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Superconducting topological surface states in non-centrosymmetric bulk superconductor $PbTaSe_2$

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Topological superconductors (TSC) can host Majorana fermions and supersymmetric particles in condensed matter systems. However, a stoichiometric bulk material exhibiting both nontrivial topological surface states (TSS) at EF and fully gapped bulk superconductivity, both are key ingredients for realizing TSC, is still lacking. Here, we report a comprehensive study on the crystalline, electronic structures and the superconducting state of the non-centrosymmetric superconductor, $PbTaSe_2$ by scanning transmission electron microscopy (STEM), spectroscopic imaging-scanning tunneling microscopy (SI-STM) and density functional theory (DFT) calculations. Our results reveal two TSS with Dirac point at E~1.0eV on Pb-terminated surface by quasiparticle scattering interference (QPI) imaging. In the superconducting state, TSS and bulk bands open a single full gap. Our observation of a superconducting gap opening in the TSS demonstrates that stoichiometric $PbTaSe_2$ is a promising candidate for TSC.