Optimization of γ-photon sources using near-critical density targets towards electron-positron pairs generation through the linear and nonlinear Breit-Wheeler processes

Iuliana-Mariana Vladisavlevici[1,2], Xavier Ribeyre[2], Daniel Vizman[1], Emmanuel d'Humieres[2]
[1]*Faculty of Physics, West University of Timisoara, 300023 Timisoara, Romania*
[2]*University of Bordeaux – CNRS – CEA, CELIA, UMR 5107, 33405 Talence, France*

At the interaction between an ultra-high intensity laser pulse ($I > 10^{22}$ W/cm^2) with matter, the electrons will be accelerated up to ultra-relativistic velocities and will emit a copious amount of synchrotron gamma photons. For even higher intensities ($I > 10^{24}$ W/cm^2), the emitted gamma photons can interact with the laser field and create electron-positron pairs by the nonlinear Breit-Wheeler process [1]. Due to the promising PW laser facilities such as APOLLON (Paris, France) and ELI-NP (Bucharest, Romania), various theoretical and numerical studies on these phenomena were performed in the last years. Studies on various absorption mechanisms using different target configurations, showed a conversion efficiency of the laser energy to gamma photons from 15% [2] up to 35% [3].

Our main goal is to investigate the high energy radiation emitted by electrons in the laser-plasma interaction, eventually leading to production of electron-positron pairs via the linear and nonlinear Breit-Wheeler processes. Through 2D Particle-in-Cell (PIC) simulations using SMILEI [4], we studied the case of an ultra-high intensity laser pulse interacting with a near critical density target. We studied the optimal parameters for the maximum conversion efficiency of the laser energy to gamma photons. In the optimal configuration, we analysed the total number of electron-positron pairs produced and the energy cut-off of the electrons, respectively positrons. We compared our results with the ones obtained by M. Lobet et al. [5][6] and we discuss their suitability for experimental campaigns.

[1] C. S. Brady and T. D. Arber, Plasma Phys. Controlled Fusion 53, 015001 (2011)

[2] Brady et al., Physical Review Letters, 109, 245006 (2012)

[3] Ridgers et al., Physical Review Letters 108, 165006 (2012)

[4] J. Derouillat et al., Comput. Phys. Commun. 222, 351-373 (2018)

[5] M. Lobet et al., Phys. Rev. Lett. 115, 215003 (2015)

[6] M. Lobet et al., Phys. Rev. Accel. Beams 20, 043401 (2017)