SESSION 8

(September 27, 2000)

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Charge/orbital ordering and its fluctuations in manganites

Sang-W. Cheong
Rutgers University & Bell Laboratories, Lucent Technologies.

In doped Mott insulators such as layered cuprates, layered nickelates and perovskite manganites, charge carriers tend to self-organize in such a way as to form stripe patterns at low temperatures. In the case of mixed-valent manganites, orbital degrees of freedom associated with Mn^{3+} can be involved in the striped ordering phenomena. This striped charge/orbital ordering at low temperatures in manganites has been observed in various forms such as long-range commensurate ordering, nano-scale mixtures of two-different commensurate orderings. The way in which the commensurate charge/orbital ordering forms or melts near phase transition temperatures has been also studied in detail. Furthermore, recent experimental results indicate the presence of very-short-range or dynamic correlation of charge/orbital ordering at high temperatures, far above any phase transition temperatures. This significant fluctuation of charge/orbital ordering at high temperatures is directly associated with the origin of the colossal magnetoresistance effect in manganites.

Sang-W. Cheong
Rutgers University & Bell Laboratories
Lucent Technologies
7000 Mountain Ave.
Murray Hill, NJ 07974, USA
fax: +1 908 582 3260
e-mail: scheong@lucent.com

Charge order in $(La,Sr)_2MnO_4$

S. Larochelle[1,2], A. Mehta[2], N. Kaneko[2], A. F. Panchula[3], L. Zhou[3],
J. Arthur[2] and M. Greven[2,3]

[1]Department of Physics, Stanford University, Stanford, CA 94305, USA; [2]Stanford Synchrotron Radiation Laboratory, Stanford, CA 94305, USA; [3]Department of Applied Physics, Stanford University, Stanford, CA 94305, USA.

Using synchrotron x-ray scattering, we have studied the low-temperature structural phases of the single-layer manganese oxide $La_{1-x}Sr_{1+x}MnO_4$ ($0.33 \leq x \leq 0.65$). The measurements indicate the existence of three distinct regimes: a disordered phase at doping $x < 0.4$, a charge-ordered phase for $x > 0.5$, and a mixed-phase regime for $0.4 \leq x < 0.5$. For $x > 0.5$, the modulation vector associated with the charge-ordered phase is incommensurate with the lattice and depends linearly on the concentration of e_g electrons. We observe weak second- and third-order harmonics, and hence conclude that the structural modulation in $La_{1-x}Sr_{1+x}MnO_4$ is nearly perfectly sinusoidal.

Keywords: *Charge order; orbital order; manganate; X-ray scattering*.

Martin Greven
Laboratory for Advanced Materials
McCullongh Building, Room 344
Stanford, CA 94305-4045, U.S.A.
phone: +1 650-725-8978
fax: +1 650-724-3681
e-mail: greven@stanford.edu

Electronic phase separation in perovskite manganites

C. H. Chen[1], S. Mori[2], M. Uehara[3], and S-W. Cheong[1,3]
[1]Bell Labs, Lucent Technologies, Murray Hill, USA. [2]Dept. Physics, Tokyo Inst. Technology, Meguro-ku, Tokyo, Japan. [3]Dept. Physics and Astronomy, Rutgers University, Piscataway, USA.

The rich physics of colossal magnetoresistive compounds with perovskite structure is dominated by the intriguing competition between ferromagnetic double exchange coupling and charge/orbital ordering facilitated by the Jahn-Teller effect. The general electronic ground state of the mixed-valence manganese oxides, such as (La, Ca)MnO_3, therefore can be a ferromagnetic metal or an insulating charge-ordered stripe phase. The competition betwecn these two predominant ground states can lead to electronic phase separation and result in an electronically (and spatially) inhomogeneous system [1]. The presence of electronic phase separation has been shown recently to play a very crucial role in the colossal magnetoresistance due to the percolative transport through the electronically phase-separated mixture [2]. The percolative transport, in particular, is responsible for the colossal magnetoresistive effect observed in systems exhibiting low Curie temperatures. In this talk I shall also discuss the electronic phase separation induced by external perturbations such as the irradiation of high energy electron beam. In this case, a pure charge-ordered domain can transform into a spatially inhomogeneous fine mixture of charge-ordered and charge-disordered clusters under the influence of the incident electron beam. The beam-induced electronic phase separation effect is found to be totally reversible.

References

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C. H. Chen
Bell Labs
Lucent Technologies
Rm. 1D-233 600
Mountain Avenue
Murray Hill, New Jersey 07974, USA
phone: (908) 582-7923
fax: (908) 582-3260

Dynamical and quenched disorder of 2-dimensional charge stripes in $La_{5/3}Sr_{1/3}NiO_4$

P. D. Hatton[1], M.E.Ghazi[1], C-H.Du[1], S.Brown[2] and S-W.Cheong[3]
[1]Department of Physics, University of Durham, U. K, [2]XMaS CRG, ESRF, Grenoble, France, [3]Department of Physics & Astronomy, RutgersUniversity, Piscataway, USA.

Using synchrotron x-ray scattering on a single crystal of $La_{5/3}Sr_{1/3}NiO_4$, we have demonstrated the existence of charge stripes at low temperatures. Satellite reflections were located at positions ($h \pm 2\varepsilon$ 0 l), (ε = 1/3, h= even and l= odd) below the charge ordering transition T_{CO}. The electronic transition into the charge stripe phase is second order without any corresponding structural transition. Above the transition ($T_{CO} \approx 240$ K) critical scattering was observed due to fluctuations into the charge stripe phase. The charge stripes are shown to be two-dimensional in nature, both by measurements of the correlation lengths ($\xi_a \approx 150$, $\xi_b \approx 300$, $\xi_c \approx 25$.), and by the critical exponents of the charge stripe melting which show that the system is in the 2D universality class ($2\beta = 0.25$). The charge stripe ordering does not develop into long range order indicating that the stripes are disordered and quenched at the lowest temperatures. Detailed measurements of the correlation lengths at higher temperatures, just below the charge stripe melting temperature, display an anisotropic broadening indicative of an order-disorder transition. We ascribe these results to a smectic-nematic phase transition at approximately 225 K. Such electronic quantum liquid-crystal phase transitions have been theoretically predicted before, but these results provide the first experimental evidence for them in charge stripe nickelates.

Keywords: *Stripes in a doped antiferromagnetic lattice, fluctuations in striped phases, X-ray scattering.*

Peter D. Hatton
Department of Physics
University of Durham
South Road
Durham DH1 3LE, UK
phone: +44 (0)191 374 2147
fax: +44 (0)191 374 3749
e-mail: p.d.hatton@durham.ac.uk