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Disentangle phonon modes using ultrafast electron diffraction and timely-resolved electron crystallography

Polaron transport, in which electron motion is strongly coupled to the underlying atomic lattice, is crucial to understanding the electrical conductivity in many solids. The accompanying atomic displacements are themselves coupled through phonons, but the specific phonon modes responsible for the dynamics of polaron motion have rarely been identified. In this presentation, I will first give an overview on the 2.8 MeV ultrafast electron diffraction instrument and the time resolved electron crystallography method we developed at BNL, then focus on its application to understand charge, orbital and lattice coupling and interaction in strongly correlated electron systems. A detailed example will be given on quantifying the dynamics of both electronic and atomic motion in the $LaSr_2Mn_2O_7$ manganite. Using photoexcition to set the electronic system in motion, we find that Jahn-Teller-like O, La/Sr, and Mn^{4+} displacements dominate the lattice response and exhibit a dichotomy in behavior overshoot-and-recovery for one sub-lattice versus normal behavior for the other. This dichotomy, attributed to slow electronic relaxation, proves that polaron transport is a key process in doped manganites. Our technique with the access to high-order reflections and being sensitive to phonons promises to be applicable for specifying the nature of electron-phonon coupling in many complex materials.

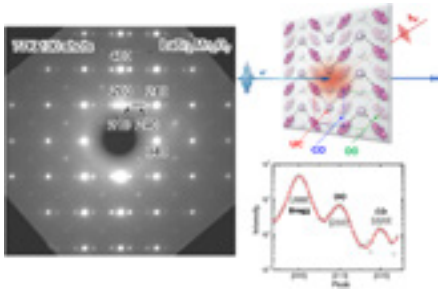

Figure-1: An electron diffraction pattern of $LsSr_2Mn_2O_7$ at 77K obtained from the BNL 2.8MeV-130fs UED (Left). Schematic of the ultrafast pump-probe approach is shown in the top panel (Right). The Bragg, orbital-ordered (OO) and charge-ordered (CO) reflections are marked and quantified in the bottom panel.

Biography

Yimei Zhu is a Senior Physicist at Brookhaven National Laboratory (BNL) and Adjunct Professor at Columbia University and Stony Brook University. He has received his BS from Shanghai Jiaotong University in 1982, MS and PhD from Nagoya University in 1987. He joined BNL as an Assistant Scientist in 1988, rising through the rank to become Tenured Senior Physicist in 2002. He is the Founding Director of the Institute for Advanced Electron Microscopy and Facility Leader of the Functional Nanomaterials at BNL. His research interests include electron crystallography of condensed matter physics of strongly correlated electron systems and advanced electron microscopy including ultrafast microscopy instrumentation. He is an Inaugural Fellow of Microscopy Society of America, a Fellow of American Physical Society and a Fellow of American Association for the Advancement of Science. He has published more than 500 peer-reviewed journal articles and delivered more than 300 invited talks at international conferences.

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