Unconventional Charge Transport in a Kondo Insulator, YbB_{12}

Z. Xiang[1,2], K.-W. Chen[1], L. Chen1, T. Asaba[1,3], Y. Sato[3], N. Zhang[2], D. Zhang[1], Y. Kasahara[3], F. Iga[4], W. Coniglio[5], Y. Matsuda[3], J. Singleton[6], Lu Li[1],

1. University of Michigan, 2. University of Science and Technology of China, 3. Kyoto University, 4. Ibaraki University, 5. NHMFL FSU, 6. NHMFL LANL

Funding Grants: Lu Li (NSF DMR-1707620, NSF DMR-2004288, DOE DE-SC0020184) G.S. Boebinger (NSF DMR-1644779)

Kondo insulators are a class of electrical insulators in which strong interactions between electrons in different energy levels open up a band gap at low temperatures. YbB_{12} is a Kondo Insulator that is thought to posses topologically protected quantum states that allow it to display characteristics of *both* a metal and an insulator.

Using the magnetic fields provided by the 45T Hybrid, 65T pulsed and 73T Duplex magnets, MagLab users measured quantum oscillations and phase transitions in YbB_{12} in magnetization, resistance and Hall effect. *These data revealed the coexistence of relatively ordinary electrons and novel charge-neutral quasiparticles. The surprising suite of observed physical properites results from scattering between the two cohabiting fermion fluids*.

The data show that the charge-neutral quasiparticles behave like Fermi-liquid states, responding to magnetic fields in a way resembling that of electrons in regular metals such as copper. On the other hand, the "ordinary" electrons act as a non-Fermi liquid, a groundstate sometimes seen in exotic systems like high-temperature superconductors. *These observations verify that a very unusual two-fluid state exists in YbB_{12}, resolving a vexing, five-year-long paradox as to how an insulator can behave like a metal in high magnetic fields and supporting the notion that this constitutes a new phase of matter*.

Facilities and instrumentation used: 45T DC Hybrid magnet, 65T pulsed magnets and the 73T pulsed Duplex magnet.

Citation: Xiang, Z.; Chen, K.; Chen, L.; Asaba, T.; Sato, Y.; Zhang, N.; Zhang, D.; Kasahara, Y.; Iga, F.; Coniglio, W.A.; Matsuda, Y.; Singleton, J.; Li, L., *Hall Anomaly, Quantum Oscillations and Possible Lifshitz Transitions in Kondo Insulator YbB12: Evidence for Unconventional Charge Transport,* Physical Review X, **12**, 021050 (2022) doi.org/10.1103/PhysRevX.12.021050

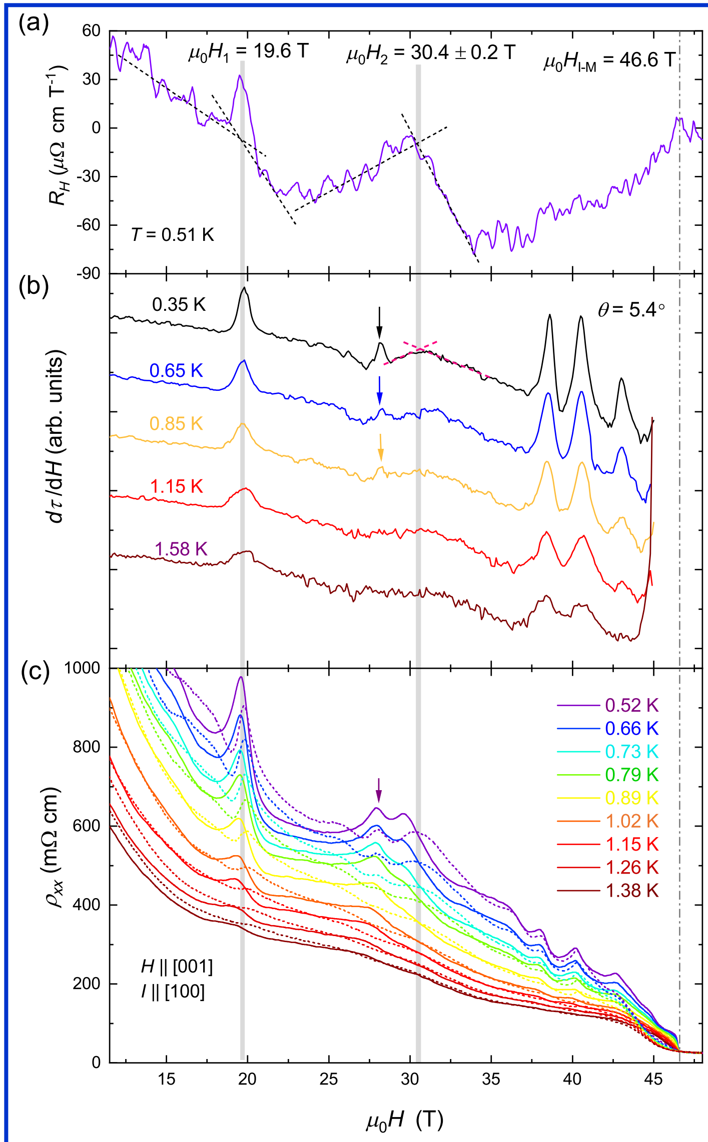

Figure: A comparison of (a) Hall effect, (b) magnetic torque, and (c) electrical resistivity in the Kondo insulator YbB_{12} confirms that quantum oscillations and phase transitions show up in all three physical measurements at the same magnetic fields.

This allows phenomena that arise from the coexisting populations of neutral fermions and "conventional" electrons to be identified.