Energy-conserving particle algorithms for kinetic plasma simulations based on a reduction of the Hamiltonian formulation of the Maxwell-Vlasov system with a non-canonical Poisson bracket

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The variational formulation of particle algorithms for kinetic plasma simulations offers a number of advantages over the formulation of standard PIC. For example, the energy-conserving property has been shown to eliminate the non-physical numerical grid heating instability observed in PIC simulations.

Variational formulations of particle algorithms traditionally proceeded from a Lagrangian viewpoint, e.g., using Low's Lagrangian, the phase-space action, etc. The continuous Maxwell-Vlasov system is "reduced" to a finite degree-of-freedom system suitable for computer simulations by a number of methods, most commonly using a truncated basis (either global or finite element).

A new approach to constructing particle algorithms was recently proposed by Evstatiev and Shadwick (JCP, 245, pp. 376-398, 2013). This variational approach uses the Hamiltonian formulation of the Maxwell-Vlasov system with a non-canonical Poisson bracket (Morrison, Phys. Lett. A, 80, pp. 383-386, 1980). By using a truncated (finite element) basis, a "reduced" Hamiltonian and Poisson bracket is derived. The equations of motion that result are in terms of the (physical) electric and magnetic fields, which may provide certain advantages over Lagrangian-based formulations. I will discuss this approach and will provide numerical examples and comparisons with the standard PIC as well as with Lagrangian energy-conserving formulations.