TIMESTEP CRITERION FOR PIC SIMULATION OF RELATIVISTIC ELECTRON ACCELERATION IN A HIGH-INTENSITY LASER FIELD

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We present a study of particle-in-cell simulation error in modeling the acceleration of a free electron in a high-intensity laser field ($I > 10^{20}$ W/cm^2), comparing the results of the codes EPOCH and LSP. We find a surprisingly small timestep is required for both codes to resolve the classical electron motion, decreasing with increasing a_o, the normalized vector potential of the laser.

We consider grid dispersion, the field solver, and the particle pusher as possible sources of error, and find by comparing the full PIC code results with a simple particle pusher that the particle pusher is the main source of error.

We derive the constraint imposed by use of the relativistic Boris particle pusher on the timestep and find that it must be much less than λ/ca_o, where λ is the laser wavelength [1]. We find the particle pusher error accumulates on the small segments of the electron trajectory where the gamma-factor is approximately unity and the laser magnetic fields are strong, and present a sub-cycled version of the simple particle pusher code which reduces error.

We then extend these results to the simulation of electron acceleration in a background plasma, examining the conditions required for numerical convergence at plasma densities from very dilute up to the critical density.

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