Magneto-Quantum Oscillations in the Specific Heat of a Topological Kondo Insulator

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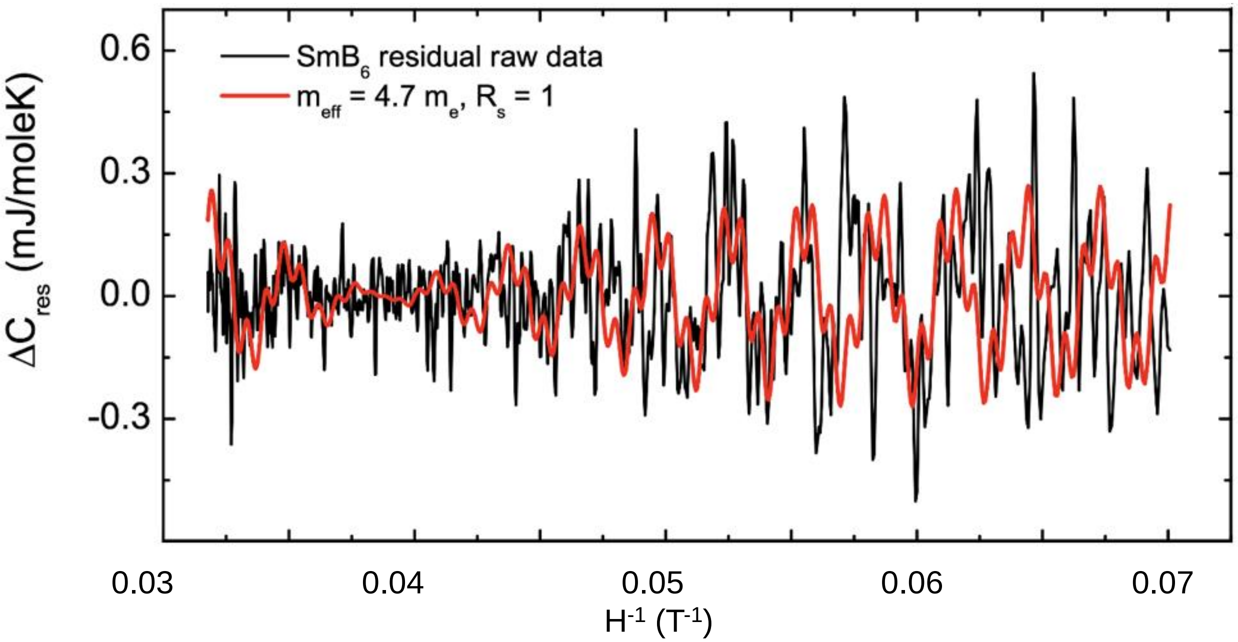
Quantum oscillations have long been observed in metals where the electron orbits on the fermi surface are quantized by the magnetic field. These oscillations have been usually detected by changes in the magnetization as de Haas-van Alphen effect (dHvA) or in the resistance as Shubnikov-de Haas effect (SdH). It is surprising, however, to observe such oscillations which are characteristic of a metal in an insulator such as SmB_6. A debate has arisen in the community as to whether these magneto-quantum oscillations are an *extrinsic effect* arising from rare-earth impurities, defects, and/or aluminum inclusions or an *intrinsic effect* revealing the existence of charge-neutral excitations in the bulk insulator.

To address this question, we have measured the low temperature specific heat of both LaB_6 and SmB_6 using custom-built rotatable micro- and nano-calorimeters. The quantum oscillation frequency and size of the fermi surface were mapped as a function of angle so that we could obtain a complete picture. ***The frequency and amplitude of the oscillations has ruled out impurities and inclusions (extrinsic factors) for this effect, establishing the existence of charge neutral excitations in the bulk of the insulator (intrinsic factors) as the source of the quanum oscillations.*** In addition, application of the Lifshitz–Kosevich (L–K) theory to determine the effective mass (a measure of interaction strength) of these excitations results in an unexpectedly heavy mass of $4.7m_e$ as shown in the figure. At lower temperatures and other orientations this value can reach $6.6m_e$. The MagLab's unique combination of 31T resistive magnet and the 32T superconducting magnet with a dilution refrigerator, single-axis rotators along with staff expertise made it possible for us to calorimetrically investigate fermi liquid-like (metallic) excitations in an insulating system.



Residual specific heat vs inverse magnetic field (H^{-1}) at T=0.58K and Φ=45°. The red curve is a comparison of the data to a fit of the L-K model using an effective mass of $4.7m_e$ determined from the node in the oscillatory specific heat and the two frequencies of oscillation (341 tesla and 1399 tesla) identified from the Fourier power spectrum at this orientation.

Facilities and instrumentation used: DC field Facility. Heat capacity measurements in Cell 9 resistive and 32 tesla all superconducting magnet.

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