Observation of ring states in a delicate topological insulator

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Topological insulators are typically characterized by particularly stable properties, such as global invariants, and can be identified by probing their robust surface states. A recently discovered novel form of band topology, delicate topology, challenges this paradigm: its defining property, multicellularity, can be removed by introducing a coupling to local orbitals anywhere in the spectrum, even far above the relevant band gap. This makes it hard to diagnose delicate topology with conventional probes that access only low-energy degrees of freedom. Here, we introduce strong local impurities as a spectroscopic probe of a delicate topological insulator which we realize in a phononic metamaterial. By tuning the impurity strength and performing orbital-resolved readout, we observe recently proposed indicators of topology: ring states, in-gap bound states whose frequencies remain pinned in the strong-impurity limit while their real-space profiles form a pronounced ring around the impurity site. We find that these ring states persist even when the multicellularity in our system is removed by a weakly hybridizing additional orbital. Our results establish impurity-induced ring states as probes of complex multiband physics, including delicate topological phases.