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Charge Dynamics in $La_{1.875}Ba_{0.125}CuO_4$ Near the Charge Order (CO) and Structural Transition

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Introduction

The possible interplay of charge order and high-temperature superconductivity has sparked a long and difficult search for dynamic COs [1]. Recent work on $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$ (LNSCO) has revealed the presence of long-lived metastable states [2], manifested in the form of avalanches, or jumps in the resistance, and long non-exponential relaxations, suggesting the presence of dynamic CO strongly pinned by disorder. This behavior was only observed in the vicinity of the nearly coincident CO and structural transition. Moreover, avalanches were also observed to be asymmetrically driven by the magnetic field H around the CO and structural transition with an additional onset of negative magnetoresistance (MR), which was attributed to the emergence of CO in both LNSCO and $La_{1.7}Eu_{0.2}Sr_{0.10}CuO_4$. In the latter, CO and structural transitions are well-separated in temperature, but avalanches were not observed. To gain further insight into the interplay of lattice and charge degrees of freedom and the origin of the negative MR, a similar study on a related material, $La_{1.875}Ba_{0.125}CuO_4$ (LBCO), is needed. In LBCO, the CO and structural, low-temperature orthorhombic (LTO) to low-temperature tetragonal (LTT), transitions are nearly coincident as in LNSCO, but unlike LNSCO, LBCO does not have magnetic moments. Furthermore, high-temperature tetragonal (HTT) to LTO transition in LBCO occurs at a temperature that is easily accessible experimentally. It is indeed the HTT/LTO transition that determines the domain patterns in both the LTO and LTT states, and thus another advantage of LBCO is that the effect of the structural domain pattern on the avalanche behavior can be investigated more easily.

Experimental

Measurements were performed on a LBCO bar-shaped single crystal. Contacts were made using gold wire and Dupont 6838 silver paste. To test the effect of domain pattern formation on the avalanche behavior, two protocols were used. For protocol one, the sample was warmed above the LTO/LTT transition but never into the HTT phase. Thus the domain patterns stay the same for all measurements. In protocol two, the sample was warmed into the HTT phase before every measurement, hence changing the domain patterns. After warming the sample well into the appropriate phase, both protocols proceed the same way. The sample is cooled down into the superconducting state and is then carefully warmed up to the measurement temperature without overshooting. The c-axis resistance R_c is then measured over ~16 hours while avalanches continue to occur. Measurements are taken throughout the transition and on either side to see how the behavior changes.

Results and Discussion

We have obtained the first evidence of dynamic behavior in LBCO. As seen in Fig. 1, avalanches continue to be observed over long periods of time. As in LNSCO, the avalanches were only observed when the measurement temperature was approached from below, i.e. from the charge-ordered phase. The number of avalanches observed was plotted as a function of temperature for both protocols. No obvious difference was seen between the two protocols, suggesting that the domain patterns do not affect the behavior. In addition, no avalanches were observed in the LTO phase but they continued into the LTT phase. This is consistent with what has been observed in LNSCO.

Conclusions

To complete the project, we will study the effect of magnetic fields on R_c in LBCO as its dopant Ba does not have the magnetic moment that is seen from Nd^{3+} in LNSCO.

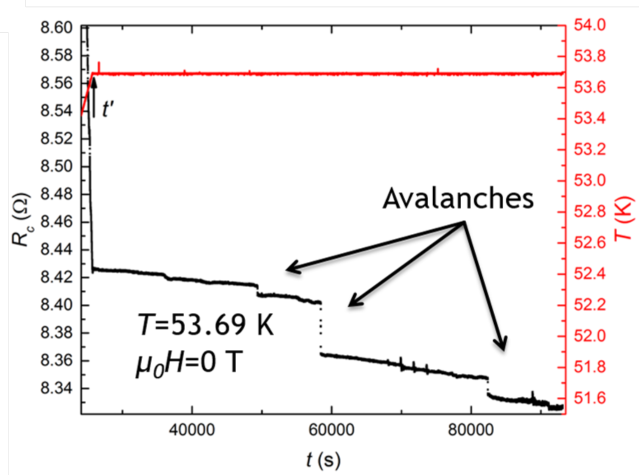

Fig.1 Resistance (black) and temperature (red) as a function of time. The large drops in R_c pointed out by arrows are avalanches.

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References

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