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Nodeless superconducting gaps in 2M-WS_2 with topological surface states

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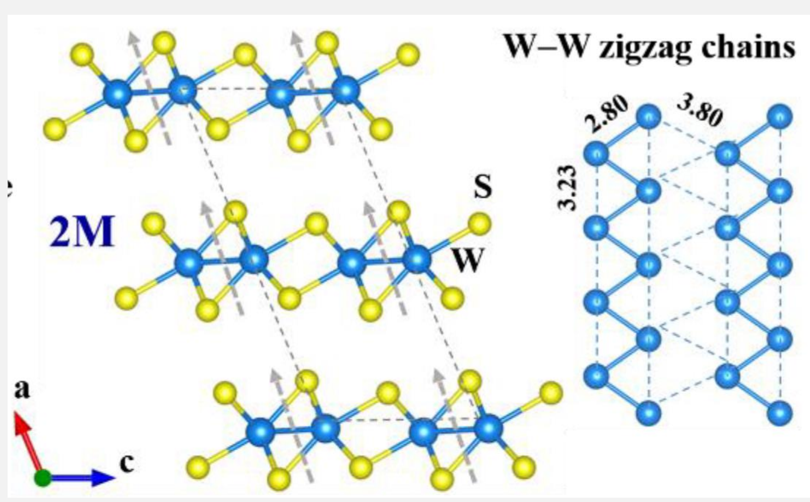
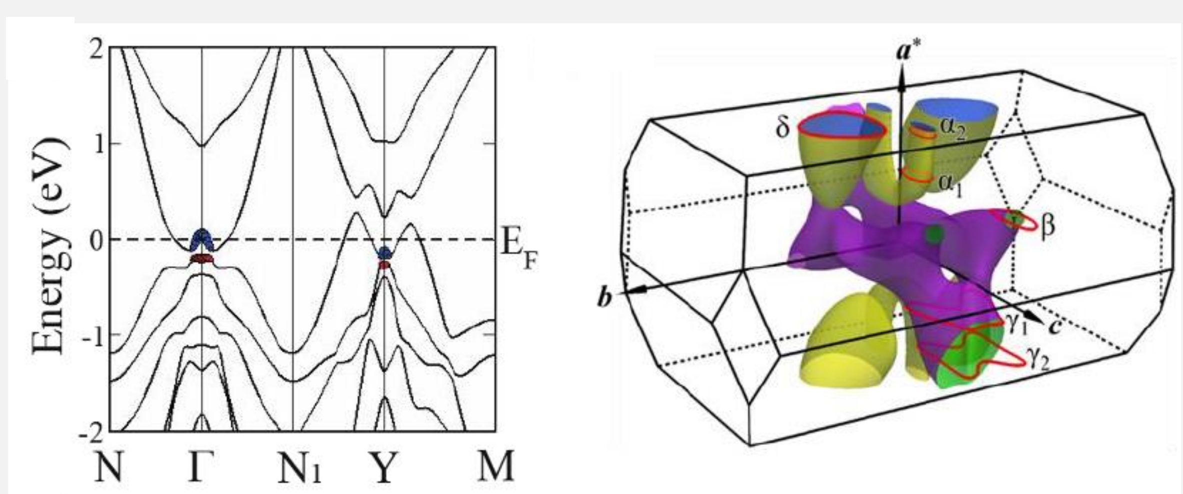
Low-temperature thermal conductivity measurements were performed on single crystal of 2M-WS_2, a new superconductor in isostructural 1T-MX_2 material with the robust topological surface appear on the (100) surface. It is found that the residual linear term κ_0/T is negligible in zero magnetic field and a slow field dependence of κ_0/T is obtained. These results suggest that bulk 2M-WS_2 has nodeless superconducting gaps, which is a necessary condition for topological superconductors if 2M-WS_2 is indeed one.

Introduction

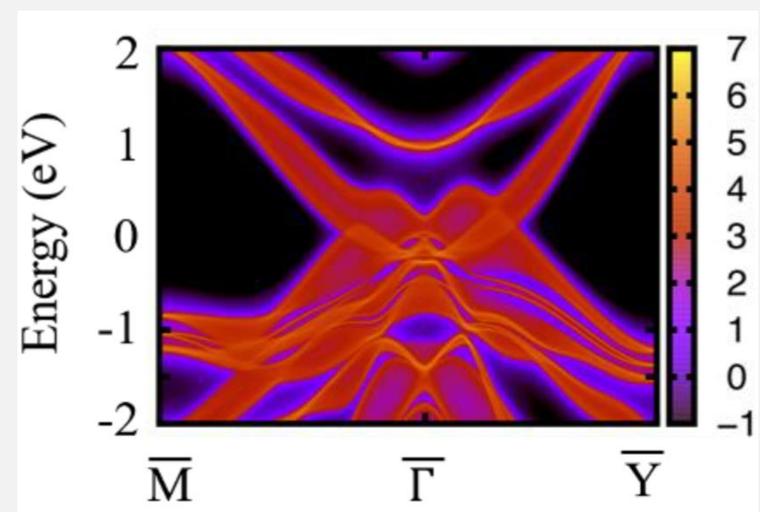
Recently, a new monoclinic compound of WS_2, which is labelled as the 2M phase, was synthesized. The crystal structure of 2M-WS_2 has a different packing manner of 1T'-WS_2 monolayers along a axis, compared with the known T_d-WTe_2 or 1T'-MoT_2. The 2M-WS_2 displays the intrinsically highest superconducting transition temperature T_c of 8.8 K among all the transition metal dichalcogenides (TMDs) materials. Moreover, the results from the first principles calculations reveal that the robust topological surface states exist on the (100) surface, which is completely different from topological Weyl semimetals previously discovered in T_d-$MoTe_2$ and T_d-WTe_2, Therefore, 2M-WS_2 is a promising candidate for the new topological superconductor (TSC)[1]. To check whether 2M-WS_2 is indeed a TSC, it will be very important to determine its superconducting gap structure first.



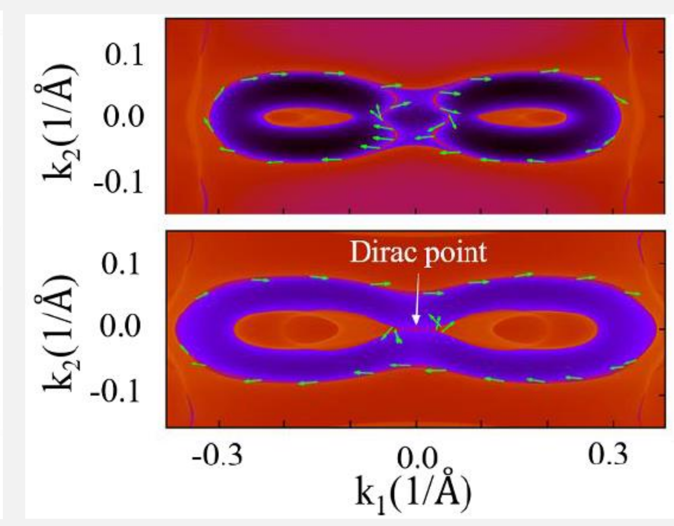
The crystal structures of 2M-WS_2 [1].



Band structure with spin orbit coupling and the 3 dimensional Fermi surfaces of bulk states indicate the coexisting of hole and electron pockets[1].

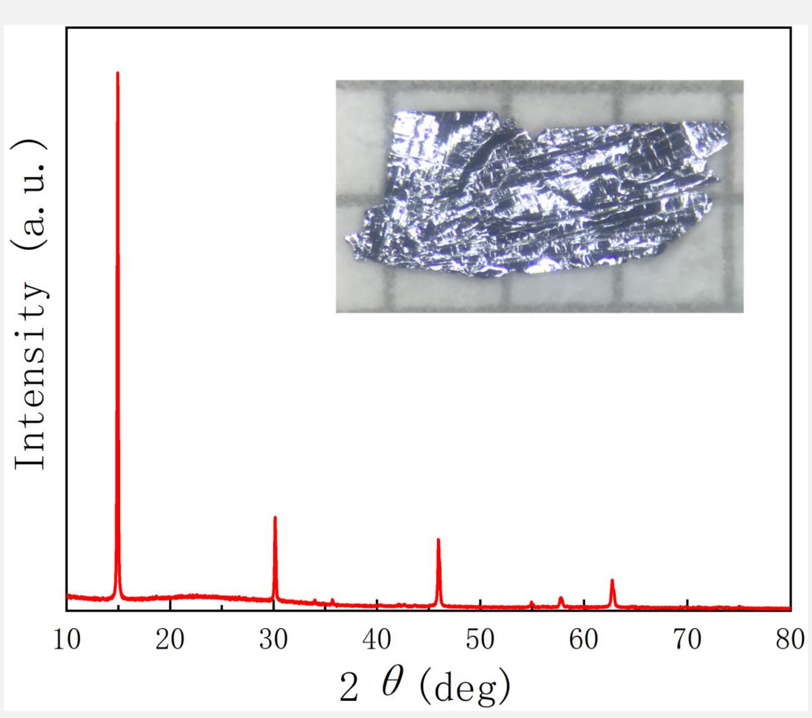


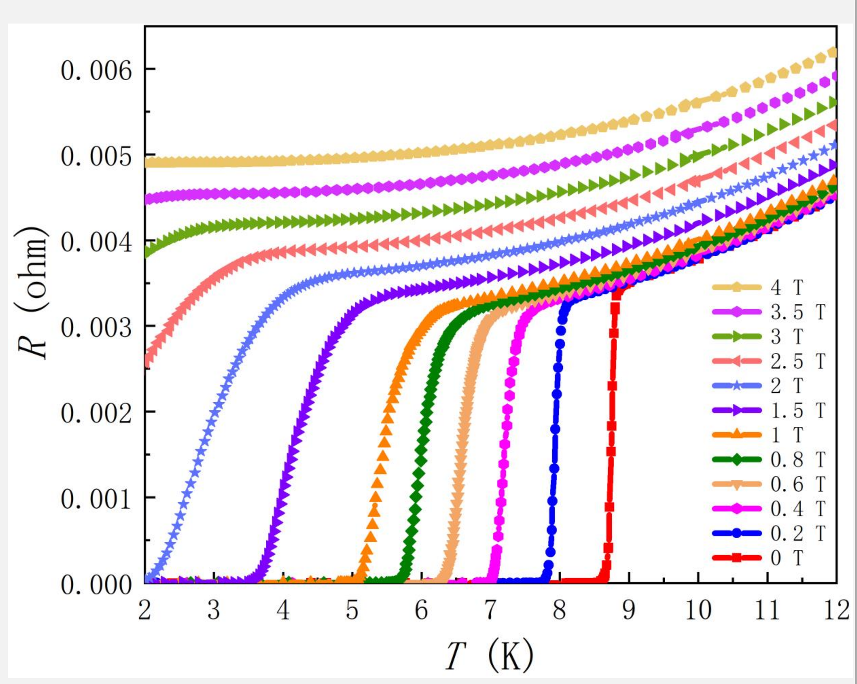
The surface states are projected to the (100) surface[1].

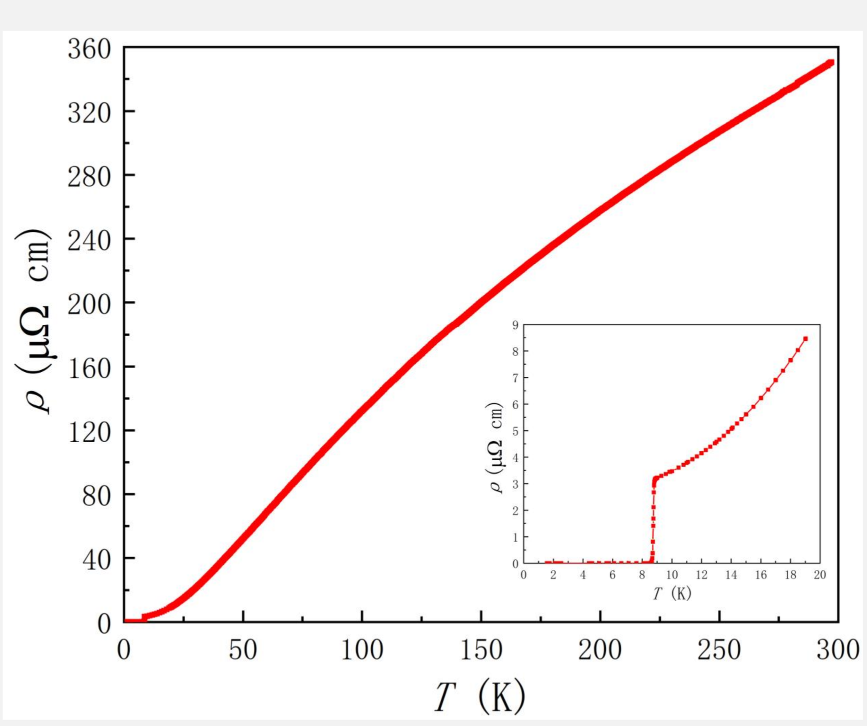


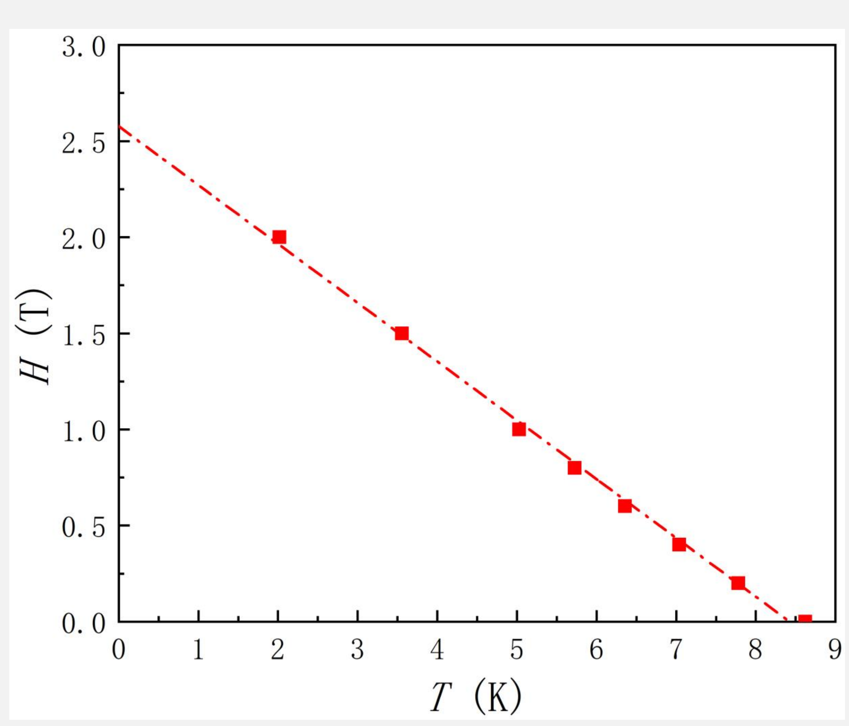
The Fermi surface at the energy level E1 and at the energy level of Dirac point [1].

XRD and resistivity measurements





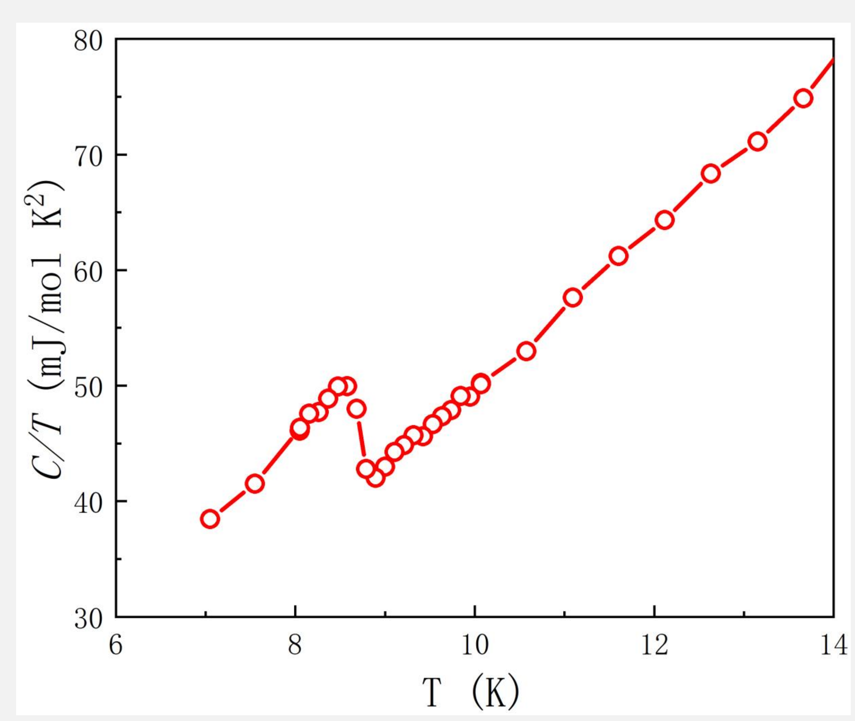


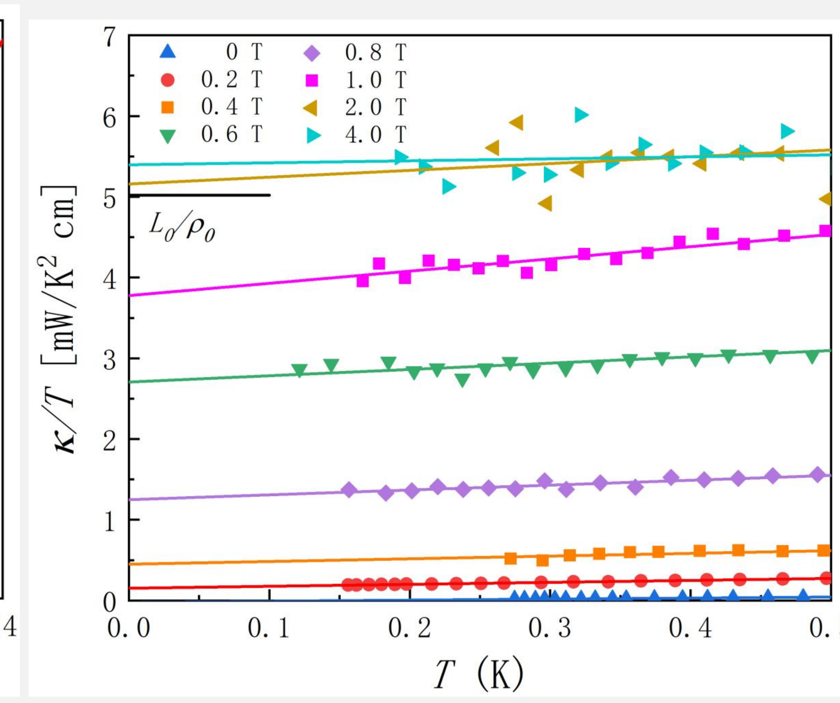


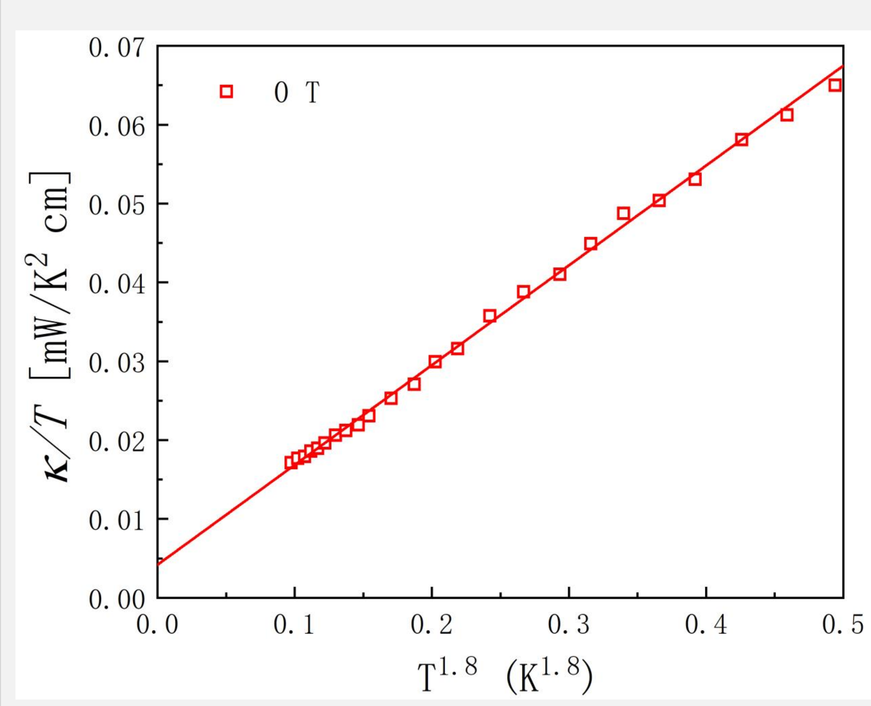
XRD pattern and temperature dependence of the resistivity in zero field for the 2M-WS_2 single crystal.

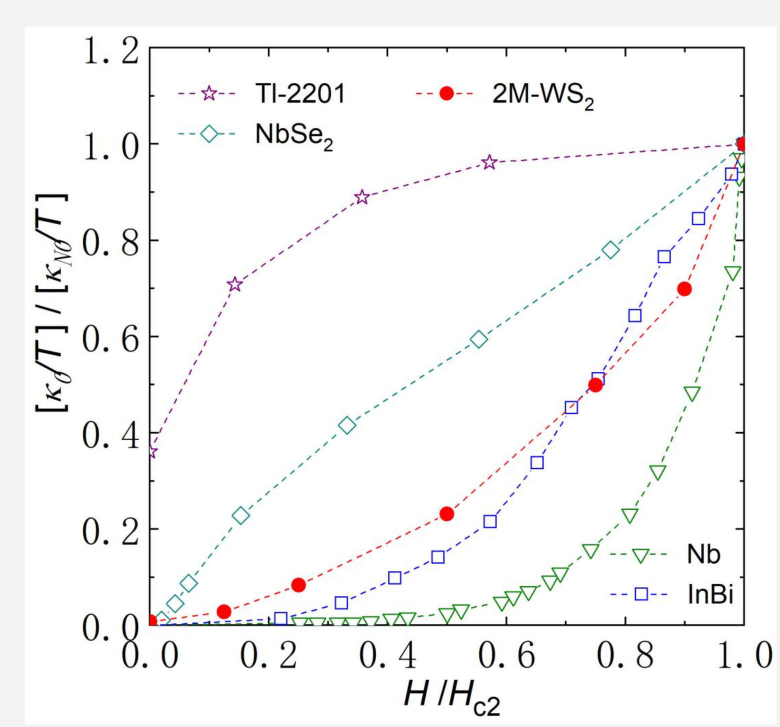
The superconducting transitions and temperature dependence of the upper critical field H_{c2} are exhibited.

The study of bulk superconducting gap









The negligible κ_0/T at zero field and the slow field dependence of κ_0/T at low field suggest a nodeless superconducting gap. In case that it is in the clean limit, such a κ_0/T behavior may result from multiple superconducting gaps.

Conclusions

The ultra-low-temperature thermal conductivity results have demonstrated that 2M-WS_2 is a fully gapped superconductor, which meets the condition of TSCs.

References

[1] Yuqiang Fang *et al.*, *Adv. Mater.* **2019**, 1901942.

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