Atoms and molecules under ultra-intense X-ray pulses: from soft to hard X-rays

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Understanding the response of atoms and molecules to intense, ultrafast X-rays is a key issue for numerous exciting applications of Free-Electron Lasers. It allows a microscopic view of processes such as radiation damage, which ultimately limit, e.g. the resolution that can be obtained from femtosecond x-ray diffraction experiments.
Here, we report on a series of experiments studying X-ray interactions with isolated heavy atoms and similar atoms embedded into molecular systems under unprecedentedly high intensities. Complementing our previous studies of the ionization of heavy atoms and heavy-atom containing molecules under intense soft X-ray radiation [1,2], we now extended these measurements to ultra-intense hard (5.5-8.3 keV) X-rays from the CXI nanofocus endstation. Reaching unprecedented X-ray intensities of ~ 10^{20} W/cm^2, we observe a record 48+ charge state for xenon atoms. Although the highest charge states are produced at the highest photon energy, the wavelength dependence of the spectra from 5.5 to 8.3 keV shows significant overall enhancement in the production of high charge states at the intermediate photon energies (6.5 keV). Similar to the soft X-ray regime, this behaviour results from the ionization enhanced by intermediate resonant excitations. We also studied molecular systems with embedded heavy atoms and present the first results for small (CH_3I) and medium-size (C_6H_5I) polyatomic molecules ionized in the CXI nanofocus.

References

[1] B. Rudek *et al.*, Nature Photonics **6**, 858 (2012).
[2] B. Erk *et al*., Phys. Rev. Lett. **110**, 053003 (2013).