LASER WAKEFIELD SIMULATION USING A SPEED-OF-LIGHT FRAME ENVELOPE MODEL

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Abstract

Simulation of laser wakefield accelerator (LWFA) experiments is computationally highly intensive due to the disparate length scales involved. Current experiments extend hundreds of laser wavelengths transversely and many thousands in the propagation direction, making explicit PIC simulations enormously expensive. We can substantially improve the performance of LWFA simulations by modeling the envelope modulation of the laser field rather than the field itself. This allows for much coarser grids, since we need only resolve the plasma wavelength and not the laser wavelength, and this also allows larger timesteps. Thus an envelope model can result in savings of several orders of magnitude in computational resources. By propagating the laser envelope in a Galilean frame moving at the speed of light, dispersive errors can be avoided and simulations over long distances become possible. Here we describe the model and its implementation. We show rigorous studies of convergence and discretization error, as well as benchmarks against explicit PIC. We also demonstrate efficient, fully 3D simulations of downramp injection and meter-scale acceleration stages.

CONTRIBUTION NOT RECEIVED