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Photon-seeded nonlinear Breit-Wheeler pair production: role of laser intensity and spatio-temporal shape versus photon energy

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The upcoming generation of ultra-intense lasers opens the way of abundant electron-positron pair production through the nonlinear Breit-Wheeler process. A configuration that will be tested in the laboratory involves the interaction of a flash of gamma photons colliding with an intense laser pulse. Such a photon flash can be created either from the interaction of an ultra-relativistic electron beam with the laser itself, or by an external source.
For upcoming laser intensities, we do not expect the produced pairs to be efficiently accelerated by the laser so as to emit in their turn hard photons which will produce many secondary pairs. We first perform a study in this regime of low secondary pair production called the soft shower.

In this regime [1], we developed a simple model to compute the number of produced pairs, starting from the interaction of gamma photons with a plane wave. We then generalised it to take into account the time envelope and spatial dependence of the laser pulse. This approach provides us with a semi analytical model for more complicated situations with either Gaussian or Laguerre-Gauss (LG) beams.
Our predictions have been confirmed by 3D Particle-In-Cell (PIC) simulations performed with the code SMILEI [2]. The role of the laser peak intensity versus the focal spot size and shape is examined as well as the influence of the order of the LG laser beams on pair creation. We concluded that, counterintuitively, for some laser intensities, a larger spot size (or a higher order in the case of LG laser beams) is more favorable than a higher peak intensity to increase pair production.

Finally we generalised the study with a more recent work where secondary pairs are taken into account. We particularly look at the cascade regime, where pairs keep being reaccelerated by the field and emitting radiation, so that an exponential growth of the number of pairs is reached. We study this regime in the two counter streaming laser pulses configuration. Using LG beams, we identify what parameters in field configuration are the most important to maximise pair production and enable the onset of the cascade regime.

References

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[2] Derouillat *et al*, Comput. Phys. Commun., **222**, 351–73 (2017) https://smileipic.github.io/Smilei