Nature of Charge Order in the Layered Manganite $La_{1-x}Sr_{1+x}MnO_4$

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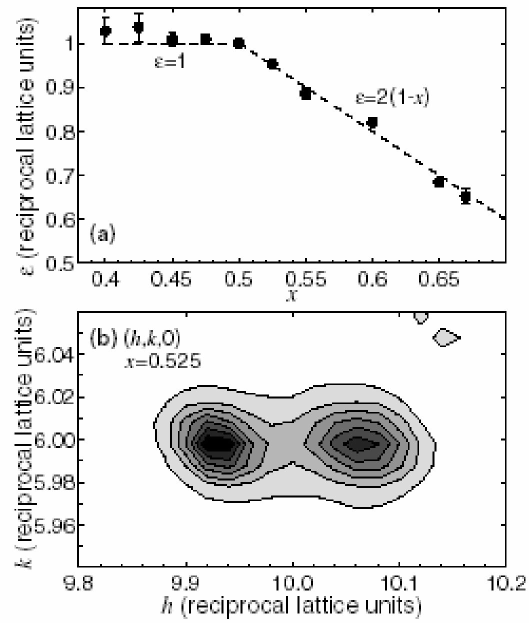
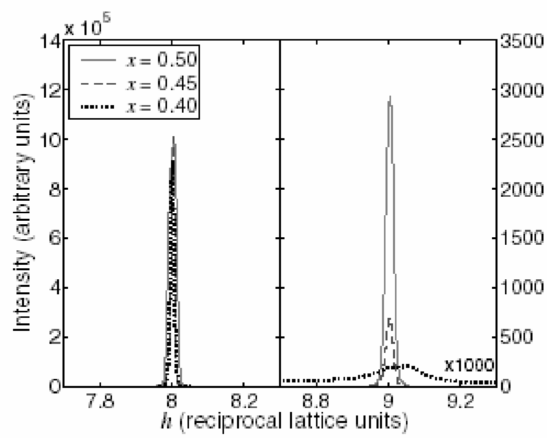
The strong electron correlations in transition metal oxides give rise to such phenomena as high-temperature superconductivity in layered cuprates and to stripe-like order in layered cuprates and nickelates. In the case of the manganites, an additional strong electron-lattice interaction leads to a very rich phase diagram in which structural, magnetic, and transport properties are intimately related. Colossal magnetoresistance (CMR) has been observed in the perovskite and double-layer manganites, but not in the single-layer system $La_{1-x}Sr_{1+x}MnO_4$ (Mn214). Nevertheless, there are signs that the physics of Mn214 is similar to that of the perovskites. Information about the low-temperature structural phases of Mn214 can be expected to provide valuable insight into the role of dimensionality on the properties of the manganites, and also to contribute to a deeper understanding of single-layer transition metal oxides in general.



(a) Superlattice wave vector $(\pm\epsilon, 0, 0)_o$ as a function of x for $La_{1-x}Sr_{1+x}MnO_4$. The dashed line for x > 0.5 is $\epsilon = 2(1 - x) = 2n_e$. (b) Linear-scale contour map (10% contours) of the scattering intensity around $(10, 6, 0)_o$ for x = 0.525.

Simon Larochelle and co-workers have grown single crystals at Stanford's new Laboratory for Advanced Materials and carried out x-ray scattering studies at SSRL Beam Line 7-2 to establish the low-temperature structural phase diagram of Mn214 [1]. For x = 1/2, this study provides a more complete picture than previous neutron [2] and x-ray [3] scattering experiments. An investigation of the effects of varying the e_g electron concentration ($n_e = 1 - x$) in the MnO_2 layers revealed three distinct regions: disordered ($x < 0.4$), mixed-phase ($0.4 < x < 0.5$), and charge-ordered ($x > 0.5$). Above $x = 0.5$, the ordering of e_g electrons is found to result in a structural distortion whose modulation period only depends on n_e. Even though Mn214 does not exhibit CMR, this trend resembles findings for $La_{1-x}Ca_xMnO_3$, which is a CMR material. This behavior furthermore is reminiscent of the charge- and spin-density wave order tendencies in the hole-doped layered cuprates and nickelates. The results of this study thus provide valuable quantitative information for tests of theories for CMR materials and layered transition metal oxides.



H scans through the $(8, 4, 0)_o$ and $(9, 4, 0)_o$ reflections for x = 0.40, 0.45, and 0.50 (*T* = 100 K). The $(8, 4, 0)_o$ peak intensities are normalized to 10^6. Below x=0.50, the $(9, 4, 0)_o$ superlattice peak intensity decreases considerably with decreasing x. For x = 0.40, the peak is noticeably broadened and its intensity is ~10^4 weaker than for x = 0.50 reflecting mixed-phase behavior

References

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2. B. J. Sternlieb *et al.*, Phys. Rev. Lett. 76, 2169 (1996).
3. Y. Murakami *et al*., Phys. Rev. Lett. 80, 1932 (1998).

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