Nonlinear resonant Auger spectra and transient x-ray absorption spectra in CO using an x-ray pump-control scheme

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Synopsis In this work we propose nonlinear femtosecond x-ray pump-probe spectroscopy to study the vibrational dynamics of a core-excited molecular state and discuss numerical results in CO. A femtosecond pump resonantly excites the carbon core-excited $1s$-$1\pi^*$ state of the CO molecule. A second strong probe (control) pulse is applied at variable delay and is resonantly coupled to a valence excited state of the molecule (Fig. **1**).The strong nonlinear coupling of the control pulse induces Rabi flopping between the two electronic states. During this process, a vibrational wave packet in the core-excited state is created, which can be effectively manipulated by changing the time delay between pump and control pulses. We present an analysis of the resonant Auger electron spectrum (Fig. **2**) and the transient absorption or emission spectrum (Fig. **3**) on the pump transition and discuss their information content for reconstruction of the vibrational wave packet [1].
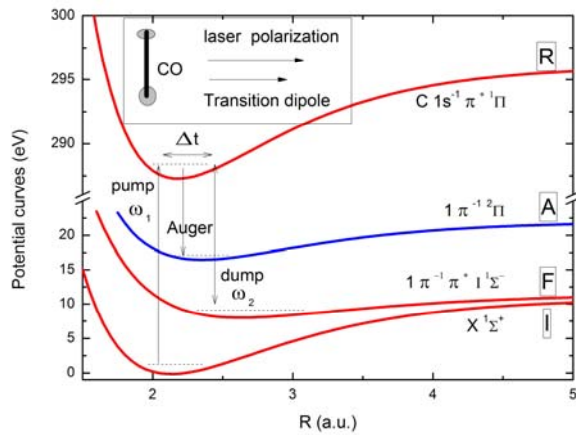
FIG. 1. Potential-energy curves for the four involved electronic states and the schematics of the present pump-probe scheme. The optical nonlinear interaction is caused by the strong probe (control) pulse on the transition between states R and F.
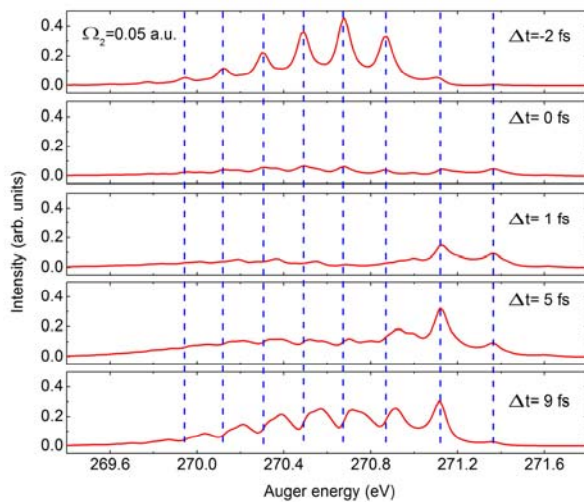

Fig. 2. The resonant Auger spectra for different Δt for a strong control pulse of $\omega_2 = 277.6$ eV and $\Omega_2 = 0.05$ a.u.
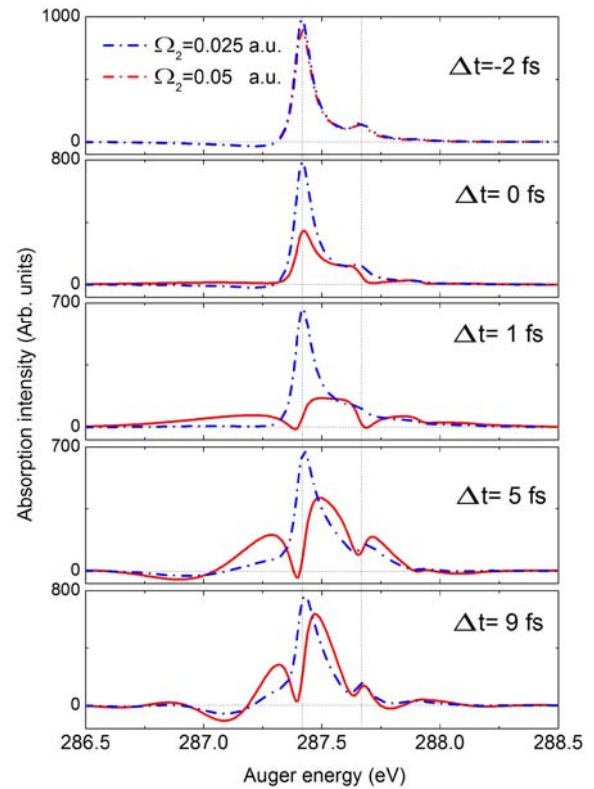

Fig. 3. X-ray transient absorption or emission spectra of CO for the pump field around 287.4 eV. Shown is a comparison for weak and strong control pulses. The absorption or emission peaks for the case of $\Delta t = -2$ fs are labeled as vertical dashed lines.

References

[1] S. B. Zhang, V. Kimberg, and N. Rohringer, Phys. Rev. A **94**, 063413 (2016)

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