

# Quantum and classical effects of radiation in relativistic laser plasma.

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The present record of laser intensity reached recently in laboratory conditions is  $2 \times 10^{22}$  W/cm<sup>2</sup> [1]. Due to the active work of two international projects, Extreme Light Infrastructure (ELI) [2] and the High Power laser Energy Research facility (HiPER) [3], this record is expected to increase by several orders of magnitude. That will require the consideration of QED effects such as hard photon radiation and electron-positron pair creation in the planning and interpretation of these experiments.

With these high intensities becoming possible for experimentalists it is timely to study the kinetic transport equations from the numerical point of view in order to model relativistic plasma experiencing the quantum effects of high-energy radiation. A central problem in simulating plasma with strong QED effects is the need for a proper model for radiation, which would simultaneously account for both classical radiation responsible for collective emission and high-frequency non-coherent hard photons and their quantum recoil on emitting electrons.

I will give a brief review of the theory needed to bridge the quantum and classical regimes of radiation in laser plasma. A special emphasis will be placed on quasi-classical description of radiation which resolves high energy part of photon spectra. This approach uses the quantum probabilities of the photon emission derived using exact solutions of the Dirac equation [4]. Hard photon radiation effects as well as electron-positron pair creation can relatively easy be incorporated into conventional plasma simulation codes and [5, 6]. However, there is a wide gap in spectrum between low frequency plasma response and hard gamma quanta for which this approach fails due to enormous soft photons emission in XUV and X-ray range. In current kinetic simulation of the relativistic plasma, the action of such photons is usually undercounted due to huge requirement for spatial and time resolution. Our efforts on incorporation the the missing part of the spectrum in plasma simulation are mainly focused in two directions. First I will describe the modified kinetic equations with effective radiation force to model integrated action of radiation in terms of effective radiation reaction force. Then I will briefly outline the status of our work on adaptive grid plasma simulation aiming for dynamical resolution of relevant scales in the course of interaction with laser pulses. Finally I will discuss the possible experimental verifications of QED plasma models.

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