Heat capacity through the magnetic-field-induced resistive transition in an underdoped high-temperature superconductor

Scott C. Riggs, O. Vafek, J. B. Kemper, J. B. Betts, A. Migliori, F. F. Balakirev, W. N. Hardy, Ruixing Liang, D. A. Bonn, and G. S. Boebinger

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Specific heat, a thermodynamic probe, is the amount of energy required to raise one mol of a material by one Kelvin. In YBCO 6.55, a high temperature superconducting material with unique magnetic properties, the application of an applied magnetic field changes the materials specific heat. The functional form of the change reveals important information as to the nature of superconductivity in this material.

Taking advantage of the Hybrid magnet revealed that the specific heat, displayed in the top panel, is proportional to the square root of the applied magnetic field, from zero to 45 Teslas. The continuous evolution of the square root behavior demonstrates that superconductivity is completely unaffected, even through the magnetic field regime where the system becomes resistive, at magnetic fields above H_{irr}. The specific heat also finds quantum oscillations that are quantitatively consistent with ordinary quasi-particles in a Fermi liquid over a wide range of temperature and magnetic field. Lower panel A is a simple single band model for quantum oscillations in specific heat with a frequency of 531T and an effective mass of 1.35 electron masses. Panels B,C demonstrate cuts in the magnetic-field and temperature phase space where data were taken. Our thermodynamic measurements demonstrate, up to 45T, the coexistence of vortices, i.e. local superconductivity with quasi-particle oscillations that are consistent with a Fermi liquid.

This experiment took advantage of the NHMFL's on site theorists. The previous night's data were analyzed and discussed thoroughly each morning, allowing the users to pinpoint critical areas of the temperature-magnetic field phase space to focus on during the allotted magnet time.

Facility Used: Cells 15, 12 of NHMFL, and 50T mid-pulse magnet of LANL.
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