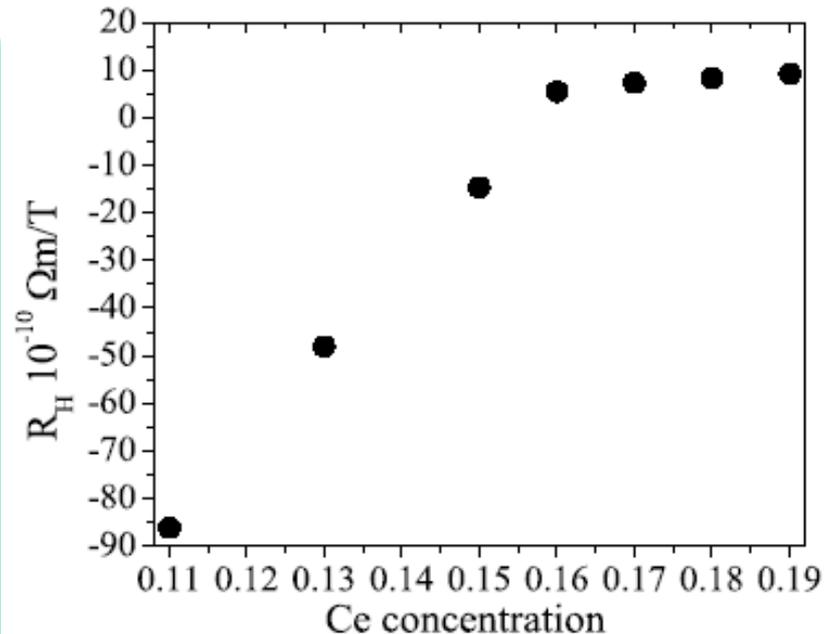


# Quantum Phase Transition in Electron-doped High-Temperature Superconductors

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The origin of high-temperature superconductivity is one of the major unsolved problems in condensed matter physics. In one theoretical model the superconductivity competes with another phase ordering, which causes a  $T=0$  transition between the two phases as a function of some control parameter, i.e. a quantum phase transition (QPT). Quantum fluctuations associated with this transition can affect many physical properties (including  $T_c$ ) at finite temperatures. In our research we have found the first direct evidence that a QPT occurs in the electron-doped high  $T_c$  system  $\text{Pr}_{2-x}\text{Ce}_x\text{CuO}_4$  (PCCO) as a function of doping ( $x$ ). The figure shows an abrupt change in the Hall coefficient at a critical doping ( $x \approx 0.165$ ). Other transport properties also show a dramatic change at that doping (1). The QPT occurs at a doping within the “superconducting dome”, which suggests a strong connection between the superconductivity and the competing phase (most likely antiferromagnetism). Further work will be necessary to determine if a QPT is linked to superconductivity in all high- $T_c$  superconductors.

1. Y. Dagan *et al.* Phys. Rev. Lett. **92**, 167001 (2004)



The Hall coefficient  $R_H$  at  $T=0.35\text{K}$  as a function of cerium doping,  $x$ . The abrupt change near  $x=0.165$  is a strong evidence for a quantum phase transition.

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## Education

Two undergraduates (Chris Hill and Matt Barr), one graduate student (Mumtaz Qazilbash) and one postdoc (Yoram Dagan) contributed to this work. Chris Hill has graduated and will be applying to graduate school next year. Matt Barr is a senior and will apply to graduate school this year. Mumtaz Qazilbash received his Ph.D. in 2004 and is presently searching for a postdoc position in the USA.

## Societal Impact

An understanding of the mechanism causing high temperature superconductivity may enable the development of new materials that are superconducting above room temperature. This would have a large impact on electronic devices and electricity generation and distribution.