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Log(1/T) flux-flow resistivity: a dynamical signature of vortices in cuprate superconductors

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High magnetic fields have played a key role in extending our understanding of the normal state of the cuprate superconductors to low temperatures. Early pulsed-field measurements, by Ando and Boebinger, revealed a transition in the underdoped regime to a state in which resistivity increases with decreasing temperature, with a puzzling log(1/T) form. Recent quantum oscillation studies have provided a wealth of additional information on electronic structure. However, the true nature of the nonsuperconducting ground state remains uncertain. A central issue is the role of local superconducting pairing in the pseudogap regime: to resolve this, a distinct physical signature of the presence of vortices is ideally needed.

Our measurements of flux-flow resistivity reveal that the transition from metallic low temperature resistivity to log(1/T) behaviour in fact occurs on the overdoped side of the phase diagram. Working deep within the superconducting phase, with the cleanest available samples of YBCO and Tl2201, we take a different approach from previous experiments and measure the response of vortices to microwave-frequency driving currents. This circumvents flux pinning and reveals a log(1/T) flux-flow resistivity that persists throughout the superconducting region of the cuprate phase diagram. This includes a regime at high carrier dopings in which the normal-state transport is Fermi-liquid-like, indicating that the log(1/T) flux-flow resistivity observed in the superconducting state is not simply a reflection of the normal state, but a dynamical property of the vortices themselves. This would imply, in turn, that the log(1/T) resistivity seen in the pseudogap phase is a signature of vortex fluctuations and therefore that local superconducting pairing persists to high magnetic fields in the underdoped cuprates.

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