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An energy- and charge-conserving, nonlinearly implicit, electromagnetic particle-in-cell algorithm GUANGYE CHEN, LUIS CHACON, DANA KNOLL, WILLIAM DAUGHTON, LANL, COCOMANS (LANL) TEAM —

A recent proof-of-principle study proposes a nonlinear electrostatic implicit particle-in-cell (PIC) algorithm in one dimension.[1] The algorithm employs a kinetically enslaved Jacobian-free Newton-Krylov (JFNK) method, and conserves energy and charge to numerical round-off. In this study, we generalize the method to electromagnetic simulations in 1D using the Darwin approximation of Maxwell's equations. An implicit, orbit-averaged central finite difference scheme is applied to both the Darwin field equations and the particle orbit equations to produce a discrete system that remains exactly charge-and energy-conserving. Furthermore, the canonical momentum in any ignorable direction is exactly conserved per particle by appropriate interpolations of the magnetic field. A fluid preconditioner targeting the stiffest electron waves has been developed to accelerate the linear GMRES solver of JFNK. We present 1D numerical experiments (e.g. the Weibel instability, kinetic Alfven wave ion-ion streaming instability, etc.) to demonstrate the accuracy and efficiency of the implicit Darwin PIC algorithm, and the performance of the fluid preconditioner.

[1]Chen, Chacón, Barnes, *J. Comput. Phys.* **230**, 7018 (2011)

Guangye Chen
LANL

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