Features of the Electron Motion in the Strongly Radiation-Dominated Regime

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With upcoming laser facilities, such as ELI, SULF, Apollon, *etc.*, investigation of laser-matter interaction in the regime of extreme intensity will become feasible. Radiation reaction is expected to accompany such interaction, although its direct impact is usually quite hard to predict beforehand. The fact that charged particles experience a recoil force when radiating has been known for more than a century; however, there is still no generally accepted way of accounting for this effect in both theoretical and numerical studies. The question of which model of radiation reaction is valid becomes more and more acute with a growing number of studies discovering possible new effects caused by radiation reaction, which vary greatly and include e.g. decrease of the ion acceleration efficiency, wakefield acceleration enhancement, highly efficient laser pulse absorption, relativistic transparency reduction, inverse Faraday effect, and many others. For the experimental study of such effects, the so-called radiation-dominated regime is preferable since it provides more prominent signatures of the radiation reaction. Estimates show that field amplitudes needed for the realization of this regime can be achieved experimentally at either future laser facilities such as ELI, XCELS, SEL, or future accelerators such as FACET-II.

Recent studies show that to some extent, in this strongly radiation-dominated regime, radiation reaction can be accounted for implicitly, i.e. without specifying its expression in motion equations [1, 2]. This is achieved by interpreting radiation reaction as a general dissipation, which leads to the formation of an attractor in the particle phase space, as it commonly happens in dissipative dynamical systems. These attractors or asymptotic trajectories can be calculated for an arbitrary field configuration and may alone significantly simplify theoretical investigations. However, numeric computations show that real trajectories converge to them only at quite high field amplitudes corresponding to intensities about 10^{25} W/cm^2 and higher. To lower the threshold of its applicability, we extend this asymptotic approach and develop a perturbation theory where deviation from the asymptotic trajectory serves as a small parameter. Applying such a method to various model field configurations, we reproduce known solutions, such as Zeldovich one [3], as well as reveal some peculiar features of the electron motion in the strongly radiation-dominated regime, such as infinite longitudinal acceleration in a plane wave and decrease of the acceleration rate in a linear accelerator.

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