Efficient Hybrid Methods for the Simulation of Plasmas with Coulomb Collisions

Official Title of Funded Project: Multiscale mathematics for plasma kinetics spanning multiple collisionality regimes*

M.S. Rosin (UCLA) with A.M. Dimits (LLNL), R.E. Caflisch (UCLA/IPAM), B.I. Cohen (LLNL)

UCLA Department of Mathematics,
520 Portola Plaza,
Los Angles, CA, 90095

Abstract

Hybrid algorithms in plasmas can achieve high efficiency at moderately small Knudsen number by combining a fluid solver to evolve the mostly dominant Maxwellian part of the distribution function, and particle-in-cell and Monte-Carlo collision implementations to evolve the non-Maxwellian remainder. Our algorithm allows for both binary and Langevin-equation-based Monte-Carlo coulomb collisions, the latter making use of a new Milstein-O(Δt) time-integration model.

As nonlinear evolution of the distribution function generally precludes a priori allocation of computational resources i.e. particles, we also introduce dynamic thermalization/dethermalization criteria to maximize efficiency.

This presentation will examine the performance of our hybrid simulation scheme and the relative benefits of the various options on relevant kinetic test problems including velocity-space isotropization, Inverse-Bremsstrahlung heating, particle injection and spatially-inhomogeneous sheath physics.

* Work performed under the auspices of the D.O.E. by UCLA under grant DE-FG02-05ER-25710 and by LLNL under Contract DE-AC52-07NA27344.