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A spin and polarization-dependent QED module for OSIRIS 4.0 for modeling strong field QED laser-plasma experiments

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With the rapid development of high-power petawatt class lasers worldwide, exploring the physics in the strong field QED regime will become one of the frontiers for laser-plasma interaction research. Here, we present the development of a full spin and polarization-included QED module based on the particle-in-cell framework OSIRIS 4.0. In this module, the dynamics of the lepton's spin involve both the spin precession process described by the classical T-BMT equation and the quantum radiation reaction-induced spin transition processes. The photon polarization-resolved quantum-radiation-rate allows us to assign the polarization state for each generated photon in the simulation. We also consider the influence of the lepton spin and photon polarization on the non-linear Breit-Wheeler pair production process calculation. This full spin/polarization distinguished quantum module is able to more accurately simulate multi-staged processes like avalanche and shower type electron-positron pair production cascade processes. We use this module to explore possible regimes for generating polarized gamma-ray beams and lepton bunches in laser-plasma interactions including laser-beam and laser-laser collision geometries.

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