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Multi-photon dynamics of non-linear quantum processes in short polarized electromagnetic pulses

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We have performed a simultaneous analysis of two essentially non-linear QED processes in circular and linear polarized short and intensive e.m. (laser) pulses: (i) non-linear Breit-Wheeler e^+e^- pair creation in the interaction of probe photon with such a pulse and (ii) the photon emission or the non-linear Compton scattering when an initial electron interacts with the short and intensive e.m. (laser) pulse. Both processes are analyzed in the multi-photon region, where several photons at the same time participate in the process. In case of non-linear Breit-Wheeler e^+e^- pair emission, the multi-photon region is determined uniquely by the variable $\zeta > 1$ or $s < s_{\rm sthr} = 4m^2$. For the non-linear Compton scattering we use the partially integrated cross section where the integration starts from the dynamical parameter $\kappa > 1$ which selects the multi-photon events and is an analog of the variable ζ in the Breit-Wheeler process.

Our analysis shows the step like ζ (κ) behavior of the total cross sections for Breit-Wheeler (Compton) process in the case of relatively long pulses with the number of oscillations in a pulse $N \geq 2$, similar to the prediction for the infinitely long pulse. In case of sub-cycle pulse ($N = 1/2$), the cross sections exhibit an exponential dependence $\exp[-b_\zeta\zeta]$ ($\exp -[b_\kappa\kappa]$). The slopes b_ζ, b_κ depend on the field intensity and the pulse duration.

The azimuthal angle distributions are very sensible and, in particularly, depend on the carrier envelope phase ϕ_{CEP}. In addition to the processes occurring in the circularly polarized e.m.\ pulses considered earlier, the case of linear polarization leads to the qualitative modification of the azimuthal distributions of outgoing electrons. These distributions are non-monotonic functions %of the azimuthal angle of outgoing electrons with peculiar maxima and minima. Their positions, heights, and depths are determined by the structure of the phase factor $P^{(L)}$ of the basis functions $\widetilde{A}_m$, and they depend on the reduced field intensity ξ^2, dynamic variables ζ, κ, and ϕ_{CEP} and the pulse width ($\Delta = \pi N$) as well. In the case of non-linear Compton scattering, the angular distributions are determined by a nontrivial destructive interference of the terms in the partial probability $w^{(L)}(\ell)$.

Our results may be used as a unique and powerful method for studying the multi-photon dynamics of elementary non-linear QED processes.

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