Photoelectron emission from atoms by ultra-short pulses: Impulse Coulomb-Volkov description.

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Synopsis: Ionization of atomic targets produced by ultra-short laser pulses is studied within a distorted-wave formalism. We introduce the Impulse Coulomb-Volkov (ICV) approximation, which makes use of the Volkov phase to describe the action of the electromagnetic field on both the initial and final channels. Here photoelectron emission from hydrogen is used as a benchmark for the theory, comparing the results to values derived from the numerical solution of the time-dependent Schrödinger equation (TDSE). We found the ICV method represents an improvement over the CV approach for laser frequencies lower than the initial electronic energy.

As a consequence of recent developments of laser facilities, photoelectron emission from atomic targets induced by strong and ultra-short laser pulses has been the subject of intense theoretical and experimental research in the last few years [1].

To describe this process, in addition to the numerical solution of the time-dependent Schrödinger equation, a considerable number of distorted-wave approaches have been proposed. Most of them are based on the use of the Coulomb-Volkov wave function to represent the final channel, while the initial channel is considered as unperturbed.

In this work we calculate the Impulse Coulomb-Volkov (ICV) approximation, which introduces the electron-laser interaction in the initial and final channels, both on equal footing. Within the ICV approach the final distorted state is represented with the Coulomb-Volkov wave function, while the initial state is described by means of ICV wave function given by Eq. (7) of Ref. [2]. This function takes into account the complete Volkov distortion of the initial bound state, satisfying the proper asymptotic conditions.

The method is applied to evaluate the ionization probability of hydrogen targets, considering different frequencies and durations of the laser pulse. In Fig. 1 and 2 we show ICV results for electromagnetic fields in the multi-photon and collisional regimes respectively, comparing them to values obtained from the numerical solution of the TDSE and the CV approximation.

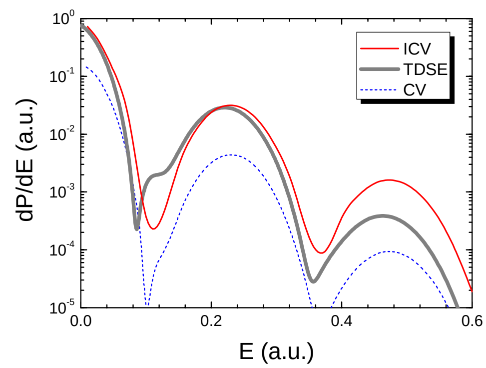

Fig. 1. Electron energy spectra of hydrogen for a six-cycle laser pulse with a field strength $E_0 = 0.05$ a.u. and a carrier frequency ω=0.25 a.u.

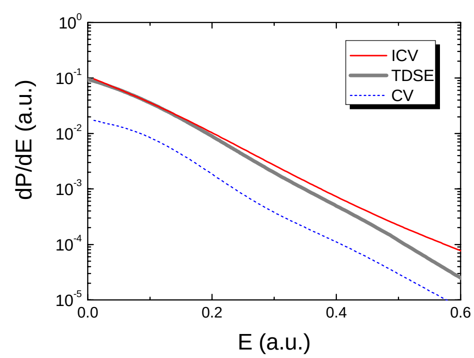

Fig. 2. Similar to Fig. 1 for a pulse with $E_0 = 0.05$ a.u., ω=0.25 a.u., and a duration τ=40 a.u.

References

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[2] P. A. Macri *et al., J. Opt. Soc. Am. B.* **20** 1801 (2003).

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