Femtosecond X-ray studies of strongly correlated electron systems

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A large number of condensed matter systems exhibit elusive correlations between different degrees of freedom. The strong interplay between charge, spin, and lattice gives rise to complex phase diagrams, with dramatic changes in the structural, magnetic, and transport properties associated with correlation effects. Recent developments in ultrafast technology enabled generation of femtosecond pulses from the THz spectral domain to the hard x-ray regime, allowing selective manipulation and measurement of a broad class of elementary excitations, which can be selectively triggered and separated in time. Ultrafast x-rays can provide direct information about the atomic and electronic structure, and how they evolve in response to specific impulsive excitations.

VO2 is a room-temperature, spin-Peierls insulator that undergoes a transition toward its metallic phase when photo-doped. We studied the dynamics of this ultrafast insulator-to-metal transition by means of a combination of femtosecond optical spectroscopy and femtosecond x-ray absorption on bulk, thin films and nanocrystals of this compound. The demonstration of femtosecond x-ray absorption spectroscopy was made possible by the use of broadly tunable bending-magnet radiation from ‘‘laser-sliced’’ electron bunches within a synchrotron storage ring. We measured the femtosecond electronic rearrangements occurring during the photoinduced insulator-metal phase transition in VO2. Symmetry- and element-specific X-ray absorption from V2*p* and O1*s* core levels (near 500 eV) separately measures the filling dynamics of differently hybridized V3*d*-O2*p* electronic bands near the Fermi level.

Recently, we have been working on the insulator-to-metal transition in perovskite manganites, in which we excite phonons using mid-IR light pulses, bypassing the more conventional photo-doping technique. Preliminary results will be reported about pump-probe experiments in Pr(1-x)CaxMnO3 and future femtosecond X-Ray experiments will be discussed

References