Plasma particle-in-cell simulations of pair production experiments using a high-Z target

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Recent progress in high intensity lasers is allowing the experimental investigation of high-energy plasma phenomena under the influence of quantum electrodynamics (QED) effects. One available example is the positron measurement carried out on a thin gold target and high intensity laser\cite{1-3}. Aiming at the numerical investigation on such experiments, we have developed a new simulation scheme including both collective plasma dynamics and stochastic QED reactions.

The developed simulation scheme consists of (1) a Particle-in-Cell scheme for relativistic plasma dynamics, (2) a Conservative semi-Lagrangian scheme for hard photon transport and (3) a Monte-Carlo scheme for the QED reactions. Considered QED reactions are Bremsstrahlung and pair production in a high-Z nuclear field, and are evaluated by the extension of the Monte-Carlo binary collision model.

A test simulation of positron production in a thin solid target is performed by means of the developed simulation scheme. The simulation result successfully demonstrates a basic process leading to the positron ejection from the target. The process involves electron acceleration due to laser-plasma interaction at the target front, hard photon emission and pair production inside the target and electrostatic positron acceleration at the target rear side. We will discuss the controlling mechanism of the positron energy spectrum, the ejection angle distribution and the laser-to-positron energy conversion rate based on the simulation results.

\cite{1} T. E. Cowan \textit{et al}, Laser and Particle Beams \textbf{17}, 773 (1999).