Quantum Fluctuations and Competing Orders in the Hg-1245 High-T_c Cuprate

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Introduction

We have found significant regions of reversible magnetic behavior, e.g. large disparities between the upper critical field H_{c2} and the irreversibility field H_{irr} in several high-T_c cuprates at high fields and low temperatures. The fact that this behavior is not consistent with models of thermal or disorder-driven depinning along with the proximity of these systems to a quantum critical point leads us to propose a model of competing orders driving quantum fluctuations that depin the vortex lattice [1].

Experimental

Here we investigate "grain-aligned" crystals of $HgBa_2Ca_4Cu_5O_x$ (Hg-1245), e.g. samples in which microscopic single crystals are aligned in an applied magnetic field and set in epoxy. Magnetization measurements were performed using the acms and the VSM (vibrating sample magnetometer) options of the 14 T Physical Properties Measurement System at NHMFL-LANL.

Results and Discussion

The magnetization M of a sample of Hg-1245 (T_c = 108 K) is shown in Fig. 1 (left) for the field H parallel to the a-b crystallographic plane. An extrapolated value of H_{irr} = 23.5 T is found, compared to the Pauli paramagnetic limiting field in this compound of H_{c2}^{ab} = 278 T, as shown in the phase diagram in Fig, 1 (right). A small upturn in M at low T shown in the inset to Fig. 1 (left) may be associated with field-induced reentrant magnetic order, and is plotted as $\tilde{H}(T)$ in Fig. 1 (right).

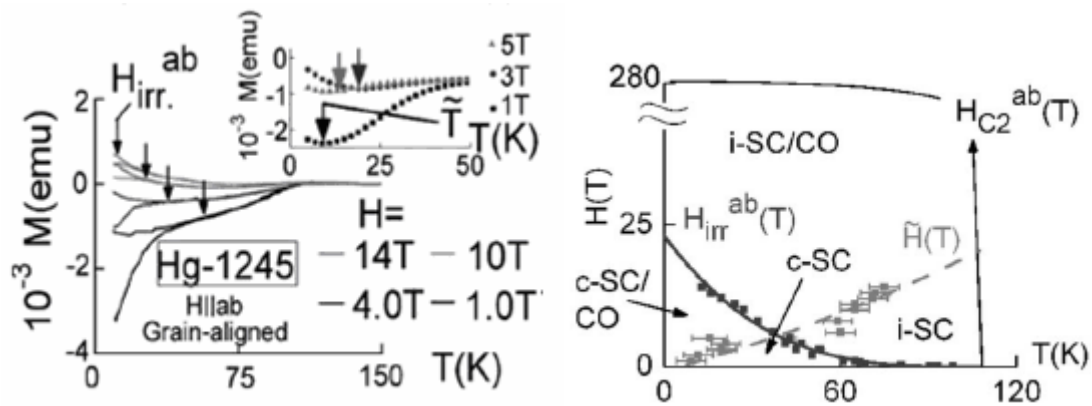

Fig. 1. (left) Magnetization vs temperature of Hg-1245 for H || ab. **Fig. 1 (right)** Phase diagram of Hg-1245 showing the irreversibility line H_{irr}^{ab}, the upturn at low temperatures $\tilde{H}(T)$, the Pauli paramagnetic limiting field H_{c2}^{ab}, and suggested regions of coherent superconductivity c-SC, incoherent SC (i-SC) and coexistence between the two.

Conclusions

The large discrepancy between H_{irr} and $H_{c2}(T)$ for H || ab and the extreme anisotropy of this compound strongly suggests the presence of quantum fluctuations in the high-H low-T region of the phase diagram. We therefore speculate that H_{irr} forms the boundary between coherent (c-SC) and incoherent (i-SC) superconductivity. Recent μSR measurements [2] have also observed antiferromagnetic order within the inner 3 layers of this 5-layer superconductor, suggesting this as the relevant field-induced competing order (CO) for $H > \tilde{H}(T)$.

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References

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