Dense Polarized Positrons and Electrons from Laser-Solid Interactions via Polarized QED-PIC Simulations

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Many works have reported that dense electron-positron pairs can be effectively generated from laser-solid interactions in the strong-field quantum electrodynamics (QED) regime with 10-PW and 100-PW laser pulses. In particular, such pairs can be easily achieved via the conventional laser-solid setup that an ultraintense linearly polarized laser pulse that irradiates a solid target with a micron-scale-length preplasma *via* an avalanche-like QED cascade [1]. This setup is generally adopted in current laser-solid experiments and is expected to be commonly used in future 100-PW laser-solid experiments aiming at various applications. Whether the created positrons and electrons are polarized has not yet been reported, limiting their potential applications and hindering the insight investigation of 100-PW-laser solid-plasma interactions.

By a recently developed QED particle-in-cell (PIC) code [2], including electron/positron spin and photon polarization effects [3], we further investigate the conventional laser-solid setup with a linearly polarized laser irradiating a solid target with a preplasma formed by the amplified spontaneous emission (ASE). We find [4] that once the pair yield becomes appreciable with the laser intensity reaching $10^{24}W/cm^2$, the pairs are obviously polarized as a function of the divergent angle. Around 30 nC positrons can acquire >30% polarization degree with a flux of $10^{12}sr^{-1}$. The polarization can reach 60% at some deflection angles. The angle-dependent polarization is attributed to the asymmetrical laser fields formed near the skin layer of overdense plasmas, where radiative spin-flip and radiation reaction play significant roles. The polarization mechanism is robust because a skin layer can be certainly formed in the conventional laser-solid setup. Therefore, the generation of polarized positrons/electrons should be ubiquitous in future 100-PW-class laser-solid experiments even aiming at other applications, which suggests that electron/positron spin and photon polarization effects should be considered. Without the two effects, our simulation preliminarily shows that the positron yield will be overestimated by about 10%.

References

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