Constraining the Hydrodynamic Efficiency in Direct-Drive Cryogenic Implosions

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Summary

Nonlocal (NL) electron transport is required in 1-D LILAC simulations to reproduce the measured hydrodynamic coupling.

- The self-emission x-ray imaging measures the hydrodynamic coupling (implosion velocity and mass ablation rate).
- The mass ablation rate is underestimated when using a time-dependent flux limiter adapted to match the experimental shell trajectory.
- LILAC with NL and CBET accurately models the hydrodynamic coupling, reproducing both the transfer of the laser energy to the plasma (absorption) and of the plasma energy to the kinetic energy of the shell.
Collaborators


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Direct-drive inertial confinement fusion implosions are driven by laser energy absorbed near the critical density and transported by electrons to the ablation surface. Measurements of the trajectory ($V_{\text{shell}}$) and the CD burnthrough [($dm/dt, M$)] constrain the coupling physics in direct-drive implosions.
Self-emission x-ray imaging provides a tool to study shell velocity and mass ablation rate in cryogenic implosions.

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In cryogenic implosions, the shell trajectories are measured from the CD emission (early time) and the DT emission (late time).
The simultaneous measurement of the trajectory and the CD/DT interface makes it possible to determine the CD burnthrough time\(^*\). The CD burnthrough corresponds to the time when the CD/DT interface separates from the ablation front.

Shell trajectories and CD burnthrough are reproduced by LILAC simulations when including CBET and NL.

When matching shell trajectory, time-dependent flux-limiter simulations predict a burnthrough time 250 ps later than in the experiment.
At the burnthrough time, the remaining mass of the shell corresponds to the initial mass of the DT.

When matching shell trajectory, time-dependent flux-limiter simulations overestimate the shell mass and the kinetic energy by 26%.
LILAC simulations that include NL and CBET reproduce both the absorption and the kinetic energy of the shell.

The code accurately models the hydrodynamic coupling in cryogenic implosions.
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- LILAC with NL and CBET accurately models the hydrodynamic coupling, reproducing both the transfer of the laser energy to the plasma (absorption) and of the plasma energy to the kinetic energy of the shell