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GeFi-E&B:A New Particle Simulation Scheme using Electromagnetic Fields

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A gyrokinetic electron and fully kinetic ion (i.e., GeFi) particle simulation scheme, valid for fluctuations with wave frequency up to $\omega \ll \Omega e$ has been developed [Lin et al., 2005, 2011]. Here, Ωe is the electron cyclotron frequency. Such scheme is applicable for simulating plasma dynamics in which the wave modes ranging from Alfven waves to lower-hybrid/whistler waves must be handled on an equal footing; e.g., the physics of collisionless magnetic reconnection with a finite guide field and lower hybrid/whistler mode waves in space and laboratory fusion plasmas., while employing the realistic ion-to-electron mass ratio mi/me In the gyrokinetic treatment, field equations are usually described by the perturbed scalar ($\delta\varphi$) and vector (δA) potential variables. Poisson's equations are thus needed to solve for the electromagnetic fields and may present computational challenges for realistic nonuniform and multidimensional magnetic field geometries. Here, we present a new GeFi particle simulation scheme that employs the electric field **E** and magnetic field **B** directly as field variables and advances particles accordingly. Contrary to previous hybrid simulation models based on the field variables, the present scheme (GeFi-E&B) also treats the displacement current self-consistently and, thus, includes space-charge waves. A corresponding nonlinear gyrokinetic equation in terms of electromagnetic fields is also derived. For the case of linear waves in a uniform plasma, simulation results are successfully benchmarked against the analytically derived linear dispersion relations.