An X-ray view of light-driven quantum materials

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Intense ultrashort lasers are an extremely effective tool for controlling the properties of quantum materials and inducing emergent states with novel functionalities. Some of the most spectacular light-induced phenomena, such as superconducting-like phases, transient charge density wave ordering, and excitonic condensation, are found to occur in materials dominated by strong electronic correlations with a large susceptibility to external stimuli. Microscopically understanding these states of matter requires a direct measurement of their transient electronic dynamics and effective interactions. In this talk, I will show how ultrafast x-ray spectroscopy enables interrogating the microscopic physics of photoexcited quantum materials with unprecedented detail. I will discuss the generation of prethermal and metastable electronic states in light-driven Mott insulators, such as quasi-1D copper oxides, which are key to the emergence η-pairing condensation and light-driven superconductivity. Further, I will illustrate how femtosecond x-rays can systematically determine the charge and spin dynamics of these nonequilibrium phases.