



Advances in the asymptotic description of the electron motion in the strongly radiation-dominated regime

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With upcoming laser facilities, such as ELI, investigation of laser-matter interaction in the regime of extreme intensity will become feasible. Theoretical studies of such an interaction are often limited by significantly simplified scenarios due to strong nonlinearity of the interaction, while numeric ones can only provide some phenomenological dependencies, scalings or parameters regions where one or another regime is realized without giving an insight into their nature. Radiation reaction which is an immanent feature of high intensity laser-plasma interaction has been a well-known phenomenon for more than a hundred years, although there is still no general understanding of how this force alters electron motion. Recent studies have shown that there is a way to implicitly account for radiation reaction and derive electrons motion equation in the strongly radiation-dominated regime [1, 2]. This equation describes a so-called asymptotic or radiation-free trajectory which attracts real trajectories. While knowledge of these trajectories (which can be calculated for an arbitrary field configuration) may significantly simplify theoretical investigations, numeric computations show that real trajectories converge to them well for quite high field amplitudes corresponding to intensity about 10^{25} W/cm² and higher.

To lower the threshold of its applicability we extend this asymptotic approach and develop a perturbation theory where deviation from asymptotic trajectory serves as a small parameter. New derived equations describe electron motion much better and exactly coincide with some known solutions like Zel'dovich one [3]. Besides general theoretical research we apply our findings to a recently found phenomenon of QED cascade development in a plane wave [4]. Cascade particles which experience strong radiation reaction are well described by our theory which allows us to develop a self-consistent model of the cascade. The results of the model are discussed and compared to full 3D-PIC numeric simulations.

The work is supported by Russian Science Foundation Grant No. 20-12-00077

References

- [1] A. S. Samsonov, E. N. Nerush, and I. Yu. Kostyukov, *Phys. Rev. A* **98**, 053858 (2018)
- [2] A. Gonoskov and M. Marklund, *Phys. Plasmas* **25**, 093109 (2018)
- [3] Y. B. Zel'dovich, *Sov. Phys. Usp.* **18**, 79 (1975).
- [4] A. S. Samsonov, E. N. Nerush, and I. Yu. Kostyukov, *Sci. Rep.* **9**, 11133 (2019)