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Failed Superconductivity in a Geometrically Frustrated 2D Mott System

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Unconventional superconductivity often emerges in complex materials in which competing orders and complicated band structure obscure its origin. In contrast, κ-organics are geometrically frustrated quasi-2D single-band systems in which superconductivity arises near the bandwidth-tuned Mott metal-insulator transition in the absence of other orders. We show that in chemically substituted κ-organics, superconductivity never achieves global coherence, even as temperature $T \to 0$. Instead, we reveal the presence of superconducting domains embedded in a percolating metallic background that undergo a magnetic field-tuned quantum superconductor-to-metal transition, followed by the surprising emergence of universal conductance fluctuations in macroscopic samples. Our findings demonstrate that failed superconductivity arises from the interplay of intrinsic inhomogeneity and quantum phase fluctuations, providing a new perspective on anomalous metallic states observed in cuprates, disordered thin films, and oxide interfaces.

email address

dragana@magnet.fsu.edu

Affiliation

National High Magnetic Field Laboratory, Florida State University

Author: POPOVIĆ, Dragana

Presenter: POPOVIĆ, Dragana

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