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Implicit relativistic PIC simulations using the four-momentum vector and the electromagnetic four-potential[1] PIERRE GOURDAIN, CHARLES SEYLER, Cornell University — New applications in high energy density plasmas and warm dense matter research demand to run long simulations to capture the different characteristic time scales. To keep the actual simulation time reasonable, implicit methods have been developed. Most of them require complex electromagnetic solvers which need to perform exceptionally well on parallel architectures. We can reduce the complexity of such implicit solvers by using the four-potential electromagnetic vector based on Lorenz' gauge instead of the usual electric and magnetic fields representation. As a result, all four potentials follow the second order wave equation. Besides the coding of a single electromagnetic solver valid for all four quantities, the main advantage of this model is the transport of any computational errors to the grid boundary, avoiding error accumulation inside the computational domain. As a particle pusher, we use the particle four-momentum vector instead of the usual momentum. This pusher is a symplectic integrator and conserves exactly the energy of the system. The integration of the implicit electromagnetic solver with the implicit symplectic pusher makes the computation of relativistic plasmas straightforward compared to methods relying directly on electromagnetic fields and conventional particle pushers.

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