High-Order Harmonic Generation in Orthogonal IR and XUV Pulses: XUV-Initiated Channel Separation and Polarization Control

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We consider high-order harmonic generation (HHG) for an atom interacting with the linearly polarized intense infrared (IR) and synchronized time-delayed perturbative extreme ultraviolet (XUV) pulses, whose polarization vectors are mutually perpendicular to each other. Atom is considered within the single active electron approximation. We assume that atom is not polarized and an active electron is in p-state, which is triple degenerate in angular momentum projection m. The angular dependence of an initial state is described in terms of tesseral spherical harmonics, which are more appropriate than spherical harmonics for description of p-electron interaction with the laser field having two independent spatial components. We show that these states interact differently with orthogonal components of the two-color field making it possible to separate different IR-induced and XUV-induced HHG channels. Our theoretical analysis, based on the analytical and numerical treatment of HHG, shows that harmonics generated from the state oriented along the IR polarization vector are formed according to the three step scenario (tunneling, propagation, and recombination) driven by the IR field, while effects from the XUV component are neglegiable. However, the XUV-initiated HHG channel, consisting in XUV-induced ionization, propagation in an intense IR field with subsequent recombination, is realized through the state oriented along the XUV polarization vector. Our analysis shows that harmonics generated from the IR-induced HHG channel are linearly polarized along the IR polarization vector, while for the XUV-initiated HHG channel generated harmonics are linearly polarized along the XUV pulse polarization vector. The aforementioned polarization properties make it possible to separate the XUV-initiated HHG channel from the IR-induced channel on a single-atom level by measuring harmonics with fixed polarization coinciding with XUV pulse polarization.

We also propose a new method for the polarization control of generated harmonics, which can be realized through the variation of the time delay between IR and XUV pulses. Since x-component of the laser-induced dipole momentum is determined by the amplitude for IR-induced HHG, it does not depend on the XUV pulse parameters and time delay between IR and XUV pulses. The magnitude and phase of the y-component in atomic dipole significantly depend on the time delay, thereby making possible complete polarization control through the time delay variation. Validity of the proposed methods is demonstrated by the numerical simulations of HHG for the Ne atom.[1]

Acknowledgements: This work was supported by the Russian Science Foundation through Grant No. 22-12-00223.

References

[1] T S Sarantseva, A A Romanov, A A Silaev, N V Vvedenskii and M V Frolov, Phys. Rev. A **107**, 023113 (2023)