Supplementary Materials to Nodeless Superconductivity and its Evolution with Pressure in the Layered Dirac Semimetal 2M-WS_2

I. BAND TOPOLOGY

In Fig. 4 of the main manuscript we showed the band structures of 2M-WS_2 under different pressures including spin-orbit coupling. It was indicated in Ref. [1] that at Γ point the band inversion occurs between the conduction band composed of d orbitals of W atom and the valence band having mostly p orbital character from S atom. While we confirm the topological indices (i.e., the parity of inversion eigenvalues of the valence bands at each inversion symmetric momentum), we note that the orbital composition of the topmost valence bands changes at the Γ point upon relaxing the structure. As a consequence, the band inversion at the Γ is harder to identify from the orbital composition of the bands.

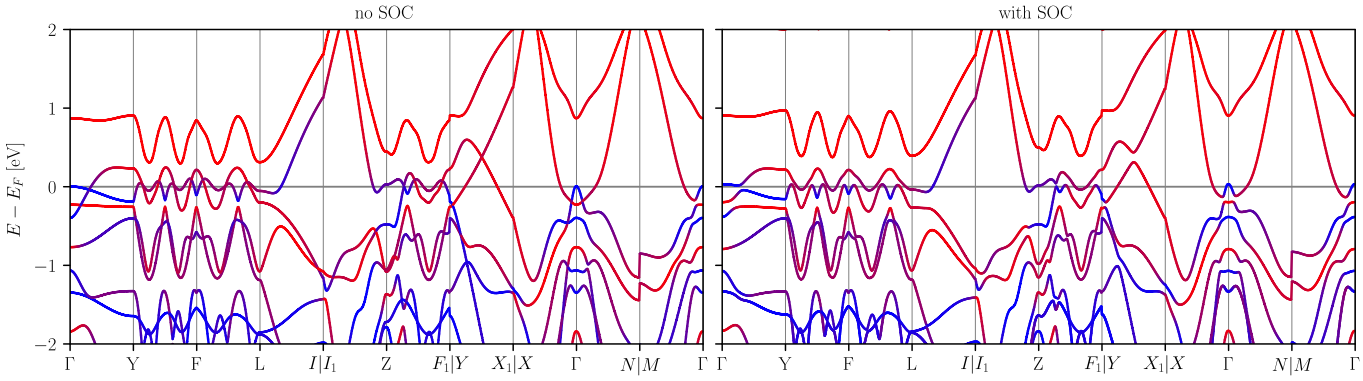

Fig. S 1. **Electronic structure of 2M-WS_2.** Band structures of 2M-WS_2 at ambient pressure without relaxation. Band inversion between the conduction and the valence bands is observed.

To support our claim, we compute topological indices using Fu-Kane formula

$$(-1)^{\nu_0} = \prod_{i \in \mathrm{TRIM}} \delta_i;\ (-1)^{\nu_1} = \delta_2\delta_4\delta_6\delta_8;\ (-1)^{\nu_2} = \delta_3\delta_4\delta_7\delta_8;\ (-1)^{\nu_3} = \delta_5\delta_6\delta_7\delta_8.$$

The products of parity eigenvalues of occupied bands at time-reversal invariant momenta (TRIM) are listed in Table I. We point out that non-trivial $\mathbb{Z}_2$ topological index remains stable within the range of pressures investigated in the main text.

Γ (000)	N (π00)	N_1 (0π0)	L (ππ)	M (π0π)	Y (ππ0)	Y_1 (0ππ)	Z (00π)	$(\nu_0;\nu_1\nu_2\nu_3)$
-	+	+	+	+	+	+	+	(1;000)

TABLE I. Product of parity eigenvalues at TRIMs and topological indices.

II. MAGNETIZATION

We measured the zero field-cooled (ZFC) and field-cooled (FC) magnetic moment in an applied magnetic field of $\mu_0 H = 1$ mT. The results are shown in Fig. 2, giving evidence for relatively sharp superconducting onset at 8.5 K as indicated by a solid arrow. The value of ZFC moment at 1.8 K corresponds to 100 % volume fraction of superconductivity. The strong diamagnetic signal below T_c is consistent with bulk superconductivity in 2M-WS_2.

The field dependence of the magnetic moment of 2M-WS_2 was studied at the base temperature $T = 1.8$ K for external magnetic fields up to $\mu_0 H = 4$ T and shown in Fig. 3b. The inset demonstrates that the initial flux penetration and the deviation from linearity determine the lower critical field of this compound $\mu_0 H_{c1} \sim 50$ mT. The second critical field was estimated to be: $\mu_0 H_{c1} \sim 3$ T.

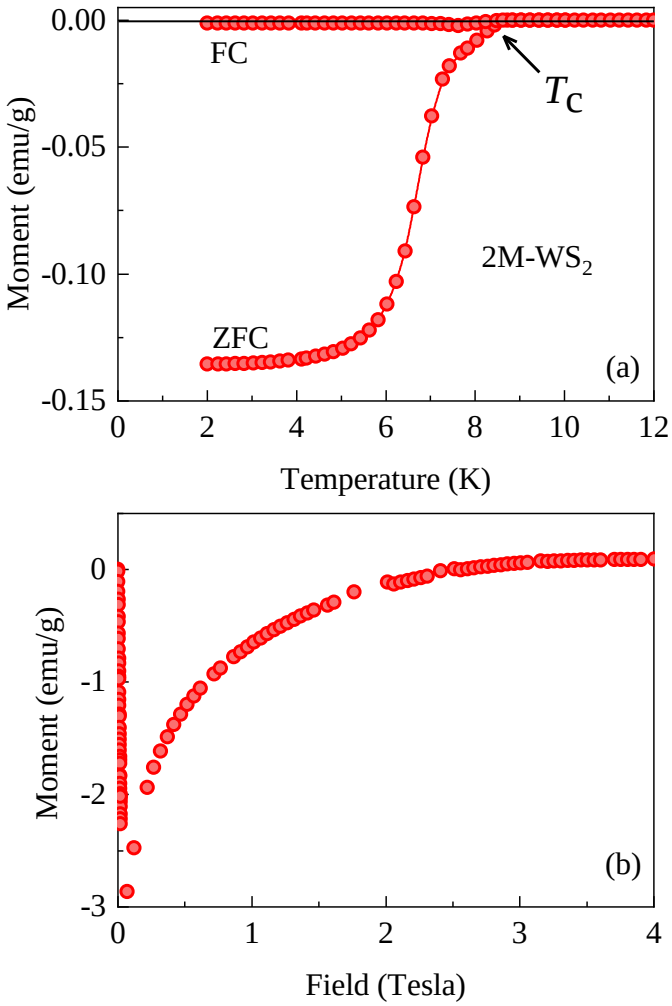

Fig. S 2. **Magnetization measurements for 2M-WS$_2$.** The temperature dependence of the ZFC and FC magnetization of 2M-WS$_2$ in a magnetic field of $\mu_0 H = 1$ mT. The arrow denotes the superconducting transition temperature T_c. (b) Field dependence of the magnetic moment at $T = 1.8$ K in an applied field up to $\mu_0 H = 4$ T.

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[1] Yuqiang Fang, Jie Pan, Dongqin Zhang, Dong Wang, Hishiro T. Hirose, Taichi Terashima, Shinya Uji, Yonghao Yuan, Wei Li, Zhen Tian, Jiamin Xue, Yonghui Ma, Wei Zhao, Qikun Xue, Gang Mu, Haijun Zhang, Fuqiang Huang. Coexistence of Intrinsic Superconductivity and Topological Insulator State in Monoclinic Phase WS$_2$. arXiv:1808.05324 (2018).