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Progress in coherence and dynamics of x-ray and inner-shell processes[1]

STEPHEN SOUTHWORTH, Argonne National Laboratory

X-ray and inner-shell processes are being investigated with new experimental and theoretical tools. X-ray free-electron lasers (XFELs) can generate one or two intense, ultrafast x-ray pulses that produce inner-shell holes and probe their decays in atoms, molecules, clusters and nanoparticles. Seeding techniques generate XFEL pulses with narrow bandwidths and high temporal coherence that enhance opportunities for exploiting quantum optics methods in the x-ray regime. Optical lasers combined with x-rays can control populations of core-excited states, exploit sidebands on resonant Auger transitions, and explore interatomic charge transfer [1,2]. Theoretical simulations can model the complex ionization pathways initiated in a many-electron atom by an XFEL pulse [3]. Those topics are reviewed along with results of pump-probe experiments using two XFEL pulses to produce inner-shell holes and probe the electronic decays and fragmentation of molecular ions.

[1] A. Picón *et al.*, Phys. Rev. A **87**, 013432 (2013); New J. Phys. **15**, 083057 (2013).
[2] B. Erk *et al.*, Science **345**, 288 (2014).
[3] P. J. Ho *et al.*, Phys. Rev. Lett. **113**, 253001 (2014).

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