Stimulated Compton Scattering of two-color soft x-ray FEL radiation by hydrogen

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We consider the ionization of the hydrogen atom interacting with a coherent superposition of two pulses in the soft x-ray domain (in the frequency range of few hundred of eV's). In stimulated Compton Scattering (SCS) a two-color radiation is applied, one photon (from field 1) is absorbed while the second photon (from field 2), of smaller energy, is emitted. The photon energy difference is absorbed by the ionized electron. We use the two theoretical approaches developed in previous works, i.e., the resolution of the time dependent Schrödinger equation (TDSE) and an approach based on perturbation theory [1,2]. We calculate the SCS photoelectron energy distributions, ionization rates and angular distributions at various relative directions of propagation of the pulses.

The nonrelativistic Hamiltonian operator is written:

$$\mathrm{H}=\frac{1}{2m_e}[\mathbf{P}-\mathrm{e}\mathbf{A}(\mathbf{r},\mathrm{t})]^2+\mathrm{e}\Phi(\mathbf{r},\mathrm{t})+\mathrm{V}(r)$$

Where $\mathbf{A}(\mathbf{r},\mathrm{t})$ and $\Phi(\mathbf{r},\mathrm{t})$ are the vector and scalar potentials. We work in the Coulomb gauge ($\Phi(\mathbf{r},\mathrm{t})=0, \nabla\cdot\mathbf{A}=0$), the vector potential for the two-color electromagnetic field is written:

$$\mathbf{A}(\mathbf{r},\mathrm{t})=\mathbf{A}_1(\mathbf{r},\mathrm{t})+\mathbf{A}_2(\mathbf{r},\mathrm{t})$$

The polarization of the fields is parallel to the *z*-axis, they propagate in the *x-o-y* plane with a relative propagation angle β. The figure below shows the photoelectron spectra calculated for $\hbar\omega_1$ = 15 a.u., $\hbar\omega_2$ = 14 a.u., and for two propagation directions; β=0 (parallel propagation) and β=π/2 (perpendicular propagation). The two pulses overlap in time, the total pulse duration being 12π a.u. and the intensity 3.51 10^{16} W/cm². The calculations are performed using the nonperturbative (TDSE) approach with the full Hamiltonian (FH, full red line) and in the dipole approximation (DA, dashed line). The figure shows the two peaks associated with one-photon ionization (close to 15 a.u.) and the SCS peak close to threshold. For one-photon ionization the FH and DA curves overlap; nondipole effects are negligible in this case. For the SCS peak, the FH and DA curves differ significantly, in particular for perpendicular propagation. In the latter case the term $\mathbf{A}(\mathbf{r},\mathrm{t})^2$, usually neglected in dipole approximation, plays a crucial role. These effects will be discussed at the conference.

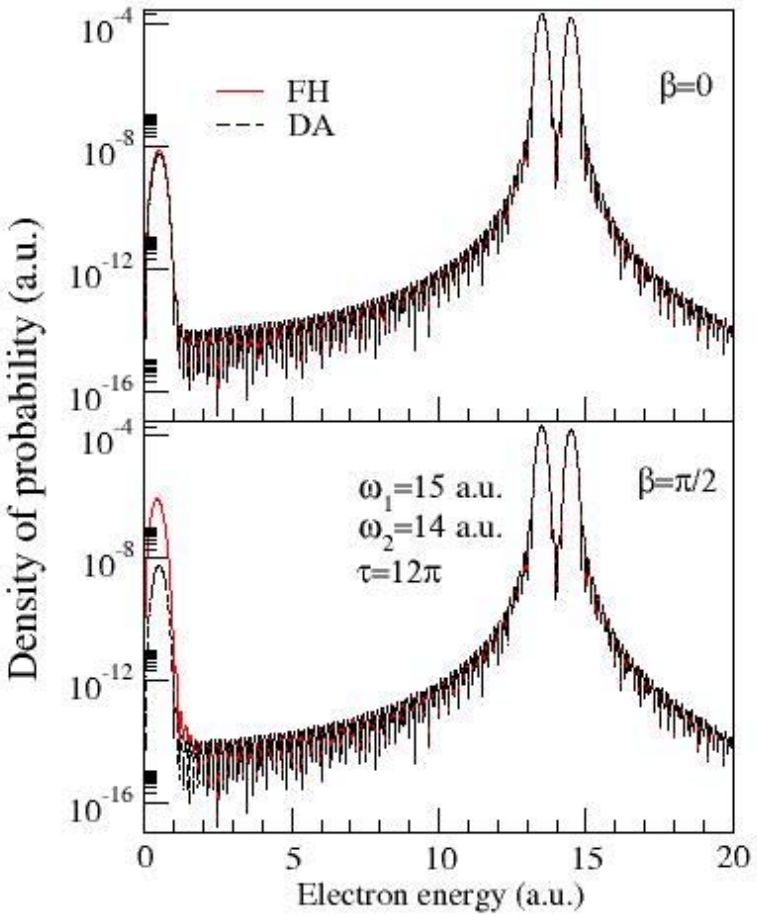

Figure: Photoelectron spectra calculated in nonperturbative approach, solving the TDSE. Calculations are performed using the full Hamiltonian (FH) and in dipole approximation (DA). The laser intensity is 3.51 10^{16} W/cm^2, β refers to the relative propagation angle of the two electromagnetic fields (see the text).

References:

[1] H. Bachau, M. Dondera, V. Florescu, *Stimulated Compton Scattering in two-color ionization of hydrogen with keV electromagnetic field*, Phys. Rev. Lett. **112**, 073001 (2014)

[2] M. Dondera, V. Florescu, H. Bachau, *Two-color ionization of hydrogen close to threshold with keV photons,* Phys. Rev. A **90**, 033423 (2014)