Title: Numerical Simulation of Counterstreaming Plasma Interactions using a Multifluid Model

Authors: Debojyoti Ghosh, Christos Kavouklis, Thomas Chapman, Richard L. Berger, Genia V. Vogman

Abstract:
Counterstreaming plasma interactions are an important phenomenon in inertial confinement fusion, where irradiation of the hohlraum with laser beams results in plasmas ablating off the hohlraum surfaces and the fuel capsules and interacting with each other. Related high-energy density physics experiments involve interactions of plasmas ablating off discs irradiated by lasers. Simulating such flows with multispecies hydrodynamic codes [1] can result in unphysical solutions due to the use of a single velocity field. Kinetic approaches [2], on the other hand, are prohibitively expensive for experimental-scale simulations. In this talk, we report on the development of EUCLID (Eulerian Code for pLasma Interaction Dynamics) based on a multifluid approach. The Euler equations are solved for each ion species and the electrons. The species interact through electrostatic forces, friction, and thermal equilibration. This model allows for distinct flows for each species through their separate velocity fields. The electrostatic potential is obtained from the charge densities using the Poisson equation. The equations are discretized on a three-dimensional Cartesian grid using a conservative finite-difference formulation, and the interface fluxes are computed using the 5th order WENO scheme. The Poisson equation is solved using a 6th order method. In addition, adaptive refinement of the mesh around regions of strong interactions is implemented using Chombo [3], a library for solving PDEs on block-structured AMR grids. The disparate masses of electrons and ions result in a stiff system of semi-discrete ordinary differential equations in time. We use the semi-implicit additive Runge-Kutta methods for time integration, where the electron acoustic modes are integrated implicitly in time, while the remaining terms in the ions and electron equations are integrated explicitly. We present the verification of EUCLID for several benchmark test cases, as well as the simulation of counterstreaming plasmas. In particular, we show that our approach is able to accurately capture plasma interpenetration when frictional forces are small, and the fluids do not converge to a single fluid within experimental time scales.

[1] M. M. Marinak et al., Physics of Plasmas 5, 1125 (1998).
[2] A. Kemp and L. Divol, LLNL Kinetic workshop 2016.
[3] M. Adams, et al., LBNL-6616E

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