# Retardation effects in two-colour ionization of hydrogen with keV electromagnetic field


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We investigate theoretically the ionization of hydrogenlike atoms in the presence of a superposition of *two* short radiation pulses, linearly polarized along the same direction, with frequencies in the XUV spectral range. The atom is described in nonrelativistic quantum theory. We use two methods: i) integration of time dependent Schrödinger equation and ii) perturbation theory. In this spectral range and for intensities of the order of the atomic unit $I_0$=3.51 $10^{16}$ W/cm$^2$, we expect both theoretical approaches to be adequate and to give comparable results.

For the mentioned working conditions the ionization yield is dominated by one photon absorption. In the present study we focus on the ionization processes involving *two photons*: a) one photon *absorbed* and one photon *emitted* (*stimulated* Compton diffusion) and b) *absorption* of two photons (with the same or different frequencies). Although their contributions to total ion yield is in general a minor one compared to that of one photon ionization, in our results the two photon ionization can be clearly identified in the energy and angular distributions of the ejected electrons.

We present and analyse results for several choices of the parameters describing the two laser pulses: intensities of the order 1-10 $I_0$, frequencies in the range 1-3 keV and durations of 20-30 cycles or higher. We investigate several configurations, differing by the angle $\beta$ between the propagation directions of the two pulses. Since in dipole approximation the results are independent on this angle, any dependence on the relative propagation direction is essentially related to *retardation* corrections. We find that the two-photon ionization process a) (see above) is more sensitive to retardation effects than the processes b) induced by a single [1-3] or two XUV pulses. We analyse these effects and the validity of a simple scaling law relating the energy spectrum with the angle $\beta$.

Examining the photoelectron angular distributions we find different behaviours for the two kinds of processes mentioned above. For ionization by absorption of two photons the angular distributions are similar with those presented in [1,2]. For stimulated Compton diffusion the angular distributions are strongly influenced by the relative direction of photon momenta. We analyse this feature considering the roles played by $\mathbf{A}^2$ and $\mathbf{A}\cdot\mathbf{P}$ coupling terms from the Hamiltonian (**A** is the vector potential and **P** the electron momentum). For the stimulated Compton diffusion leading to the emission of low energy electrons the role of $\mathbf{A}^2$ is dominant in most of the situations. This feature is clearly observed for photon energies of the order of the keV and it is accentuated for increasing photon energies.


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References:


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