Magnetic Field Driven Phase Transition in underdoped YBCO

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The copper oxide superconductor known as YBCO ($YBa_2Cu_3O_{6+x}$) is famous for its very high temperature superconductivity of 94 K, yet has recently been revealed as a material with a complex and subtle phase diagram. Despite nearly thirty years of research, this material's behavior remains quite mysterious as new phases continue to be discovered.

The phase diagram is fundamentally a thermodynamic construct, and bulk thermodynamic measurements, such as specific heat, are among the most powerful tools to study a phase diagram. The present study focused on measuring specific heat in magnetic fields up to 35 T on the materials $YBa_2Cu_3O_{6.47}$ and $YBa_2Cu_3O_{6.43}$. The study is unprecedented in the precision and accuracy of the measurement in magnetic fields to 35 T. It is also the first to examine such compounds with a technique sensitive to changes within the super-conducting phase.

The results show an unexpected magnetic-field-driven phase transition within the superconducting phase, showing the transition from behavior expected of a standard d-wave superconductor (at low fields) *to a curious linear-in-H behavior (at high fields) that remains mysterious despite its simplicity.* This result shows how much is left to understand in the copper oxide superconducting phase diagram, and how subtle phases can evade observation for decades until techniques develop.

Facilities: DC and pulsed field facility

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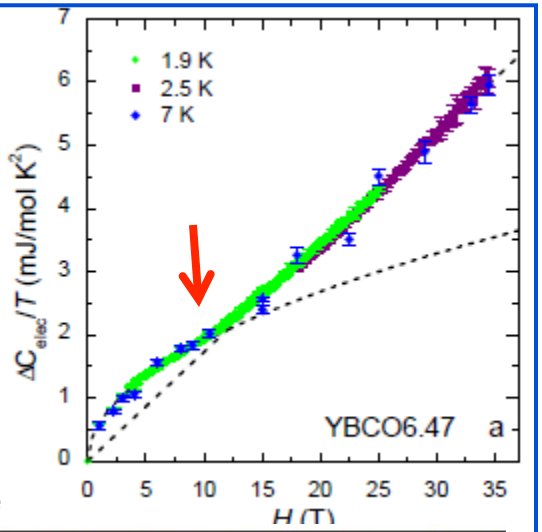
(Top) Electronic specific heat versus magnetic field at very low fixed temperature. The kink indicated by the red arrow is evidence of a phase transition driven by magnetic field.



(Bottom) Underdoped YBCO phase diagram as a function of magnetic field, temperature and chemical doping (which relates to the oxygen content or "**x**"). The red arrows indicate the same phase transition shown in the data above. The high magnetic field phase above the transition is not understood.