Ultra-bright GeV photon source via controlled cascade in optimally focused laser fields

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The next generation high-intensity laser facilities have the capacity of triggering non-linear Compton scattering and Breit-Wheeler pair production. This will give us access to, e.g., exotic types of particle dynamics and the creation of ultra-dense electron-positron plasmas via electromagnetic cascades. In terms of using such processes for further fundamental studies, one of the most intriguing possibilities is currently associated with the creation of unique secondary sources of emission. For example, electromagnetic cascades have the potential to act as a new kind of gamma photon source of unprecedented brightness [1, 2]. However, in many scenarios the efficient generation of photons is restricted to the sub-GeV level of energy because of exhaustive radiation losses and the field suppression by the impetuous cascade development. Here, we present and elaborate a concept for efficient and directed generation of GeV photons [3]. This is based on the controlled interplay between cascades and anomalous radiative trapping [4]. This is possible in the electromagnetic fields of a dipole-type wave, formed by several optimally focused laser pulses. Using large-scale 3D QED-PIC simulations [5] and detailed analytical studies, we examine the feasibility and capabilities of this setup. We demonstrate that the concept is feasible even for facilities with a total peak power of 10 PW level. At higher peak powers, around 40 PW, the concept can provide 10^9 photons with GeV energies in a well-collimated 3 fs beam, achieving peak brilliance 9×10^{24} ph $\text{s}^{-1}\text{mrad}^{-2}\text{mm}^{-2}$/0.1%BW, which exceeds peak values of laser Compton sources in GeV range by several orders of magnitude. This source can thus open qualitatively new possibilities for studying photo-nuclear processes.

References

[1] M. Jirka, *et al.* Phys. Rev. E **93**, 023207 (2016).

[2] T. Grismayer, *et al.* Phys. Plasmas **23**, 056706 (2016).

[3] A. Gonoskov, *et al.*, arXiv:1610.06404 [physics.plasm-ph] (2016).

[4] A. Gonoskov, *et al.*, Phys. Rev. Lett. **113**, 014801 (2014).

[5] A. Gonoskov, *et al.*, Phys. Rev. E **92**, 023305 (2015).