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Emergence of superconductivity from the dynamically heterogeneous insulating state in $La_{2-x}Sr_xCuO_4$

The properties of the insulating state and the onset of superconductivity at low doping have been key issues in the physics of cuprate high-temperature superconductors. In lightly doped, insulating $La_{2-x}Sr_xCuO_4$ (LSCO), magnetotransport and resistance noise measurements have revealed the existence of a charge glass state at very low temperatures deep within the spin glass phase (at temperatures $T \ll T_{SG}$). In particular, the hysteresis and memory in the magnetoresistance (MR) and the onset of non-Gaussian noise suggest that the charge dynamics becomes increasingly slow and correlated as *T* approaches zero. The analysis of the higher order noise statistics provides evidence for the existence of a collective ground state of charge clusters ("cluster charge glass") located in CuO_2 planes, which seem to coexist with charge-poor antiferromagnetic domains that are frozen at such low *T*.

The hysteretic positive magnetoresistance exhibited at low fields has been used as a practical tool to detect the underlying charge glassiness in $La_{2-x}Sr_xCuO_4$ for doping levels that range from the insulator to the superconductor. Moreover, by extending the MR measurements to high fields, we have been able to probe the presence of superconducting fluctuations. We find that the charge glass behavior, characteristic of the insulating state, is suppressed with doping, but it coexists and competes with superconducting fluctuations that emerge on the insulating side of the superconductor-insulator transition (SIT). Our findings are consistent with the picture of the SIT driven by phase fluctuations and localization of Cooper pairs by the competing charge order.

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