Strong field control of x-ray processes

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Control of x-ray processes using intense optical lasers represents an emerging scientific frontier—one which combines x-ray physics with strong-field laser control. While the past decade has produced many examples where phase and amplitude controlled lasers at optical wavelengths are used to manipulate molecular motions, the extension to control of ultrafast, intraatomic, inner-shell processes is quite new. Gas phase systems are particularly suitable for illustrating the basic principles underlying combined x-ray and laser interactions. We will discuss three scenarios by which strong electromagnetic fields can be used to modify resonant x-ray absorption in a controlled manner: (1) Ultrafast-field ionization of atoms[1] at laser intensities in the range 10^{14}–10^{15} W/cm^2; (2) modification of electronic structure of inner-shell-excited systems by laser dressing[2] at 10^{12}–10^{13} W/cm^2; and (3) control of resonant x-ray absorption by molecules through laser-induced spatial alignment[3] at 10^{11}–10^{12} W/cm^2. The x-ray microprobe methodology developed for these demonstrations can be applied to ultrafast imaging of laser-controlled molecular motions and Ångstrom-level structural imaging of biomolecules without the need for crystallization.

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