



Ultrahigh supercurrent density in a two-dimensional topological material



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Since the discovery of superconductivity by Heike Kamerlingh Onnes in 1911, superconductors have revolutionized science and technology through numerous applications ranging from high-field magnets to superconducting qubits. High-field magnets, fabricated from superconductors with high critical current density, have enabled scientific discoveries across the physical, chemical, and biological sciences. New superconducting materials that exhibit topological properties offer additional technological possibilities beyond present-day applications, opening a new frontier to implement fault-tolerant quantum information technologies.

MagLab users discovered an unprecedentedly high superconducting critical current density (17MA/cm² at 0T) in atomically thin 1T'-WS₂, exceeding those of all two-dimensional superconductors reported to date. It was also discovered that 1T'-WS₂ features a strongly anisotropic superconducting state that is not only anisotropic with regard to in-plane and out-of-plane orientation of the magnetic field, but also within the two dimensional plane. To measure these anisotropies, the sample was rotated around different two axes with respect to the applied field direction. The maximum in-plane critical field was found to approach 30T, which violates the Pauli paramagnetic limit by a factor of two, signaling the presence of unconventional superconductivity.

Even under an 8T in-plane magnetic field, the J_c of 1T'-WS₂ is large (7MA/cm²). By comparison, critical current densities of commercial magnet building materials are much smaller: Nb-Ti alloy is 0.1MA/cm² at 10T and Nb₃Sn is 0.5MA/cm² at 10T. The large J_c at zero and finite magnetic fields makes 1T'-WS₂ a candidate for future study on building next-generation superconducting magnets.

Facilities and instrumentation used: 41 Tesla Resistive Magnets (Cell 6).

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