High Field Studies of Electron-Doped Cuprate Thin Films

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Introduction

The high transition temperatures and critical fields of the hole-doped cuprate superconductors continue to challenge our basic understanding of superconductivity and promise important technological advances. The electron-doped (n-type) counterparts of the hole-doped cuprates have an advantage in that the magnetic field needed to quench superconductivity is much lower, on the order 10 T at optimal doping. This makes it feasible to study the doping dependence of the normal state transport properties across the superconducting dome. The mechanism of the high temperature superconductivity and the normal state strange metal behavior is not understood yet. One theory suggests that these are associated with the quantum fluctuations of a quantum phase transition, i.e. a transition between two phases at T=0, that often manifests itself as a Fermi surface reconstruction. To better understand this, we are studying the resistivity of the electron-doped superconductor $La_{2-x}Ce_xCuO_4$ (LCCO) as a function of temperature and field. The aim of this project is to measure the magnetoresistance (MR) at low and high fields to understand its relation to the low temperature T-linear resistivity found earlier [1] in films for doping at the QCP (quantum critical point) and above. The scattering mechanism that causes the T-linear resistivity is unknown and represents a major unsolved problem for cuprate physics.

Experimental

Thin films of LCCO are grown by pulsed laser deposition. In our low field (14 T) and recent high field magnet experiments, we have measured the MR for doping x=0.15, x=16 and x=17 at temperatures from 360 mK to 60 K and field up to 31 T. The measurement was performed in DC magnet, cell-9 with He3.

Results and Discussion

In the Fig. 1, we show ab plane magnetoresistance (MR) at temperatures between 360 mK and 60 K for c-axis dc field up to 31 T for doping x=0.15 and 0.16. At low temperatures the normal state MR is linear-in-field for all doping. A linear-in-H to quadratic-in-H crossover occurs at higher temperatures at low field (<15 T) as shown in Fig.1. The linear-in-H behavior is different response than for quasiparticles in conventional metals, where one expects a MR ~H2 for fields where wct <<1. The work done at the MagLab supports the low field work done at UMD. From this study, we find that the magnitude of the linear-in-H resistivity mirrors the magnitude and doping evolution of the linear-in-T resistivity, with both going to zero at the end of the superconducting dome and these results suggest that there is a strong correlation between the quantum critical excitations of the QCP and the high-Tc superconductivity [2].

Conclusions

We have found an unexpected unconventional, linear-in-field magnetoresistance at low temperature in the electron doped cuprate LCCO above the FSR [3]. This behavior is found over an extended doping regime above the purported quantum critical point(x=0.14). Its magnitude scales with T_c, which suggested a link between the causes of this anomalous magnetoresistance and the superconductivity.

Acknowledgements

The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida and by the NSF under Grant No.DMR-1708334 and the Maryland “Center for Nanophysics and Advanced Materials (CNAM).

References

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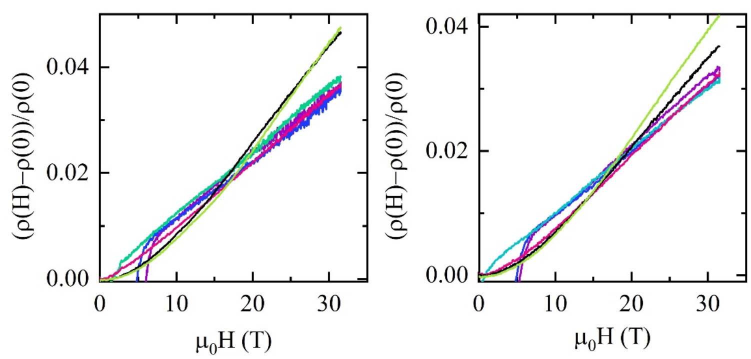

Figure:1 Transverse ab plane magnetoresistance MR for doping x= 0.15 (left panel-0.36 K (—), 1.6 K(—), 15 K(—), 25 K(—), 42 K(—), 60 K(—)) and 0.16 (right panel- 0.36 K(—), 1 K(—), 18 K(—), 25 K(—), 42 K(—), 60 K(—)) measured up to dc field of 31 T.