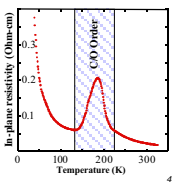
Nanoscale Orbital Stripes in CMR Manganites

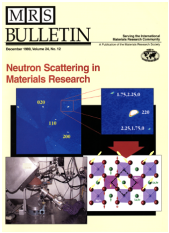
B.J. Campell, S. Rosenkranz, R. Osborn, J.F. Mitchell, C.D. Ling, D.N Argyriou, Z. Islam, S.K. Sinha, U. Ruett,
Argonne National Laboratory
L. Vasiliu-Doloc, J.W. Lynn, NIST Center for Neutron Research

Motivation

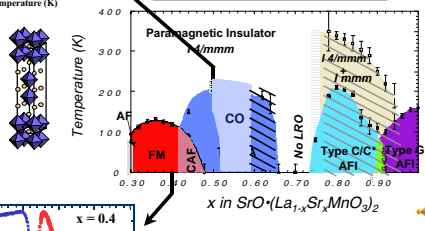
Colossal magnetoresistance (CMR) in the manganites is strongly influenced by an intricate competition among spin, charge, and lattice correlations. What happens when the underlying interactions favor ground states with incompatible long-range order?

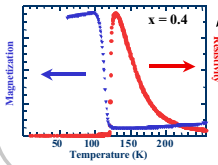


Left: resistivity peak due to long-range reentrant charge/orbital order at x = 0.5. Right: Single-crystal neutron diffraction pattern reveals the corresponding pattern of C/O order.

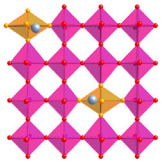


Phase diagram of $La_{2-2x}Sr_{1+2x}Mn_2O_7$ bilayered perovskites

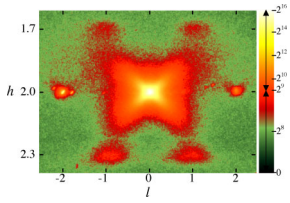




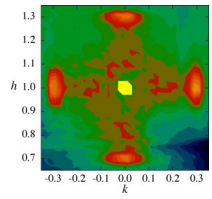
Left: magnetization and resistivity vs. temperature at x = 0.4. Right: illustration of polaronic e_g electrons and their associated lattice dis-tortions.



Polaron correlations

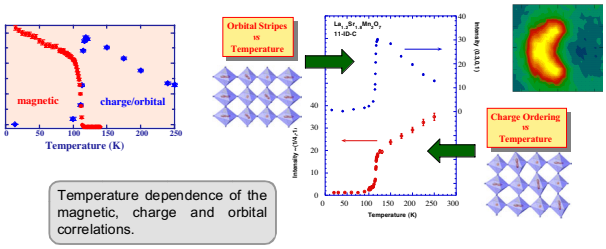


115 keV X-ray single-crystal diffuse scattering data around the (0,0,2) Bragg reflection.



36 keV X-ray diffuse scattering around the (1,0,18) Bragg reflection.

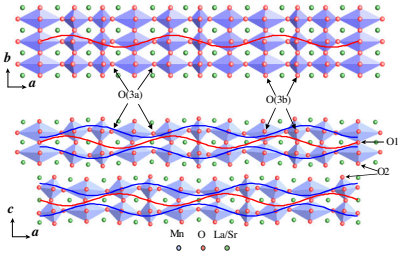
In the region where CMR is observed (x~0.4), long-range charge/orbital order is no longer observed. Instead, the competition between charge, orbital and magnetic order leads to frustration driven short-range orbital correlations.



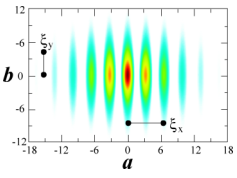
Temperature dependence of the magnetic, charge and orbital correlations.

Polaronic fluid

The crystallographic analysis of the integrated intensity of 109 unique superlattice reflections yields a detailed structural model: a novel longitudinal modulation implicating JT coupled charge-density-wave fluctuations in the bilayered manganites.



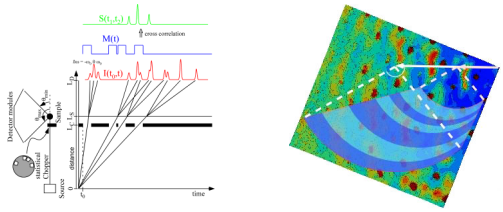
The structure of longitudinal JT polaron correlations. The red and blue curves track the phases of the *x* and *z* components of the modulation.



The in-plane displacement-displacement correlation function of the structural modulation.

Future Directions

A detailed understanding of frustration driven nanoscale correlations, a theme central to many phenomena of technological importance, requires measurements of diffuse scattering over large volumes of reciprocal space as well as efficient analytical tools for analyzing and modeling such data. We are developing advanced diffuse scattering instrumentation and methods which will permit broad surveys of reciprocal space as well as focused measurements in special sample environments.



Schematics of an optimized neutron diffuse scattering instrument with elastic discrimination, utilizing a pseudorandom chopper.

B.J. Campbell R. Osborn, D.N. Argyriou, L. Vasiliu-Doloc, J.F. Mitchell, S.K. Sinha, U. Ruett, C.D. Ling, Z. Islam, J.W. Lynn, Phys. Rev. B65, 014427 (2001).

BES - DOE

This work was supported by the U. S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38.

MSD - ANL

ARGONNE NATIONAL LABORATORY · UNIVERSITY OF CHICAGO