PLASMA VISCOSITY EFFECTS IN ICF IMPLOSION SIMULATIONS

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Plasma viscosity is often neglected in hydrodynamic simulations of Inertial Confinement Implosions (ICF). However, recent simulation studies show that momentum dissipation by viscosity may play a role in ICF by reducing small scale late time fluctuations [1], and a second study [2] finds that both plasma viscosity and species mass diffusion are important in modifying R-T (Rayleigh-Taylor) and K-H (Kelvin-Helmholtz) instability growth under plasma conditions and scale lengths relevant to ICF. In the present work, we examine the role of plasma viscosity by comparing simulations of an 'Omega-scale' ICF implosion both with and without plasma viscosity.

The ICF implosions are simulated using 1-D Lagrangian hydrodynamics with a 3T (ion, electron and radiation temperatures) model previously calibrated in DT burn test problems. Plasma viscosity in the momentum equation and viscous dissipation in the energy equation are implemented in the spherical geometry coordinates, using formulations consistent with recent dissipative plasma closures [3]. A 'base case' ICF implosion is defined for a DD fuel and CH capsule experiment with Omega-scale laser energy input, and we confirm that the simulations are generally consistent with available data, including neutron yields and implosion timings.

Results are compared in detail between simulations with and without plasma viscosity. The main shock converges almost 10% faster with viscosity compared to the inviscid case, however, it converges almost 10% slower with viscosity in the momentum equation and neglecting viscous dissipation in the energy equation. Burn weighted temperature, neutron production and timing of the initial shock while converging on axis are strongly influenced by viscosity while the compression phase sees only a minor effect.

Lagrangian hydrodynamics typically requires an artificial viscosity for numerical stability and to match shock Hugoniot jump conditions. We find that after the main ICF shock converges at the fuel center we are able to turn off the artificial viscosity and the plasma viscosity is sufficient to stabilize the later time simulations. Under these conditions the reflecting shock waves are considerably less attenuated than with the artificial viscosity, suggesting a more unstable plasma may exist than predicted by dissipative numerical methods such as those with artificial viscosity.

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