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Fully gapped superconducting state in Au_2Pb: A natural candidate for topological superconductor

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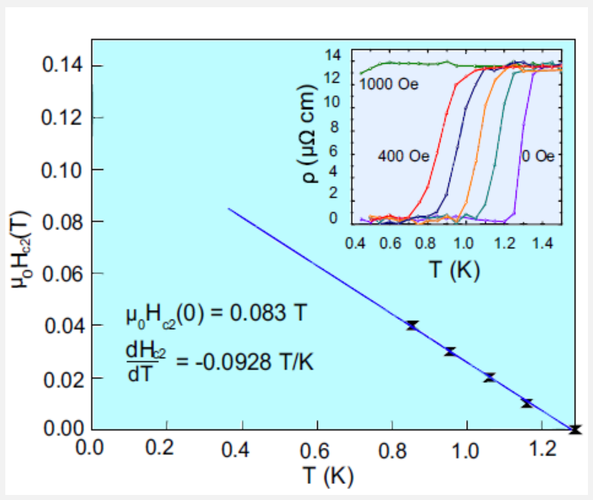
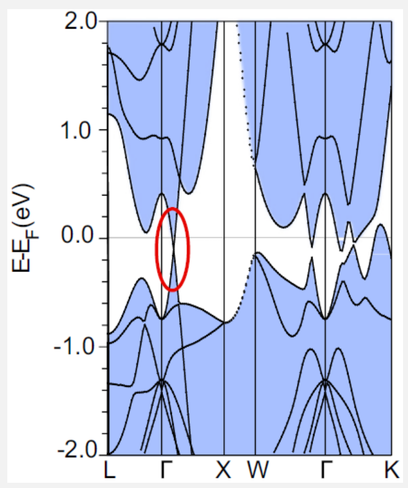
We measured the ultra-low-temperature specific heat and thermal conductivity of the Au_2Pb single crystal, a possible three-dimensional Dirac semimetal with a superconducting transition temperature $T_c \approx 1.05$ K. The electronic specific heat can be fitted by a two-band *s*-wave model, which gives the gap amplitudes $\Delta_1(0)/k_BT_c = 1.41$ and $\Delta_2(0)/k_BT_c = 5.25$. From the thermal conductivity measurements, a negligible residual linear term κ_0/T in zero field and a slow field dependence of κ_0/T at low field are obtained. These results suggest that Au_2Pb has a fully gapped superconducting state in the bulk, which is a necessary condition for topological superconductors if Au_2Pb is indeed one.

Introduction

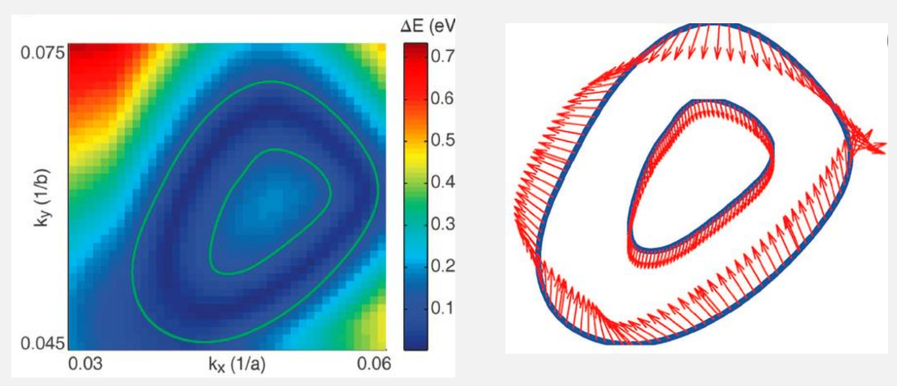
Recently, it was argued that the cubic Laves phase Au_2Pb ($T_c \approx 1.2$ K) may be a natural topological superconductor (TSC) candidate [1,2]. Electronic band structure calculations predicted that cubic Au_2Pb has a bulk Dirac cone at room temperature [1]. With decreasing temperature, Au_2Pb undergoes structural phase transitions, and only the orthorhombic phase remains below 40K [1]. Their calculations showed that the structure transition gaps out the Dirac spectrum in the high-temperature phase, and results in a low-temperature nontrivial massive 3D Dirac phase with $Z_2 = -1$ topology [1]. In ref. [2], the first principles calculations also point to the nontrivial topology of the orbital texture near the dominant Fermi surfaces, which suggests the possibility of topological superconductivity. To check whether Au_2Pb is indeed a TSC, it will be very important to determine its superconducting gap structure first.



Superconductivity occurs at $T_c \approx 1.4$ K and the critical fields show a linear temperature dependence [1].

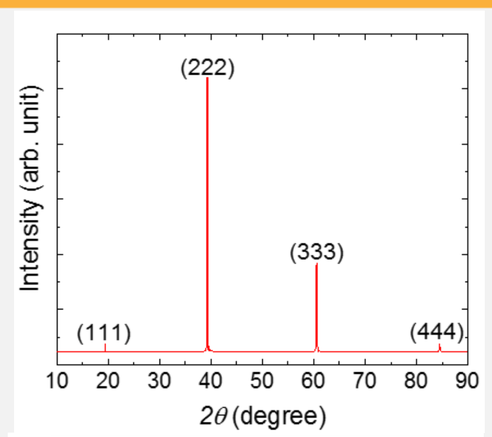


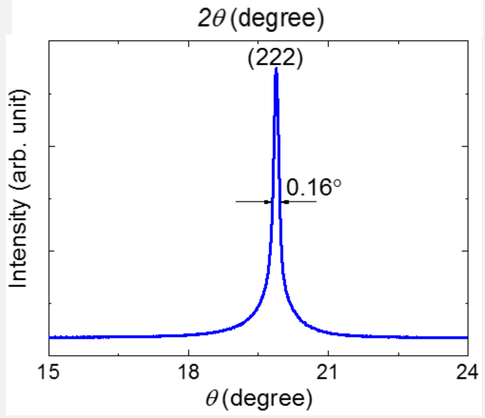
Electronic structure of high temperature cubic and low temperature orthorhombic Au_2Pb [1].



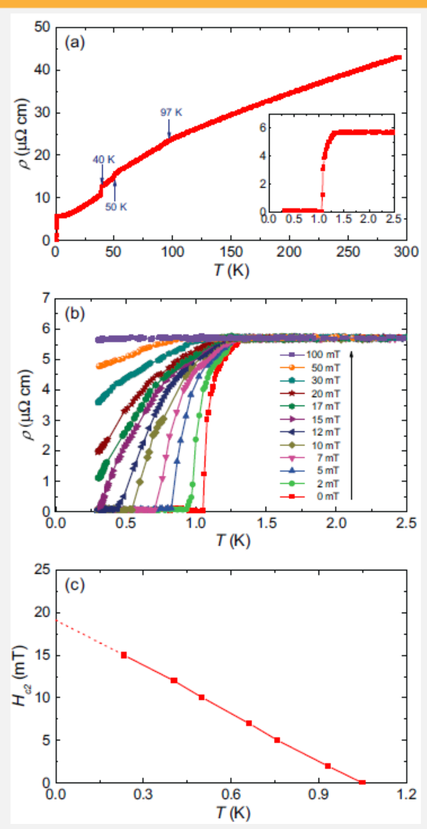
Orbital texture of the topological superconductor candidate Au_2Pb [2].

XRD and resistivity measurements



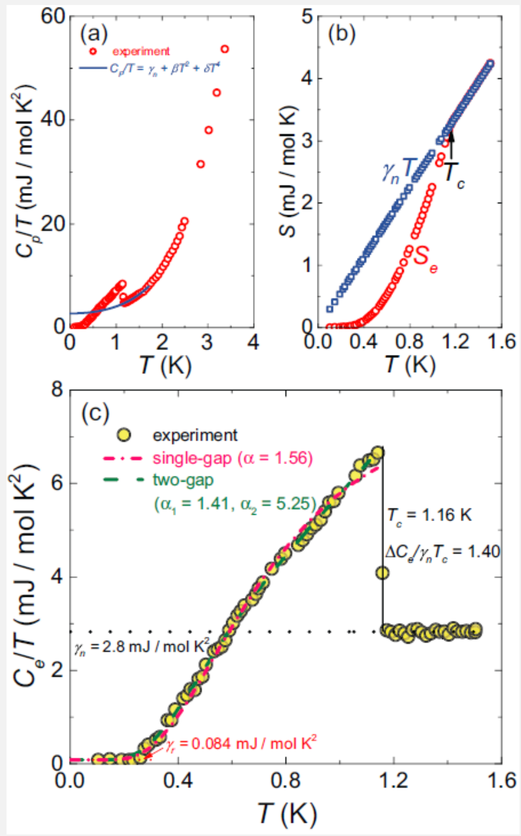


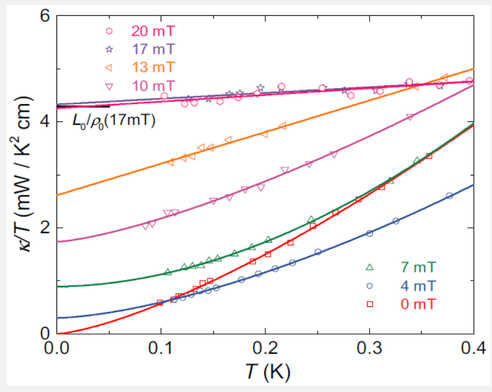
XRD measurements show high quality of our Au_2Pb single crystals.

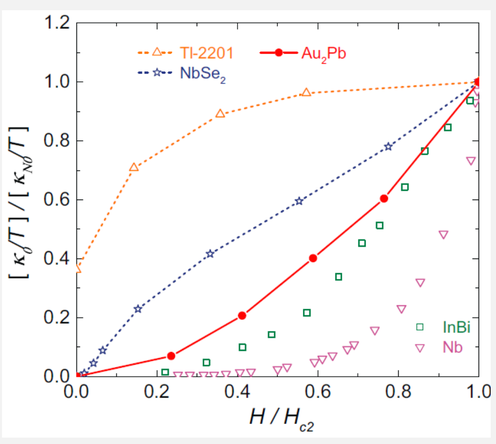


The structural and superconducting transitions are exhibited.

The study of bulk superconducting gap







- The electronic specific heat C_e/T extrapolates to a negligible value at ultra-low temperature, and can be fitted by a two-band *s*-wave model very well.
- The residual linear term κ_0/T is negligible and the normalized field dependence is somewhat like that of the dirty *s*-wave superconductor InBi.

Conclusions

- The ultra-low-temperature specific heat and thermal conductivity results have demonstrated that Au_2Pb is a fully gapped superconductor, which meets the condition of TSCs.
- The analysis of the electronic specific heat suggests a multigap characteristic in Au_2Pb.

References

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