Linear Breit-Wheeler Pair Creation as a Dominant Mechanism in Structured Targets Irradiated by Counter-Propagating Laser Pulses

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Creation of electron-positron pairs *via* annihilation of two photons (linear Breit-Wheeler process) is a fundamental prediction of quantum electrodynamics, but it is yet to be observed in a laboratory using real photons. The recently constructed ELI-NP laser facility offers a two-beam high-power laser system that is well-suited for creating the necessary conditions inside a laser-irradiated plasma. However, making quantitative predictions is challenging because none of the modern particle-in-cell codes is equipped to evaluate binary photon collisions. We have recently developed a post-processing algorithm that groups photons into mono-energetic beamlets and enable one to efficiently compute the yield of the linear Breit-Wheeler process inside a photon-emitting plasma. With the help of this algorithm, we have discovered an unexpected regime [1] where the linear Breit-Wheeler process dominates over the nonlinear Breit-Wheeler and Bethe-Heitler processes at experimentally accessible laser intensities. Specifically, we found that over 10^8 linear Breit-Wheeler pairs can be produced by two lasers of intensity 2×10^{22} W/cm^2 colliding inside a structured plasma target. These pairs are created inside a laser-driven magnetic filament with a slowly evolving azimuthal field. The polarization of this field is such that it can confine the positrons, enabling their acceleration to ultra-relativistic energies by the laser pulses after the collision of the pulses. This process is similar to the electron acceleration before the collision [2]. The positrons can therefore form collimated ultra-relativistic jets, which should aid their experimental detection. Our work offers not only a promising experimental setup for studies of the linear Breit-Wheeler process, but it also prompts a reconsideration of the neglect of this process in ultra-intense laser-plasma interactions.

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References

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