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1P31 - Speed-Limited Particle-in-Cell Modeling of Low-Temperature Plasma Discharges

Monday 24 June 2019 13:00 (1h 30m)

Speed-limited particle-in-cell (SLPIC) modeling is a new simulation technique [Werner *et al.*, PoP **25**, 123512 (2018)], potentially much faster than conventional PIC, for modeling plasmas characterized by low-velocity kinetic processes. Numerical constraints (e.g. timestep limitations associated with particle cell-crossing times or stability limits) often place challenging restrictions on PIC models of these plasmas; even though the kinetic physics of interest predominantly involves slow particle evolution, the fastest particles dictate the maximum allowable timestep. For high-Z plasmas, large ion/electron mass ratios separate the species timescales to the point that kinetic simulation may be prohibitive, and computational costs can be high even in hydrogenic plasmas. SLPIC provides a possible solution. SLPIC (like PIC) retains a fully kinetic description of the plasma, but imposes an artificial speed limit on fast particles whose kinetics do not play a meaningful role in the system dynamics. Larger simulation timesteps, which enable faster simulations of such discharges, are thus permitted. The speed-limiting is done in a mathematically rigorous sense to maintain accuracy over longer timescales; we may, for instance, speed-limit the bulk of the electron distribution to evolve only on characteristic ion timescales (and use larger simulation timesteps, which need only resolve these scales, to simulate the discharge).

In this poster we'll demonstrate the use of SLPIC methods using the VSim code [Nieter & Cary, JCP **196**, 448 (2004)], moving from simple models of collisionless sheath formation (for which SLPIC has achieved >150x overall speedup relative to PIC with comparable accuracy) to more general low-temperature plasma discharges that include collisional effects and complex geometries. We'll also demonstrate how SLPIC can rapidly model plasma discharge evolution through transient or fluid-like phases, and then continuously transition to a smaller-timestep conventional PIC model as kinetic processes in the discharge become important.

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