SESSION 15

(September 29, 2000)

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Polaron ordering in ferromagnetic colossal magnetoresistive oxides

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X-ray and neutron scattering measurements reveal diffuse scattering associated with lattice distortions around localized charges, i.e., polarons, in the paramagnetic phase of the optimally doped colossal magnetoresistive manganite $La_{2-2x}Sr_{1+2x}Mn_2O_7$ with $x = 0.40$ [L. Vasiliu-Doloc *et al.*, Phys. Rev. Lett. **83**, 4393 (1999)]. The polarons exhibit short-range incommensurate correlations that grow with decreasing temperature, but disappear abruptly at the combined ferromagnetic and insulator-metal transition because of the sudden charge delocalization. The "melting" of the polaron ordering as we cool through T_C occurs with the collapse of the quasistatic polaron scattering. The polaron order is characterized by an ordering wave vector $q = (0.3, 0, 1)$ that is almost independent of x for $x \geq 0.40$, and is consistent with a model of short-range stripe order. The polaron order at $x \geq 0.40$, however, persists down to low temperatures, consistent with the A-type antiferromagnetic and insulating ground state. It is the delicate balance between double exchange, Coulomb repulsion, and the lattice strain field that dictates whether the material is a ferromagnetic metal or charge-ordered insulator at low temperatures.

Work supported by DARPA/ONR, the state of Illinois under HECA, U.S. DOE BES-DMS (W-31-109-ENG-38), NSF (DMR 97-01339).

*In collaboration with R. Osborn, S. Rosenkranz, S. K. Sinha, J. W. Lynn, B. Campbell, Z. Islam, C. Ling, D. Argyriou, and J. F. Mitchell.

Keywords: *colossal magnetoresistance, x-ray scattering, neutron scattering, polaron ordering.*

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Interplay between orbital-, charge order and magnetism in $La_{0.89}Sr_{0.11}MnO_3$

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Recently, in several synchrotron x-ray scattering studies it was shown, that orbital and charge order can be investigated through the use of resonant scattering methods [1]. In the case of the manganites, there is still a debate ongoing concerning the mechanism responsible for the observed strong orbital resonances [2]. We used this same technique to study the orbital (OO) and charge (CO) ordering in the doped manganite $La_{1-x}Sr_xMnO_3$ and to shed some light on this problem. We show, that below the cooperative JT transition at 308K and above the charge order transition at 124K, the "orbital order" intensity is proportional to the orthorhombicity. Combined with the specific energy dependence, this is a clear indication, that the splitting of the Mn 4p levels is predominantly caused by the JT distortion and not by the Mn 3d-4p Coulomb repulsion. The observation of orbital order in the manganites is therefore an indirect one, as was theoretically inferred by Benfatto et al. Our observation of orbital order is contradictory to Endoh et al's results [3]. The drop of the OO intensity in the CO state is explained by an OO structure factor, which is coupled to the charge order.

Keywords: *Colossal magnetoresistance, orbital order, charge order, manganites*

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Formation of stripes in manganites

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The stripe formation is naturally affected (and favored) by commensurability effects, which are most pronounced in Nd-doped 214 compounds near hole-doping 1/8. In the presence of commensurability the system has an insulating character with a fully developed gap, which renders qualitatively reliable a Hartree-Fock (HF) analysis. In this framework the two-dimensional three-band Hubbard model in the presence of a long-range interaction has been considered and recent HF calculations, suitably generalized with slave-bosons to treat the strong local correlations, have revealed the formation of partially filled domain walls (one doping hole every two stripe sites) along the (1,0) or (0,1) directions. The same analysis shows that stripes also form in electron-doped compounds with different orientation [in the (1,1) direction] and filling (one doped electron every stripe site). These different features suggest that the more pronounced insulating character of the electron doped materials can make them more similar to the 214 nickelates. When doping and/or the crystal structure are not suitable for commensuration, the stripe phase has an incommensurate (and likely dynamical) character. The possibility that the edge-gaps around the M-points in the metallic state of underdoped cuprates arises directly from particle-hole scattering due to charge ordering and indirectly from particle-particle pairing mediated by charge-fluctuation has been considered. Indeed a quasi-static charge ordering taking place in the underdoped regime can directly explain the coexistence of gaps and arcs on the Fermi surface if the charge texture has an eggbox form. In the lack of evidences for that, we then investigated the local pairing induced by charge-stripe fluctuations. A proper description of the strong anisotropy of both the interactions and the Fermi velocities requires a two-gap model for pairing. We find that a gap due to incoherent pairing forms near the M-points, while coherence is established by the stiffness of the pairing near the nodal points. By taking into account anisotropy in k-space, this model provides a new approach to superconductivity besides the traditional BCS and Bose-Einstein condensation limits and allows for a continuous evolution from a pure BCS pairing (over- and optimally doped regime) to a mixed boson-fermion model (heavily underdoped regime).

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Lattice modulation and metal insulator transition in $La_{0.9}Sr_{0.1}MnO_3$ thin film

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X-ray scattering experiments have revealed the presence of an in-plane superstructure which corresponds to a substrate induced coherent strain modulation of ~ 223 Å in $La_{0.9}Sr_{0.1}MnO_3$ thin films epitaxially grown on $SrTiO_3$ (100) substrates, for film thicknesses ranging between 100 and 500 Å. The modulation is due to a distortion of the lattice in order to accomodate the lattice discommensuration between film and substrate. The dependence of the structural modulation as function of temperature reveals a strong correlation between lattice distortion and a recently observed metal-insulator transition.

Keywords: *Manganites, thin films, metal-insulator transition.*

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Metal-to-insulator transition in $RNiO_3$ perovskites

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We have studied the magnetic and crystallographic behavior of the family of transition-metal oxides with formula $RNiO_3$, where R is a lanthanide cation. Besides the lanthanum compound, all the elements of the series show a metal-insulator transition.

These nickel perovskites present two important characteristics that make their study particularly attractive. In contrast to other oxides, the metal-insulator transition takes place in the stoichiometric compounds and the critical temperature of this electronic transition depends in a continuous way upon the size of the rare earth. Neutron and synchrotron diffraction data of small rare-earth members of the series provide the first observation of changes in the crystal symmetry at the metal-insulator transition. At high temperatures, $RNiO_3$ are orthorhombic metals and below T_{MI} they become monoclinic insulators. The structural reorganization at T_{MI} gives rise to two crystallographically independent Ni positions and the insulating phase consists of alternating expanded ($Ni1O_6$) and contracted ($Ni2O_6$) octahedra along the three directions of the crystal cell. The finding of very distinct mean Ni-O distances has been interpreted as a charge disproportionation effect.

We have studied the compounds with R from Ho to Lu. We find that contrary to the regular evolution of the monoclinic angle, the average distances do not change significantly along the series.

Keywords*: Diffraction; metal-insulator transition; electron-phonon coupling.*

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Amalous charge- spin-, and lattice dynanics in the charge-ordered phase of $Bi_{1-x}Ca_xMnO_3$ (x>0.5)

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We report on inelastic light scattering and spectroscopic ellipsometry studies ot the effects of charge ordering on the charge-, lattice- and spin-dynamics in $Bi_{1-x}Ca_xMnO_3$ (x>0.5). We demonstrate that charge-ordering results in spectacular changes of the dielectric properties, which become strongly anisotropic below T_c. We also observe precursor effects at temperatures well above his transition. Moreover, we sbow that charge ordering results not only in anomalous phonon behavior, such as the appearance of 'activated' modes, but most significantly, we observe in the CO/AFM state the development of a quasielastic light scattering response of distinctive T_{1g} symmetry. This distinctive scattering symmetry transforms like both the spin-chirality ($S_1*S_2xS_3$) and magnetic dipole operators, and thus the development of this T_{1g} quasielastic response betrays the presence of strong fluctuations associated with such a time-reversal symmetry broken state in the CO/AFM phase. As will be discussed, among the most likely sources of this anomalous response are (i) chiral spin fluctuations, i.e., fluctuations in ($S_1*S_2xS_3$), and (ii) flutuations associated with closed-loop charge currents arising from the strong constraints placed on conduction by the complex spin-texture of the Neel state and the double-exchange hopping mechanism. Such a response would originate from magnetic fluctuations associared with 'chiral' charge motion in the CO/AFM phase.

This work was financially supported by the DOE via DEFGO2-96ER45439, the DFG via Ru 773/1-1, the NSF through the STCS via DMR91-20000, and NSF-DMR-9802513.

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