Testing strong-field CED and QED with intense laser fields

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Classical electrodynamics (CED) and quantum electrodynamics (QED) are well established theories and have been tested experimentally in different regimes. However, there are still areas of CED and QED that deserve theoretical and experimental investigation. In view of the increasingly stronger available laser fields it is becoming feasible to employ them to test CED and QED under the extreme conditions supplied by ultra-intense fields.

A fundamental problem in CED is the so-called "radiation reaction" problem: classically, when a charged particle (an electron, for definiteness) is accelerated by an external field, it emits radiation and this emission changes the motion of the electron. In the realm of CED, the so-called Landau-Lifshitz (LL) describes the motion of an electron by including the effects of radiation reaction [1]. What is the quantum analog of radiation reaction? In [2] we have answered this question and we have investigated the so-called quantum radiation dominated regime, in which quantum recoil and radiation reaction effects both dominate the dynamics of the electron.

In [3] we have shown that at the quantum level the interaction of the electron with its own electromagnetic field significantly alters the spin dynamics of the electron. We have indicated that an electron initially prepared in a definite spin state will undergo spin-flip while passing through a strong laser field only due to the interaction with its own electromagnetic field and even if it does not radiate photons. We have in addition shown that the classical expression of the electron quasi-momentum is also modified by quantum self-field effects.

Finally, we present a quasiclassical approach to investigate problems in strong laser and atomic fields which allow to include both fields exactly [4]. This approach is applied to determine the influence of a strong laser field in the Bethe-Heitler process in the field of a heavy ion.

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[1] A. Di Piazza et al., Rev. Mod. Phys. **84**, 1177 (2012).

[2] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. **105**, 220403 (2010).

[3] S. Meuren and A. Di Piazza, Phys. Rev. Lett. **107**, 260401 (2011).

[4] A. Di Piazza and A. I. Milstein, arXiv:1204.2502 (2012).