Laser-Driven Lepton Polarization in the Quantum Radiation-Dominated Reflection Regime

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Generation of ultrarelativistic polarized leptons during interaction of an ultrarelativistic electron beam with a counterpropagating ultraintense laser pulse is investigated in the quantum radiation-dominated domain. While the symmetry of the laser field tends to average the radiative polarization of leptons to zero, we demonstrate the feasibility of sizable radiative polarization through breaking the symmetry of the process in the reflection regime. After the reflection, the off-axis particles escape the tightly focused beam with polarization correlated to the emission angle, while the particles at the beam center are more likely to be captured in the laser field with unmatched polarization and kinetic motion. Meanwhile, polarization along the electric field emerges due to the spin rotation in the transverse plane via precession. In this way, the combined effects of radiative polarization, spin precession and the laser field focusing are shaping the angle-dependent polarization for outgoing leptons. Our spin-resolved Monte Carlo simulations demonstrate angle-dependent polarization degree up to $\sim$20% for both electrons and positrons, with a yield of one pair per seed electron. It provides a new approach for producing polarized high density electron and positron jets at ultraintense laser facilities.