Contribution of the Collective Electron Dynamics to the Polarization Response of an Atom Subjected to an Intense IR and Weak XUV Pulses

A A Romanov[1,2], A A Silaev[1,2], N V Vvedenskii[1,2], A V Flegel[1,3], and M V Frolov[1,3]

[1] *Faculty of Radiophysics, Lobachevsky State University of Nizhny Novgorod, 603950, Nizhny Novgorod, Russia*
[2] *Institute of Applied Physics, Russian Academy of Sciences, 603950, Nizhny Novgorod, Russia*
[3] *Theoretical Physics, Voronezh State University, 394018, Voronezh, Russia*
Contact Email: flegel@cs.vsu.ru

The high-order harmonic generation (HHG) process can be well described in terms of an atomic polarization response (APR), which determines the HHG amplitude at a given frequency. This response is the key object for studying the propagation effects of a pump field and secondary generated radiation (SGR) through a laser-modified gas medium, which can enhance or suppress a radiation at a given frequency.

In this work, we analyze the HHG in an intense infrared (IR) field assisted by a weak extreme ultraviolet (XUV) isolated attosecond pulse (IAP). Our theoretical analysis is based on the recently developed adiabatic aproach for the laser-dressed atomic state in an intense IR and weak XUV pulses [1]. This approach accurately treats effects of the binding potential, while the interaction of an electron with an intense IR and perturbative XUV pulses is considered with quasiclassical accuracy and within the perturbation theory, respectively. Thus, our approach can be used for a theoretical justification a physical mechanism of XUV-related APR-increasing (see, *e.g.*, [2]). To take into account collective electron effects in HHG, we numerically solve the time-dependent Kohn-Sham equations for the Ne atom dressed by XUV and IR laser pulses.

Based on the analytical expression for the XUV-assisted HHG amplitude and numerical simulations, we show the crucial importance of the XUV re-emission channel, neglected in the recently developed quantitative rescattering model of HHG in synchronized IR and XUV pulses [3]. This elastic scattering channel (determined by the polarizability of an atomic system) results in the increasing of the SGR yield in the spectral range of the XUV pulse. We show that the account of the collective electron dynamics (by the contribution of $2s$ and $2p$ orbitals) significantly increases the polarizability of Ne atom, thereby enhancing contribution of the XUV elastic re-emission channel to APR and increasing of the SGR yield by more than an order of magnitude. The interference of this enhanced re-emission channel with HHG channels in the IR field, the SGR yield (*i.e.*, absolute squared APR at a given frequency) can show the specific interference pattern that carries information about the phase of generated harmonics of the intense IR field. We show that the interference fringes can be utilized for retrieving the phase of IR-induced high-order harmonics, which is essential for the production of attosecond pulses.

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References

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