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Spatial interference during the ionization of noble gas atoms by few-cycle XUV laser pulses

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Synopsis We have investigated the spatial interference effects, which appear during the ionization of noble gas atoms by few-cycle XUV laser pulses. By using *ab initio* calculations, and single active electron model potentials, we have studied how the spatial interference pattern is influenced by the atomic species of the target.

At high field intensities, when a few-cycle laser pulses interact with atomic systems, the dominant process is the ionization. During and after the ionization secondary processes also occur, which have a significant impact on the final momentum distribution of the electrons. These secondary processes are mainly the result of interference between electronic wave packets following different paths[1]. From the numerous possible scenarios only two have significant impact on the final momentum distribution of the free electrons: In the first scenario electronic wave packets emitted at different time moments interfere (temporal interference) leading to a fringe structure in the electron energy spectrum [2], consisting of circular interference maxima and minima (see the $k_{par} < 0$ part of Fig. 1). In the second scenario electronic wave packets emitted at the same time (i.e. during the same quarter pulse cycle) follow different paths, accumulating different final phases, leading to a radial fringe structure (see the $k_{par} > 0$ part of Fig. 1) in the electron spectra [1]. This radial fringe structure is a result of the interference between the direct (i.e. unscattered) and the scattered wave packets, where the direct wave packet can be considered as a reference, while the scattered wave packet as a signal wave. In this picture the interference fringe structure can be interpreted as the holographic mapping (HM) of the target atoms or molecules state [1].

So far, we have studied in details [3] how the structure of the HM interference pattern is influenced by the laser pulse parameters, and in agreement with other studies [1], we found that the density of the HM interference fringes is mainly determined by the z_0 parameter, i.e. the distance reached by the free electronic wave packet before it is redirected toward the core.

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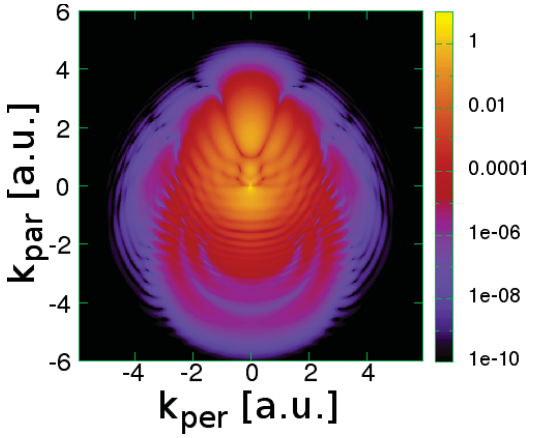

Figure 1. Ionization probability density as a function of electron momentum components for the ionization of H atom by a laser with $\tau = 28.26$ a.u. duration, $E_0 = 1$ a.u. field strength, and $\omega = 0.4445$ a.u. frequency.

As a continuation of these studies, we have investigated how the HM pattern is influenced by the binding Coulomb potential (i.e. by the atomic species of the target) using single active electron (SAE) model potentials [4] to represent the He, Ne, and Ar atoms. For the given model potentials the time-dependent Schrödinger equation was solved numerically (time-dependent close-coupling method), and accurate ionization probability densities were calculated by projecting the calculated time-dependent wavefunctions into exact continuum eigenstates.

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