Photoionization of hydrogen by a chirped, short X-ray pulse in the presence of a laser field

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Photoionization of hydrogen by a chirped, short X-ray pulse in the presence of a laser field

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Synopsis The ionization of hydrogen by a chirped XUV pulse in the presence of a few cycle infrared laser pulse is investigated. It is found that the combined action of the chirped pulse and the laser field brings about asymmetries in the photoelectron momentum distribution that may be exploited for obtaining information on both the chirp and XUV pulse duration.

We report on the properties of the momentum distribution of electrons ionized from the ground state of the H atom by a relatively weak single attosecond XUV pulse in the presence of an IR laser pulse. The effect of an additional IR laser pulse on the momentum distributions of photoelectrons produced by a few-cycle attosecond XUV pulse with well-defined carrier envelope phase has been addressed in ref. [1]. Here our focus is on the effect produced by a linearly chirped attosecond XUV pulse on the photoelectron spectra. The case study is the hydrogen atom ionization by the simultaneous action of a XUV pulse and an IR radiation. An approximate analytical form of the differential ionization probability giving the electron momentum distribution produced by the XUV ionization in the presence of the IR radiation may be derived by treating the interaction of the atom with the XUV pulse at the first order of the time-dependent perturbation theory and describing the freed electron by the Coulomb-Volkov wavefunction that is assumed, though approximately, to account for the the electron interaction with both the Coulomb and the IR fields by taking both the pulses linearly polarized along the z-axis and in dipole approximation.

In our calculations an attosecond, linearly chirped Gaussian, XUV pulse will be assumed with the electric field given by

$$E_H(t) = E_{0H} \exp\left\{-\frac{4\ln 2}{(1+\beta^2)\tau_H^2}(t-t_H)^2\right\} \cos\left(\omega_H(t-t_H)+\delta(t)\right) \quad (1)$$

where $\delta(t) = (4\ln 2)[\beta(t-t_H)^2/(1+\beta^2)\tau_H^2]$ and β stands for the dimensionless linear chirp rate.

The IR laser electric field, with frequency ω_L and field amplitude E_{0L}, is taken as

$$\mathbf{E}_L(t) = E_L(t)\hat{\mathbf{u}}_z = E_{0L} f(t)\cos(\omega_L t)\hat{\mathbf{u}}_z \quad (2)$$

with $f(t) = \cos^2 \pi t/\tau_L$ for $-\tau_L/2 \leq t \leq \tau_L/2$ and zero elsewhere, τ_L is the total IR pulse duration.

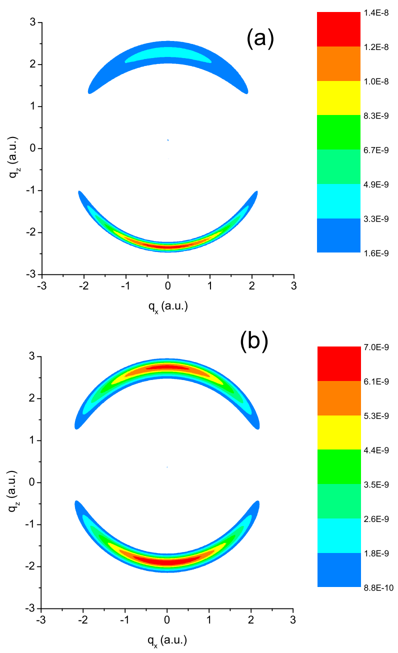

Figure 1. Momentum distribution $P(q_x, 0, q_z)$ of photoelectrons ionized by a XUV pulse having $\tau_H = 150$ $asec$ FWHM, $\beta = \sqrt{3}$, central photon energy $\omega_H = 90$ eV and peak intensity $I_H = 10^{11}$ W/cm^2, in the presence of a 6-cycle IR pulse with wavelength 750 nm and peak intensity $I_L = 2\cdot 10^{13}$ W/cm^2. The peak of the XUV pulse is centered at (a) $t_H = 0$ and (b) $t_H = T_L/4$, T_L being the IR pulse period.

References

[1] L.-Y. Peng, E.A. Pronin and A. Starace 2008 *New J. Phys.* **10** 025030

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