FEMTOSECOND X-RAY STUDIES OF PHASE TRANSITION DYNAMICS IN STRONGLY CORRELATED SOLIDS

Andrea Cavalleri

Materials Sciences Division, Lawrence Berkeley National Laboratory

A large number of solids exhibit elusive correlations between structural and electronic effects, appearing "simultaneously" in time-integrated measurements and evidencing ambiguities in their cause-effect relationship. However, the intrinsic response times of individual degrees of freedom of a condensed-matter system are dramatically different if observed on the ultrafast timescale. They range from the attosecond regime for electronic correlations to the hundred-femtosecond timescale for structural motion. Recent advances in ultrafast technology enable generation of femtosecond pulses continuously ranging from the THz to the hard x-ray spectral domain. Separate manipulation and measurement of different elementary excitations is therefore now possible on the fundamental timescale of a structural phase transition.

In this talk, I will discuss femtosecond x-ray/visible experiments in VO_2, a non-magnetic oxide undergoing an insulator-to-metal transition upon a ~1% structural distortion above 340 K [1]. The nature of the low-T phase of VO_2 has been heavily debated in the past [2,3], the issue being the respective roles of structural distortion (Peierls) and electronic correlations (Mott-Hubbard) in determining its insulating properties. I will firstly report on femtosecond x-ray diffraction experiments using short pulses of Cu-K_α fluorescence from a laser-produced plasma. A sub-picosecond, long-range structural transition is observed upon intense optical excitation of the low-temperature insulator [4]. I will then discuss experimental progress using femtosecond, tunable x-ray pulses at the *Advanced Light Source* [5]. Simultaneous measurements of NEXAFS [6] and EXAFS on the femtosecond timescale are a means of correlating the electronic transition with short-range structural dynamics, with particular respect to the roles of V-V and V-O distortions. Parallel studies on nanocrystalline forms of the same oxide permit investigations on the role of mesoscopic effects in the dynamics of the first-order phase transition. Finally, mid-IR femtosecond pulses (2-20 μm) are being developed for direct excitation of coherent V-O distortions in an IR-pump, x-ray probe experiment.

References

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