Polarization Response in Extreme Nonlinear Optics: Quantum-Electrodynamical vs Semiclassical Approach

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The possibility to apply the semiclassical approach for the study of polarization response in the case of high-intensity laser field when the population of the initial (ground) state is depleted during the laser pulse action was questioned recently in [1]. It was demonstrated that calculations of the emission of quantum system driven by high intensity laser field based on the semiclassical approach is generally in contradiction with quantum electrodynamical calculations. In [2] the new approach to study the emission of atomic system in the presence of high-intensity laser field was developed. This approach is based on the first order perturbation theory applied to the interaction of the atomic system dressed by the external laser field with a lot of quantized field modes under the assumption that initially all the modes are in a vacuum state.

Here we apply this approach to study the emission of the model single-electron atom driven by the femtosecond pulse of Ti-Sa laser (eV). We find that only odd harmonics of fundamental frequency are emitted by the atom only in rather weak external laser fields when the strong-field atomic dynamics can be studied in the frames of the quantum-mechanical perturbation theory. Beyond the applicability of the perturbation theory in the regime of effective atomic ionization both odd and even harmonics of the fundamental frequency are found to exist as a result of the electron bremsstrahlung in strong laser field.

Comparative analysis of the obtained data with those derived in the semiclassical approximation is performed. It is found that semiclassical approach that is widely used to study the high order harmonics generation fails in strong field limit.

References