

An atomic two-color XUV interferometer

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Synopsis The relative phase of first (ω) and third harmonics (3ω) extreme ultraviolet light pulses was varied to control the population of the $2s^2$ state in helium through the interference of $\omega + \omega$ and $3\omega - \omega$ two-photon excitation paths. Maximum photoelectron yield occurs when the relative phase of the two harmonics matches the phase difference of complex atomic amplitudes governing the two excitation paths. These results open the way to access phase differences of two-photon ionization paths involving energetically distant intermediate states and to perform interferometry in the extreme ultraviolet range by monitoring final state populations.

Quantum mechanics offers a unique possibility to control transition probability by setting up relative amplitudes of two or more paths leading from one initial to one final state. The last decade has seen rapid development of intense free-electron laser (FEL) sources and the question arises whether the coherent control can be executed entirely by using the extreme ultraviolet (XUV) light. We report here the results of an experiment at the free electron laser facility FERMI where the novel $\omega + \omega$ and $3\omega - \omega$ two-photon interference scheme (Fig. 1) is employed to manipulate the population of $2s^2$ doubly excited state in He. Recently, the 2ω and $\omega + \omega$ absorption paths were combined to measure angle-resolved phases in atomic photoemission [1]. The presented approach is a development of previous all-optical coherent-control experiments [2] and RABBITT experiments [3], entering the XUV wavelength range, and demonstrates the possibility to measure phase difference of multi-photon excitation paths connecting energetically distant intermediate states by observing the final state populations. The two-path experimental configuration thus forms an atomic XUV interferometer, where an ensemble of atoms delivers a maximum response in terms of the emitted electron yield when the phase difference of the ω and 3ω XUV harmonic components at the target equals an atom-specific value for the selected pair of

light frequencies.

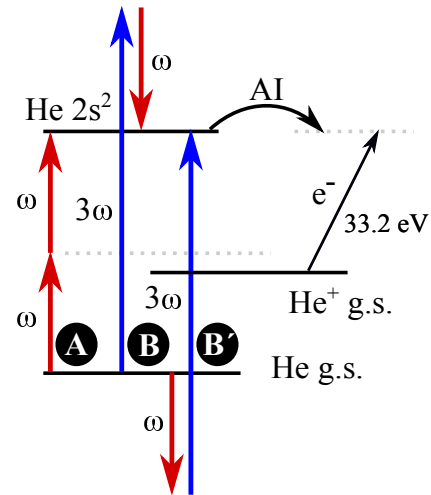


Figure 1. Two-photon excitation of the $2s^2$ autoionizing state in helium with the fundamental (ω , short red vertical arrow) and the third harmonic (3ω , long blue vertical arrow). Path A: two-photon $\omega + \omega$ excitation; path B: two-photon $3\omega - \omega$ excitation; path B' (time-reversed path B): two-photon $-\omega + 3\omega$ excitation; AI: autoionization decay.

References

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