Study of the Modulated Structures of Transition-Metal Oxides Using X-ray Scattering

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Strontium-doped La_2NiO_4 (LSN) is isostructural with the high-TC cuprates, $La_{2-x}Sr_xCuO_4$ (LSC) and $La_{2-x}Ba_xCuO_4$ (LBC). With substitution of 15% Sr, LSC shows a superconducting transition at TSC ≈ 35 K, but LSN remains insulating at doping levels up to 70%. It has been suggested that stronger electron-phonon interactions in LSN are responsible for this behavior as it was recognized that electron-phonon interactions are critical for the persistent insulating character of the Mott insulator. The hole-doped La_2NiO_4 is a prototypical system for the understanding of transport phenomena observed in compounds of LSC or LBC.

The substitutions of La with Sr provide hole carriers, and the doped holes tend to order in a stripe-like structure acting as domain walls within the NiO_2 planes. The interplay between this ordered state and the spins of Ni dominates the transport behavior at low temperatures. Transport and optical conductivity measurements have demonstrated the anomalous phenomena resulting from the formation of the charge stripes, in particular a pronounced change in conductivity has been observed in $La_{5/3}Sr_{1/3}NiO_4$.

In $La_{2-x}Sr_xNiO_4$ at doping levels of $x \approx 1/3$ and 1/2 commensurate charge modulations have been observed by Chen et al. using electron diffraction and were explained to originate from ordering of polarons. Using neutron scattering the charge ordering and the spin ordering have been evidenced to be the common feature in nickelates. Based on these experimental findings, Zaanen and Littlewood proposed a model of polaronic instabilities, suggesting that the polarons bind to, and thereby stabilize, the domain walls formed due to either Sr-doping or oxygenation, and that these domain walls order into a striped phase.

Using high-resolution x-ray scattering, we demonstrated that the charge stripes possess the characteristic of two- dimension in nature and quasi-long range order at low temperature as shown in figure 1. Such a disordered state suggested the possible existence of charge liquid state around the transition temperature.

In order to further study this fascinating charge liquid phase, we probed the evolution of the correlation lengths along three crystallographic axes with the application of currents along the b^*-axis. Under such a condition, we observed that the charge stripes were steered by the applied current as displayed in figure 2. This is the indication of existence of charge liquid state. However, the detailed information about this fascinating charge liquid is of need the further studies.

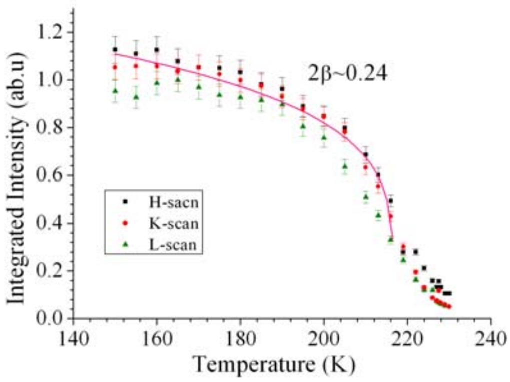

Figure 1. Evolution of the integrated intensity of the satellite reflection due to the formation of charge stripes as a function of temperature. The order parameter can be fitted with a power law with an exponent of 2β~0.24, suggesting a class of 2D-Ising model.

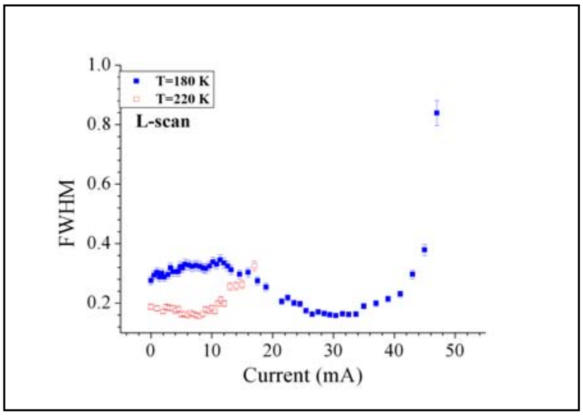

Figure 2. Evolution of the ratio of FWHM along L-direction, as a function of current at T=220 and 180 K.