Photon emission from a scalar field under the strong laser field

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Physics in intense fields has been becoming an important subject in various aspects, for example, Schwinger mechanism in a strong electrostatic field and creation of quarks and leptons in a strong magnetic field or color field which appear in high energy heavy ion collision. In such fields, some phenomena forbidden in the vacuum are allowed because particles interact with multiple photons or gluons through non-linear processes.

In laboratories the non-linear QED dynamics can be studied in interaction of probe photons and electrons with intensive laser pulses. Thus, non-linear Breit-Wheeler process has been experimentally verified in the experiment E-144 at SLAC [1] in reaction $\gamma^* + \text{laser} \to e^+ e^-$. In this experiment the minimum number of photons involved in production one pair reaches 5. Dynamics of the non-linear QED processes is determined by the effective field strength parameter $\xi$ which is related to the laser intensity $I_L$

$$\xi^2 = \frac{4\pi\alpha(hc)^3}{M_e^2e^4\omega^2} \frac{I_L}{c} \approx 0.56(\omega(\text{eV}))^{-2}10^{-18}I_L \text{ (W/cm}^2\text{)} ,$$

where $\omega$ is the frequency of the laser field and $\alpha = 1/137$ is the fine structure constant. In SLAC experiment $I_L \approx 2 \cdot 10^{18}$ W/cm$^2$ which results in $\xi^2 \approx 0.1$. A laser intensity of $\sim 2 \times 10^{22}$ W/cm$^2$ has been already achieved recently and intensities of the order of $I_L \sim 10^{23}...10^{25}$ W/cm$^2$ are envisaged in near future (cf. Ref. [2]). Such large laser intensities allow for larger values of $\xi^2 \sim I_L$ compared to the SLAC E-144 experiment, up to $10^6$. On the other hand new generations of optical laser beams are expected to be essentially realized in short pulses (with femtoseconds duration) with only a few oscillations of the e.m. field. The Breit-Wheeler process in a short pulse has been recently discussed in [3]. The photon and neutrino emission from electron in a long pulse was considered in [4]. The main aim of our presentation is discussion of the photon emission in a short pulse from a fermion like electron and a charged scalar fields like pion. Interaction of the charged particles with strong electromagnetic field is considered non-perturbatively, using Volkov-type solutions. As result, we predict for the first time non-trivial bump-like dependence of differential production rate which is clearly reflected non-perturbative multi-photon character of considered processes. We also discuss practical realization of our prediction.