Pair-production in vacuum and plasmas using the Wigner formalism

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For ultra-strong electromagnetic fields, much new phenomena, such as e.g. relativistic Landau quantization and pair-production enters the picture. This can be studied making a gauge-invariant Wigner transform of the Dirac equation, such that the coupled strong field dynamics of electrons and positrons is described in phase space. The 16 scalar equations resulting from this, first derived by Ref. [1], are usually referred to as the Dirac-Heisenberg-Wigner (DHW) equations. The coupling of the electron and positron degrees of freedom makes the interpretation of the theory slightly non-trivial. However, the system has a number of conservation laws (energy, momentum, angular momentum, etc.), which help guiding the intuition. The DHW-equations have been used for studying pair-production in given electric fields through the Schwinger mechanism (see e.g. Refs. [2,3]), which we briefly review. Some newly studied aspects related to the momentum perpendicular to the electric field, which has been omitted in previous works, are also discussed [4]. Adding a plasma into the picture, it turns out that pair-production can be possible even in linearized theory, although a high frequency is required [5]. To understand this properly, a renormalization must be made, in order to handle the ultra-violet divergences

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[3] Xin-li Sheng, *et al*., Phys. Rev. D, **99**, 056004 (2019).

[4] H. Al-Naseri, J. Zamanian and G. Brodin, In preparation.

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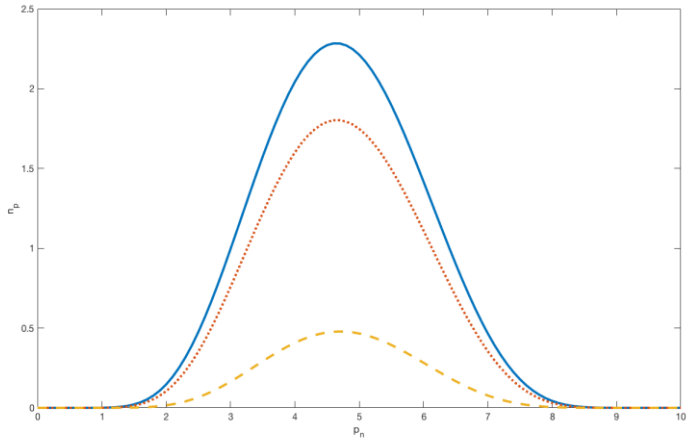

Fig.1 The number of generated electron-positron pairs as a function of normalized parallel momentum, for different values of the normalized perpendicular momentum.

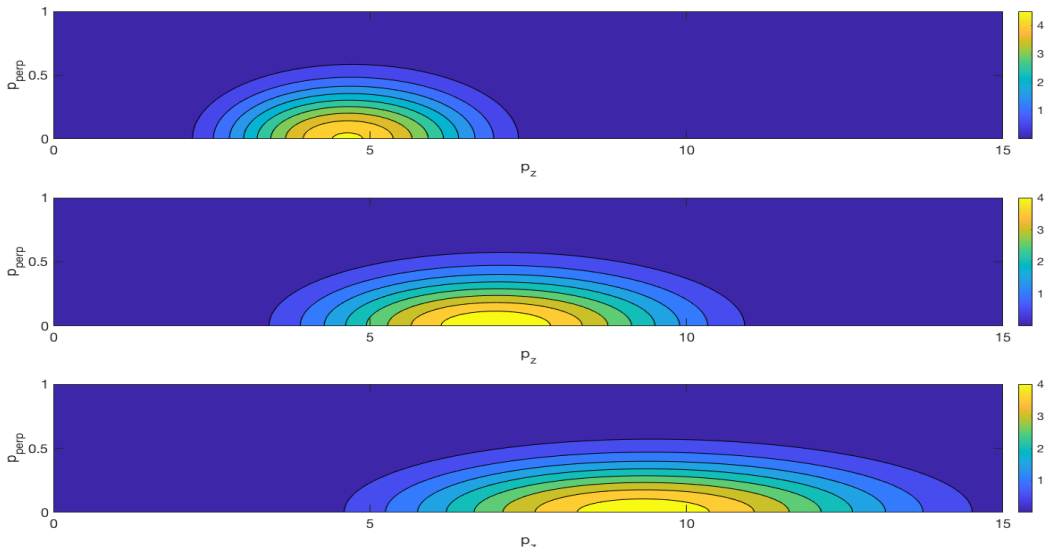

Fig.2 Contour curves in momentum space for the generated electron-positron pairs for different magnitudes of the electric field.

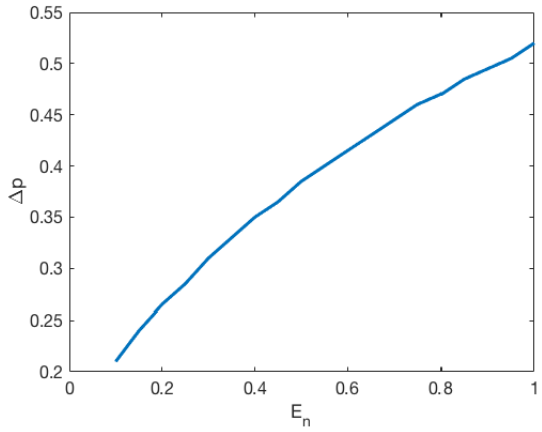

Fig.3 The spread in perpendicular momentum as a function of the normalized electric field. .