oscillations for ZrSnTe in magnetic torque measurements. Properties consistent with the predicted nodal-line states in these materials, including light effective mass, high quantum mobility, and non-trivial Berry phase have been probed. From the angular dependence of quantum oscillation frequencies, we found that the Fermi surface enclosing the nodal-line states in ZrSnTe displays clear 3D characters (Fig. 1c).

Conclusions

In conclusion, we have synthesized the single crystals of ZrSnTe and performed dHvA quantum oscillation studies. The analyses of dHvA quantum oscillation reveal properties consistent with the theoretically predicted bulk topological semimetal state. Our results not only provide complementary bulk characterization to the surface state probed by ARPES experiments, but also demonstrates that topological fermions can also be harbored by the Sn network. Owing to the strong interlayer coupling, the Dirac bands of ZrSnTe exhibit clear 3D nature despite its layered structure. The heavier effective mass and reduced quantum mobility seen in our analyses also sheds light on the effect of SOC on the Dirac bands in the WHM-type materials.

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References

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