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All-Optical Gamma-Rays and Positrons Source by Ultra-Intense Laser Irradiating an Al Cone

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Abstract : A strong electromagnetic field with E>1015V/m can be supplied by an intense laser such as ELI and HiPER in the near future. Exposing in such a strong laser field, laser-matter interaction enters into the near quantum electrodynamics (QED) regime and highly non-linear physics may occur during the laser-matter interaction. Recently, the multi-photon Breit-Wheeler (BW) process attracts increasing attention because it is capable to produce abundant positrons and it enhances the positron generation efficiency significantly. Here, we propose an all-optical scheme for bright gamma rays and dense positrons generation by irradiating a 1022 W/cm2 laser pulse onto an Al cone filled with near-critical-density plasmas. Two-dimensional (2D) QED particle-in-cell (PIC) simulations show that, the radiation damping force becomes large enough to compensate for the Lorentz force in the cone, causing radiation-reaction trapping of a dense electron bunch in the laser field. The trapped electrons oscillate in the laser electric field and emits high-energy gamma photons in two ways: (1) nonlinear Compton scattering due to the oscillation of electrons in the laser fields, and (2) Compton backwardscattering resulting from the bunch colliding with the reflected laser by the cone tip. The multi-photon Breit-Wheeler process is thus initiated and abundant electron-positron pairs are generated with a positron density ~1027m-3. The scheme is finally demonstrated by full 3D PIC simulations, which indicate the positron flux is up to 109. This compact gamma ray and positron source may have promising applications in future.

Keywords : BW process, electron-positron pairs, gamma rays emission, ultra-intense laser
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