Atomic, Molecular, and Optical Physics Using Short-pulse Soft X rays

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The proposed short-pulse soft x-ray facility at the Advanced Photon Source offers numerous opportunities for research on chemically important atoms and molecules containing first-, second-, and third-row elements. Low-Z elements have relatively narrow core-hole widths, so symmetry-selective core-to-valence resonances in x-ray absorption spectra are generally well resolved. The high repetition rate of APS is well suited to coincidence and event-mode measurements, and high rep-rate lasers can be used to initiate dynamical processes including dissociation, ionization, isomerization, and impulsive alignment. Optical control of resonant x-ray absorption [1] was demonstrated [2] at the ALS femto-slicing beamline by using a strong laser pulse to couple the core-excited states of atomic neon. In molecules, a strong infrared laser field is predicted to couple symmetry-allowed and symmetry-forbidden core-hole states [3]. Experimentally, optical control of x-ray processes remains largely unexplored. The advantage of SPX for such experiments is that high repetition rate, picosecond lasers of modest power can be used to produce the required peak intensities of $\sim 10^{13}$ W/cm^2. Beyond this class of laser-dressed experiments that depend only on wavelength and intensity, will be x-ray probes of coherently controlled atoms and molecules using amplitude-shaped pulses [4].

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[2] T. E. Glover *et al*., "Controlling x rays with light," *Nature Phys*. **6**, 69 (2010).
[3] J.-C. Liu *et al*., "Symmetry-forbidden x-ray Raman scattering induced by a strong infrared-laser field," *Phys. Rev. A* **77**, 043405 (2008).
[4] H. Rabitz *et al*., "Wither the future of controlling quantum phenomena?," *Science* **288**, 824 (2000).