Title: A Semi-Implicit Algorithm for the Simulation of High-Z Plasma Interpenetration

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Abstract:
High-energy density physics (HEDP) experiments often involve laser-induced counterstreaming plasmas that interpenetrate each other and interact through electrostatic and collisional forces. The simulation of such flows requires a multifluid model that allows distinct velocity fields for the plasma streams. Recently, we developed EUCLID (Eulerian Code for pLasma Interaction Dynamics) [1] that solves the inviscid Euler equations for each plasma stream and species. This approach allows distinct flows, including cases where the same species need to be partitioned into multiple populations or streams. The fluids interact with each other through electrostatic forces, friction, and thermal equilibration. We further simplify our model by assuming inertia-less electrons and a quasi-neutral plasma, and remove the necessity to solve the Poisson's equation for the electrostatic potential. One of the primary challenges in solving the resulting equations is that the collisional (friction and thermal equilibration) time scales are significantly faster than the acoustic and advective time scales. This difference is exacerbated for higher-Z species such as aluminum and gold. Explicit time integration methods are thus inefficient since the time steps are constrained by the collisional scales. We investigate the use of high-order implicit-explicit (IMEX) Additive Runge-Kutta (ARK) methods, where the friction and thermal equilibration terms are integrated implicitly in time, while the advective flux and the electrostatic terms are integrated explicitly. The equations are discretized in space on a three-dimensional Cartesian grid using a conservative finite-difference formulation and the 5th order MPWENO scheme. The semi-implicit time integration results in a nonlinear system of equations that are solved using the Jacobian-free Newton-Krylov approach. In this talk, we report on our implementation and we present simulations of several one- and two-dimensional plasma interpenetration cases that are representative of the HEDP experiments. In particular, we present results showing the interaction of high-Z species.

[1] D. Ghosh et al., "A Multispecies, Multifluid Model for Laser-Induced Counterstreaming Plasma Simulations", Submitted.

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