Ultrafast thermometry via the pump-probe X-ray core-hole photoemission spectroscopy

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We calculate the the current of the electrons from a pump-probe x-ray photoemission spectroscopy experiment emitting electrons from a deep core-level hole. In this experiment, an intense light pulse excites electrons near the Fermi energy into nonequilibrium, and a second ultrashort high-energy x-ray probe pulse knocks out an electron from a deep core-level. The presence of the core-hole potential causes a particle-hole excitations within the conduction band, which ultimately result in a filling of the core-hole. The spectral function of a deep core-level hole provides information about the nonequilibrium dynamics of the electrons from the conduction band. We examine the spinless Falicov-Kimball model, which has an exact solution within the nonequilibrium dynamical mean-field theory. We found that there is a strong correlation between the integrated weights of the peaks of the X-ray photoemission spectra, with the equilibrium occupancies of the appropriate many-body states of the conduction electrons, which can be used as a probe of the effective temperature of the pump-excited electrons. Additionally, we calculated the X-ray absorption spectra (for the same model), which also demonstrate a strong correlation with the occupancies and can also be employed for ultrafast thermometry.