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$\rightarrow \infty$ 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=$1, 2, 3, \ldots$ 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 $(x, y, v_{\|})$. The ions are treated as gyrokinetic and the 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

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