Directly Imaging Heavy Surface States within the Insulating Gap of the Strongly Correlated Topological Insulator SmB_6

Harris Pirie,[1,2] Yang He,[1] Michael Yee,[1] Dae-Jeong Kim,[3] Zachary Fisk,[3] Dirk Morr,[4] Mohammad H. Hamidian,[1,5] and Jennifer Hoffman[1]

[1] *Department of Physics, Harvard University, Cambridge, MA, USA*
[2] *Department of Physics & Astronomy, University of British Columbia, Vancouver, BC, Canada*
[3] *Department of Physics and Astronomy, University of California, Irvine, CA, USA*
[4] *Department of Physics, University of Illinois, Chicago, IL, USA*
[5] *Department of Physics, University of California, Davis, CA, USA*

The extremely successful description of topological insulators in the past several years is based on the theory of non-interacting fermions. Among the achievements of the theory have been predictions of the quantum spin Hall and anomalous quantum Hall effects, Dirac-like chiral surface states that carry information of a Z_2 topological invariant, and a complete classification of the non-interacting topological insulators. However, the next generation of topological quantum matter will harness strong electron interactions with aims to generate exotic topological orders, fractional quasiparticles, non-abelian statistics, and platforms for quantum computation.

SmB_6 is a strongly-correlated electronic material in which interactions generate an insulating state whose gap arises from heavy fermion hybridization of low lying *f*-states with a Fermi sea. Predictions of SmB_6 as a candidate strongly-correlated topological insulator have recently been supported by transport, quantum oscillation, and spin-resolved ARPES experiments showing surface states near the chemical potential. However, because of the narrow energy scales harboring all of the active correlated physics, the essential features of the bulk and surface states that identify their topological progeny have not yet been observed.

Using spectroscopic imaging STM to probe real and momentum space structure, our measurements on SmB_6 first reveal the temperature dependent evolution of the insulating gap from heavy fermion hybridization, clearly revealing the *k*-space structure changes responsible for the long observed transport anomalies at higher temperatures. Within the narrow gap, we then directly image the structure of a heavy dispersing surface state that converges to a Dirac point very close to the chemical potential, in excellent agreement with theories predicting a topological origin from strong interactions.