

One Colour (EUV) Multiphoton Ionization and Two Colour (EUV + IR) Photoionization Control at Free Electron Lasers - Neon and Acetylene

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Short wavelength free electron lasers, operating in the EUV and X-ray spectral ranges and interacting with atoms and molecules, establish the primacy of few photon-few electron effects. One consequence is that it is difficult to drive direct (simultaneous) multiphoton ionization (MPI) processes unless very high intensities are reached [*e.g.*, 1 and Refs within]. Examples of direct observation of even two photon (direct) ionization (2PI) *via* electron spectroscopy are quite sparse in the literature [*e.g.*, 2,3].

In a recent look-back at some data from the FLASH FEL in Hamburg [4] we observed direct 2PI and even 3PI (1P1 + 2PI) with a Ne target. This case will be presented in Part 1 of the talk. Specifically, Ne was irradiated with intense 93 eV free electron laser (FEL) pulses at FLASH and studied with the aid of photoelectron spectrometry. This resulted in two and three photon, single and double ionization of neon, removing electrons from 2s and 2p subshells of the neutral Ne atom via multiple different pathways. The spectral features of the photoelectrons were identified through comparison with the NIST database and field averaged time- dependent density matrix theory. The calculations show the direct multiphoton ionization processes to be extremely sensitive to the focused FEL intensity [5].

In Part 2 of the talk an open-loop control scheme of molecular fragmentation (acetylene) will be presented [6]. It is based on transient molecular alignment combined with single-photon ionization induced by a short- wavelength free electron laser (FEL). Photoelectron spectra, complementing ion yield measurements, are used to demonstrate that the control scheme results from changes in the electronic response with molecular orientation relative to the ionizing field. The experimental findings are supported by theoretical calculations.

If time permits some comments on attosecond XFELs from an overview talk presented at the UK XFEL ‘Town Hall’ meeting ‘Frontiers of Measurement’ [7] in Belfast, June 2023 will be given.

References

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