Resonance-Enhanced X-ray Multiple Ionization of Heavy Atoms at LCLS Studied by Covariance Mapping

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The interaction of ultra-intense X-rays with xenon [1] and krypton [2] atoms was studied at the Linac Coherent Light Source (LCLS) using ion time-of-flight (TOF) and X-ray fluorescence spectroscopy at two photon energies (1.5 keV, 2 keV) with different X-ray pulse lengths and various pulse energies. Following a series of inner-shell ionizations, unprecedentedly high charge states were reached within a single shot. Xenon, in particular, was ionized up to 36+, which requires ionization energies far exceeding the photon energy. Combined experimental and theoretical analysis of ion charge state distributions and simultaneously recorded fluorescence spectra showed that resonant excitations are responsible for the enhanced ionization. This resonantly enhanced X-ray multi-ionization process (REXMI) is predicted to boost ionization in certain ranges of photon energy and thus enhance radiation damage in the vicinity of heavy atoms.

To demonstrate the advantage of simultaneous shot-to-shot measurements of the X-ray fluorescence along with the ion TOF spectra, we employ a statistical analysis, the so-called covariance mapping [3], to extract fluorescence spectra for individual final ionic charge states produced by the X-ray multi-photon ionization of neon and xenon atoms. These covariance spectra provide information about transient core-hole states populated during the multiple ionization pathways *before* the final charge state is reached.

References:

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