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Fully implicit particle-in-cell algorithm. HYUNG KIM, UIUC, LUIS CHACON, GIOVANNI LAPENTA, LANL — Most current particle-in-cell (PIC) algorithms employ an explicit approach. Explicit PIC approaches are not only time-step limited for numerical stability, but also grid-intensive due to the so-called finite-grid instability.[1] As a result, explicit PIC methods are very hardware-intensive, and become prohibitive for system scale simulations even with modern supercomputers. To avoid such stringent time-step and grid-size requirements, the implicit moment method PIC approach (IM-PIC) was developed.[2] IM-PIC advances the required moments (density, current) using Chapman-Enskop-based fluid equations, and then advances the particles with such moments. While being able to employ much larger time steps and grid spacings than explicit PIC methods, IM-PIC is limited in that the time-advanced moments and the particle moments are inconsistent, resulting in lack of energy conservation. To remedy this, we propose here a fully implicit, fully nonlinear PIC approach (FI-PIC) where the particles and the moments are converged simultaneously using Newton-Krylov techniques. This guarantees the consistency of moments and particles upon convergence. We will demonstrate the feasibility of the concept using a purely electrostatic Vlasov-Poisson model, and will show its effectiveness with several fully kinetic examples.

[1]C. Birdsall and A. Langdon, *Plasma physics via computer simulation*, McGraw-Hill, New York, 1985
[2]J. Brackbill and D. Forslund, *J. Comput. Phys.* **46**, 271 (1982).

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