Magnetic-Field-Driven Superconductor-Insulator Transition in Stripe-Ordered $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$

Baity, P.; Shi, Z.; Popović, D. (FSU, Physics and NHMFL); Sasagawa, T. (Tokyo Inst. of Tech.)

Introduction

Our recent study [1] on the magnetic-field-driven superconductor-insulator transition (SIT) in highly underdoped ($T_c \approx 4$ K) $La_{2-x}Sr_xCuO_4$ (LSCO) revealed an intermediate phase with two quantum critical points separating the superconductor and the insulator. While charge distribution in highly underdoped LSCO seems to be inhomogeneous, its sister compound $La_{1.6-x}Nd_{0.4}Sr_xCuO_4$ (LNSCO) with x=0.12 is known to have a charge-stripe order already in zero magnetic field (H = 0) at low enough temperatures (T). We have performed magnetoresistance (MR) measurements on LNSCO single crystals to study further the effects of the magnetic field in underdoped cuprates, the nature of the H-driven SIT, and the interplay with charge ordering.

Experimental

Magnetoresistance measurements on high quality LNSCO single crystals with x=0.12 have been carried out at 0.3 < T (K) < 90 for H up to 9 T using a standard four-probe ac technique in the Ohmic regime with field sweep rates low enough to avoid sample heating. The onset of the charge-stripe order is at $T_{str} \approx 69$ K. Figure 1 shows the low-T ($T << T_{str}$) out-of-plane resistivity $\rho_c(T)$ for several $H||c$ that were extracted from the MR curves at fixed T.

Results and Discussion

The results are similar to those measured in the same material over a more limited range of T and H [2]. We observe a peak in $\rho_c(T)$, which occurs at decreasingly lower temperatures with increasing field. Using a phenomenological fit of the H dependence of this peak temperature (T_{max}), we find that the maximum is expected to vanish at $H \approx 14$ T. Above this field, the curves should assume insulating-like behavior. The same behavior is expected for $\rho_{ab}(T)$, based on an earlier study [3]. It is generally known, however, that the emergence of insulating-like behavior does not necessarily signify a transition into an insulating state. In cuprates, superconducting fluctuations (SCFs) are known to persist to surprisingly high T and H. Indeed for the previous studies on LSCO single crystals [1], fields up to 35 T were necessary to fully suppress SCFs and probe the insulating state.

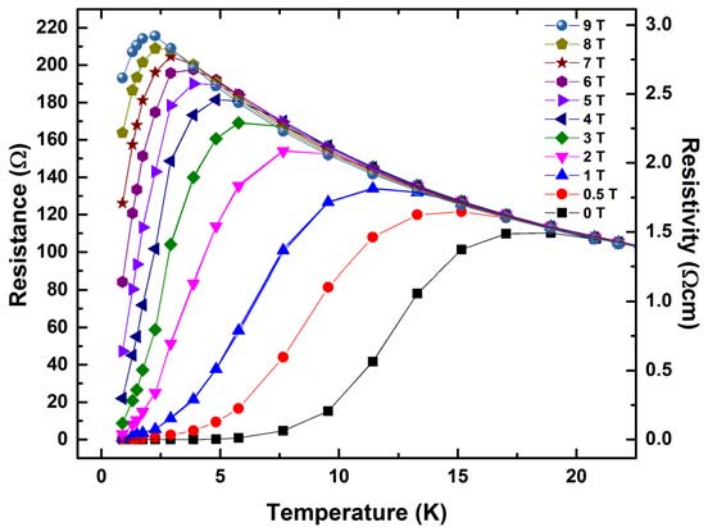

Fig.1 $\rho_c(T)$ curves for constant $H||c$. A peak in the resistivity as a function of temperature can be observed. The peak temperature decreases with increasing field, and it seems to vanish (not shown) when $H \approx 14$ T. The curves are expected to assume insulating-like behavior at higher H.

Conclusions

These preliminary results provide the foundation for future measurements on the stripe-ordered cuprate LNSCO. Further measurements on ρ_{ab} and ρ_c are planned at higher fields with $H||c$ and $H||ab$ in the user facilities of the NHMFL. These results will give key insight into the roles that charge ordering and anisotropy play in the H-driven SIT of the cuprates.

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References

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