Interference effects in laser assisted photo-ionization of atoms

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Synopsis Interference effects in laser assisted photoionization of atoms by an XUV pulse is considered by means of the Coulomb Volkov approximation. We find that the interference pattern can be related with the time delay between the laser and the XUV pulse.

In this work, we study the angular and energy distribution of photoelectrons generated by an attosecond-pulse in the presence of a strong laser field. This kind of process is particularly relevant to understand attosecond streak camera experiments [1] where an intense pulse exchange many photons with the electron after it has been ionized by a weaker and shorter pulse. The duration of the attosecond pulse, the shape of the IR streaking field and the time delay between them are the three main parameters that rule the measurements. Henceforth, finding a reliable theory allows to reconstruct some of this features from the available data.

The usual theory for streaking experiments is the strong field approximation (SFA) where the photoelectron is assumed to be influenced only by the strong laser field neglecting the interaction with the the atomic core. However, differences between the predictions of the SFA and more accurate calculations involving Coulomb atomic potential were found in the double differential distributions [2]. The present work is based on the Coulomb Volkov Approximation (CVA) [3]. In this approximation the evolution of the electron after ionization is influenced by both the Coulomb potential and the laser field. In the Figure 1, we present double differential probability for laser assisted XUV photoionization of H in the forward (Figs. 1a and 1c) and backward (Figs. 1b and 1d) direction. The IR laser parameters are wavelength $\lambda = 800$ nm, 8-cycle envelope and laser intensity $I_L = 2 \times 10^{13}$ W cm^{-2}. The XUV pulse has a 8-cycle envelope, with a mean energy of $\omega_X = 90$ eV, and pulse intensity $I_X = 1 \times 10^{11}$ W cm^{-2}. The laser and XUV pulses have a $\sin^2$ profile. In Figs. 1a and 1b the XVU pulse center is delayed half laser cycle respect to the center of the laser pulse while in Figs. 1c and 1d there is no delay between the XVU an the IR pulse. We find that time delay between the pulses produces an interference pattern which is smoothed when the time delay is reduced. This interference can be rooted from ionization pathways of electrons emerged at different instants of the XUV pulse. In this way is possible to estimate the time delay between the pulses characterizing the interference pattern. Preliminary time-dependent Schödinger equation calculations show that this characterization is very sensitive to the fine details introduced by the Coulomb interaction when the electron is in the continuum state.

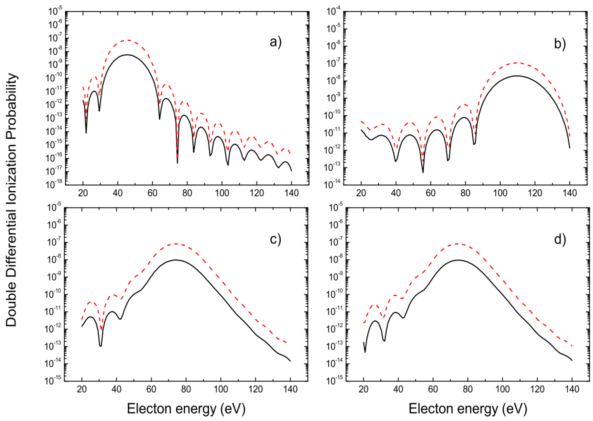

Fig. 1. Double differential ionization probability. Full lines: CVA. Dashed lines: SFA. a) Forward ionization with time delay. b) Backward ionization with time delay. c) Forward ionization without time delay. d) Backward ionization without time delay.

References

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