Few-cycle strong-field ionization of atomic hydrogen with elliptically polarized infrared light

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Synopsis The strong-field ionization of atomic hydrogen induced by elliptically polarized light is studied in detail. In particular, we investigate the ionization spectra for various pulse characteristics, consider the circular dichroism from an excited oriented electronic state, and finally analyze the tunneling regime for few-cycle pulses.

The utilization of pulses with elliptical or circular polarization is currently of great interest due to many important applications, such as photoelectron circular dichroism for the investigation of chiral molecules, or in attoclock experiments to time-resolve the dynamics of light absorption by atoms and molecules. Even for the simplest case of atomic hydrogen, the ultrafast electron dynamics in an intense few-cycle elliptically polarized optical pulse represents a complex problem, whose complete description remains a challenge.

In this work, we present a detailed theoretical and computational investigation of the strong-field ionization of atomic hydrogen by elliptically polarized light in the long-wavelength regime (800 nm). Solving the time-dependent Schrödinger equation, we analyze the ionization spectra at various peak intensities up to 4×10^{14} W/cm^2 for a variety of pulse ellipticities. The calculations are performed with the length and velocity forms of the electric dipole operator. In particular, we compare the extreme cases of circularly and linearly (studied in [1]) polarized light, considering important features such as the partial-wave population over time and the maximum angular momentum needed to achieve convergence.

Starting from an oriented atomic state, we also consider the dynamics (see Figure 1) responsible for the circular dichroism [2], from the multiphoton to the tunneling regime and a variety of pulse lengths. A model based on the strong-field approximation is employed in an attempt to predict the variation of the dichroism as a function of the laser peak intensity.

Finally, we analyze the asymptotic electron momentum distribution and its offset angle with respect to the starting direction of a circularly polarized pulse to shed some light on the electron dynamics in the tunneling regime and to assist in the design and understanding of attoclock experiments.

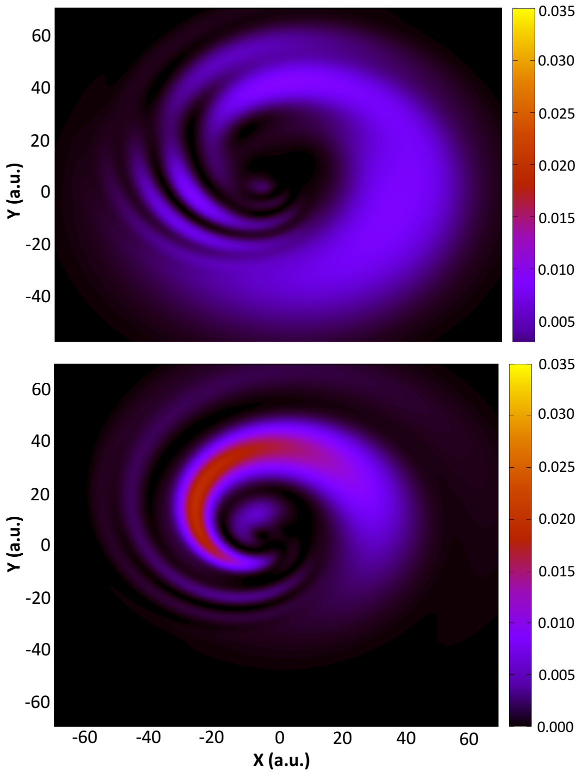

Figure 1. Electron wave-packet probability ($t = 5$ fs) in the photoionization of hydrogen initially in an oriented 2p state, induced by a 4-cycle 770 nm circularly polarized infrared pulse with peak intensity 4×10^{13} W/cm^2, for the initial state co-rotating (top panel) or counter-rotating (lower panel) with the field.

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References

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