GEC15-2015-000085

Abstract for an Invited Paper
for the GEC15 Meeting of
the American Physical Society

Multidimensional, fully implicit, exactly conserving electromagnetic particle-in-cell simulations[1]

LUIS CHACON, LANL

We discuss a new, conservative, fully implicit 2D-3V particle-in-cell algorithm for non-radiative, electromagnetic kinetic plasma simulations, based on the Vlasov-Darwin model.[2] Unlike earlier linearly implicit PIC schemes and standard explicit PIC schemes, fully implicit PIC algorithms are unconditionally stable and allow exact discrete energy and charge conservation. This has been demonstrated in 1D electrostatic[3] and electromagnetic[4] contexts. In this study, we build on these recent algorithms to develop an implicit, orbit-averaged, time-space-centered finite difference scheme for the Darwin field and particle orbit equations for multiple species in multiple dimensions.[5] The Vlasov-Darwin model is very attractive for PIC simulations because it avoids radiative noise issues in non-radiative electromagnetic regimes. The algorithm conserves global energy, local charge, and particle canonical-momentum exactly, even with grid packing. The nonlinear iteration is effectively accelerated with a fluid preconditioner, which allows efficient use of large timesteps, $O(\sqrt{\frac{m_i}{m_e}}\frac{c}{v_{eT}})$ larger than the explicit CFL. In this presentation, we will introduce the main algorithmic components of the approach, and demonstrate the accuracy and efficiency properties of the algorithm with various numerical experiments in 1D and 2D.

[1]Support from the LANL LDRD program and the DOE-SC ASCR office

[2]Nielson and Lewis, *Methods Comput. Phys.* **16** p.367 (1976)

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

[4]Chen and Chacón, *Comput. Phys. Commun.* **185** p.2391 (2014)

[5]Chen and Chacon, *Comput. Phys. Commun.*, submitted