Space-time resolved approach to strong field pair creation processes

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Abstract

We discuss a numerical procedure that can look into the space-time dynamics of the pair creation process. There are many interesting ways to create pairs including using a static supercritical force field or using a time dependent subcritical force field. Pair creation can be viewed as associated with continuum-continuum, continuum-bound or bound-bound state mixings between the positive and negative energy manifolds of the Dirac equation. It turns out that the usual charge renormalization manifests itself surprisingly in a theory in which the strong field is not second quantized.

Summary

Strong laser-atom interaction has resulted in many interesting physical processes such as ionization, harmonic generation, and atto-second pulse generation. In extremely strong lasers for which the photon energy exceeds twice the electron rest mass, it is possible to break down the vacuum to create particle-antiparticle pairs such as electrons and positrons. We discuss a numerical procedure that can look into the space-time dynamics of the pair creation process. There are many interesting ways to create pairs including using a static supercritical force field or using a time dependent subcritical force field. Pair creation can be viewed as associated with continuum-continuum, continuum-bound or bound-bound state mixings between the positive and negative energy manifolds of the Dirac equation. It turns out that the usual charge renormalization manifests itself surprisingly in a theory in which the strong field is not second quantized [1-8].

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References

[1] Q. Su, W. Su, Q.Z. Lv, M. Jiang, X. Lu, Z.M. Sheng and R. Grobe, *Phys. Rev. Lett.* **109**, 253202 (2012).
[2] M. Jiang, W. Su, Q.Z. Lv, X. Lu, Y.J. Li, R. Grobe, Q. Su, *Phys. Rev. A* **85**, 033408 (2012).
[3] Q.Z. Lv, Y. Liu, Y.J. Li, R. Grobe and Q. Su, Phys. *Rev. Lett.* **111**, 183204 (2013).
[4] M. Jiang, Q.Z. Lv, Z.M. Sheng, R. Grobe and Q. Su, *Phys. Rev. A* **87**, 042503 (2013).
[5] Q.Z. Lv, A. Vikartofsky, S. Norris, Y.J. Li, R. Wagner, Q. Su and R. Grobe, *Phys. Rev. A* **89**, 042105 (2014).
[6] A.T. Steinacher, R. Wagner, Q. Su and R. Grobe, *Phys. Rev. A* **89**, 032119 (2014).
[7] Y. Liu, M. Jiang, Q.Z. Lv, Y.T. Li, R. Grobe and Q. Su, *Phys. Rev. A* **89**, 012127 (2014).
[8] Q.Z. Lv, J. Betke, Q. Su and R. Grobe, *Phys. Rev. A* (submitted).