Chez Pierre

Presents ...

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MIT Room 4-331

Special Chez Pierre Seminar

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"Atomic-scale Visualization of Topologically Emergent States in Correlated Quantum Matter"

Discovery of topological insulators has sparked a movement to harness the topological properties of quantum matter, all within a framework of non-interacting fermions. The ultimate target, however, is to engineer electronic systems with *topological order*, possessing non-trivial ground state degeneracies, long-range entanglement, fractionalized excitations, and non-Abelian statistics. Electronic correlations will be a key ingredient in constructing these exotic quantum phases thus directing the search towards strongly interacting topological systems.

The Kondo insulator SmB_6 has recently emerged as a promising candidate in the search for correlated topological matter. Predictions of a correlation-driven gap protecting a bulk topological invariant anticipate the emergence of surface modes that entangle with localized *f*-electrons , spawning heavy Dirac fermions. To address the topological nature of SmB_6 we use heavy-fermion quasiparticle interference imaging (QPI) [1] and co-tunneling spectroscopy to directly map out the electronic structure. On cooling, we observe the opening of a Kondo insulator gap that expanded to $\Delta^* \approx 10$ meV at 2 K, in agreement with bulk sensitive experiments. Within the gap, momentum-space imaging reveals flatly dispersing Dirac surface states with effective masses reaching $m^*=(330\pm20)m_e$. Collectively, these data provide the first visualization of a correlated topological phase hosting the heaviest known Dirac fermions [2].

Looking forward, the search for exotic phases in quantum materials and devices will require advances in atomic-scale electronic structure visualization techniques. I will briefly present next-generation technologies including scanning Josephson tunneling microscopy [3], to directly image Cooper-pair condensates and their quantum phases, as well as shot noise microscopy to map out electron fractionalization and correlations. Their integration with modern material synthesis methods will enable detailed microscopic exploration of novel electronic systems to discover fundamentally new states of nature.

[1] Nature 466, 374 (2010)
[2] Under Review (2018) – Preprint Available Upon Request
[3] Nature 532, 343 (2016)