Magnetic-Field-Tuned Superconducting Quantum Phase Transition in Bi-2201

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Introduction

Hole-doped cuprates feature rich phase diagrams due to their high anisotropy, the presence of various competing degrees of freedom, and the inevitable disorder [1]. In order to reveal the normal state, magnetic field (H) is used to suppress superconductivity, however the presence of various types of charge order in superconducting cuprates [2] have deterred the full understanding of the normal state. Previous work on underdoped La-based cuprates [3-5], in which charge order occurs in the form of "stripes" near x=1/8 doping, has enabled the determination of the upper critical field (H_{c2}) and the study of the high-field ground state. To investigate the universality of behaviors observed in La-based cuprates and to further study the interplay of high-temperature superconductivity, charge order and disorder, we have performed a similar study of Bi-2201 in both (1) underdoped regime, where pseudogap and short-range charge order are present, and (2) overdoped regime where both pseudogap and charge order vanish.

Experimental

In-plane and out-of-plane magnetoresistance (MR) have been measured in parallel and perpendicular magnetic fields on both underdoped and overdoped Bi-2201 single crystals using a standard four-probe ac method. These measurements were done at low temperatures with low current and field sweep rates to prevent Joule or eddy current heating from affecting our measurements. They were carried out in several systems at the NHMFL's DC Field Facility: SCM1 and resistive magnets in Cells 12 and 15.

Results and Discussion

Figure 1 shows MR measurements up to 35 T for the out-of-plane transport on underdoped La-Bi2201. Suppression of the transition temperature T_c with the increasing field is found, similarly to the in-plane samples, and to the in- and out-of-plane measurements of overdoped Bi-2201. At intermediate fields, a suppression of superconductivity is observed with a metallic-like temperature dependence, while at the highest fields H > 25 T and lowest T, the sample exhibits a weaker positive MR along with the insulating-like temperature dependence.

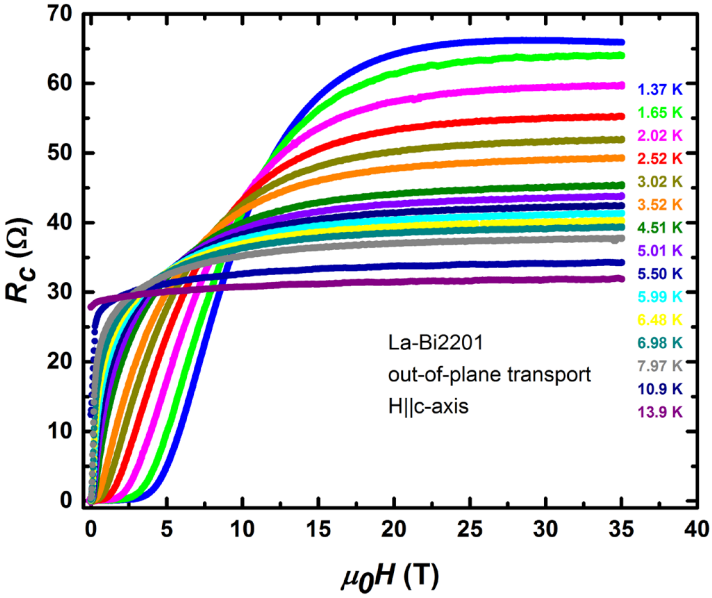

Fig. 1 Out-of-plane MR measurements on underdoped La-Bi2201 in fields up to 35 T (Cell 12) using a VTI.

Conclusions

Measurements on underdoped La-Bi2201 suggest a transition from a superconductor to an insulating-like normal state at high fields and lowest temperatures. Although our measurements so far have enabled us to start formulating (T, H) phase diagrams for both doping regimes, to complete the study of superconducting quantum phase transitions, additional measurements of angle-dependent MR as well as Hall coefficient at very low temperatures are needed.

Acknowledgements

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References

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