Prefer Oral Presentation

The Particle-Continuum Method: An Algorithmic Unification of 
Particle-In-Cell and Vlasov Methods

Srinath Vadlamani, Scott E. Parker, Yang Chen and Charlson Kim

Center for Integrated Plasma Studies, University of Colorado, 
Boulder, CO 80309

A new numerical algorithm that encompasses both the \( \delta f \) particle-in-cell (PIC) method and a continuum method, similar to Denavit’s “hybrid” method \([1]\), has been developed. The basic algorithm is a modification of the \( \delta f \) method and easy to implement. This method provides a mechanism for coarse-graining phase space and solves the “growing weight” problem observed in gyrokinetic particle simulations of microturbulence \([4]\). Briefly, the algorithm is the following: 1) load particles (or characteristics) on a uniform lattice in phase space. The loading need not be uniform, but it greatly simplifies the algorithm, 2) advance the characteristics \( M \) timesteps, using the usual \( \delta f \) PIC algorithm which involves a grid interpolation, deposition, then field solve all on a spatial grid only, 3) every \( M \) timesteps, re-deposit \( \delta f \) on a higher-dimensional phase space grid, then reset the particle phase space coordinates back to their initial value on the phase space lattice locations. Also, reset the particle value of \( \delta f \) to the phase space grid value. For \( M \to \infty \) one recovers the usual \( \delta f \) PIC algorithm with a somewhat peculiar uniform loading of particles. For \( M=1 \) the algorithm is similar to the Vlasov method of Cheng and Knorr\([3]\) except characteristics are evolved forward in time and PIC deposition is used instead of a spline fit. Any value of \( M=1,2,3,... \) is permissible. The simulation method is demonstrated using a simple nonlinear two-dimensional bounded slab model of the ion-temperature-gradient instability where the phase space is \((x, y, v_y)\). The ions are treated as gyrokinetic and the electrons are assumed to be adiabatic. Both linear and quadratic particle interpolation schemes are implemented \([2]\) and the effective phase-space dissipation or diffusion due to periodic re-deposition to a phase-space-grid is analyzed. The theoretical estimate of diffusion agrees well with simulation results. Demonstration of the solution of the growing weight problem will be presented for the simplified test problem.

References