Inner Shell Excitation During High Harmonic Generation: The Giant Resonance in Xenon

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Abstracts: *Recolliding electrons with energy greater than 100 eV are shown to cause inner shell excitation in xenon atoms. This leads to high harmonic emission associated with the 4d shell even though a 5p electron was initially ionized.*

Long-wavelength few-cycle laser sources can extend the photon energy of high harmonic sources into the water window and beyond. We report a high harmonic study of xenon atoms using a 1.8 μm, 2 cycle CEP-stable laser source [1]. These spectra contain features due to collective multi-electron effects involving inner shell electrons, in particular the giant resonance at 100 eV.

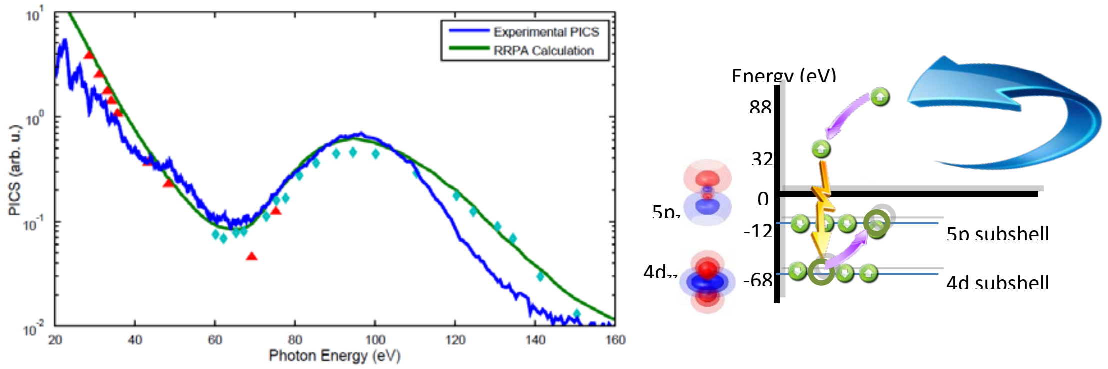

Fig. 1: (Left) The HHG spectrum from xenon. The blue curve is from the HHG experiment. The green curve is a multi-electron calculation of the photoionization cross section. The symbols are synchrotron measurements of the cross section. (Right) Effect of inelastic scattering on HHG. The returning electron can promote a lower lying electron into the valence band and then re-combine to the vacancy in the lower lying state. A 100 eV photon is emitted by recombination to the 4d vacancy.

The large enhancement seen at 100 eV is recognized from photoionization studies as the xenon giant resonance. The peak results from the influence of inner shell 4d electrons (binding energy 70 eV) which have a large photoionization cross section in this region. The recolliding electron has sufficient energy to cause an e-e Coulomb interaction with the 4d electron, which is promoted to fill the 5p hole. The 4d hole is later filled by the continuum electron, leading to the emission of an xuv photon. Remarkably, the process results in phase matched emission. This represents the first time that e-e correlations and excitation of the ion have been observed in gas phase HHG [2]. We show that high harmonic spectroscopy gives access to multi-electron dynamics through their spectral signature, much as in photoionization studies, but with the added potential of attosecond temporal resolution.

[1] B.E. Schmidt et al. “Compression of 1.8 micron laser pulses to sub two optical cycles with bulk material,” Appl. Phys. Lett. 96, 071111 (2010).
[2] A.D. Shiner et al., "Probing collective multi-electron dynamics in xenon with high harmonic spectroscopy ", Nature Physics 7, 464 (2011).