One-Dimensional Simulation of the Effects of Unstable Mix on Neutron and Charged-Particle Spectra from Laser-Driven Implosion Experiments

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Summary

Modeling of mix in the 1-D hydrocode *LILAC* reproduces experimentally observed behavior of primary and secondary neutron production

- The mix model includes the transport of target constituents, thermal energy, and turbulent energy due to both the acceleration and deceleration instabilities.

- Primary neutron yields are reduced by mixing fuel with cold shell material.

- Neutron-averaged source temperatures are higher when mix quenches the cooler outer core.

- Secondary neutron yield, energy spectra, and their dependence on target composition are significantly modified by mix.
Outline

- Modeling of mix in 1-D
- Primary and secondary DD neutrons
- Modification of neutron production by mix
- Illustrative examples
- Conclusions
“Bubble and spike” mixing thickness is obtained from a multimode Rayleigh–Taylor perturbation model* 

\[ \frac{d^2}{dt^2} A_\ell = \gamma^2(t) A_\ell \]

including Bell-Plesset effects

\[ A_\ell(t) > \frac{2R(t)}{\ell^2} \]

Takabe form for \( \gamma^2(t) \)

Haan saturation procedure for

Initial perturbation spectrum \( A_\ell(t = t_0) \) specified at ablation surface and fed through to fuel–pusher interface over time.

Mix is modeled as a diffusive transport process.

Secondary DT neutrons from the fuel and from CD layers have distinct energy spectra.

Cooling by fuel–pusher mix lowers DD neutron yield to observed levels

- 1-μm CD in 900-μm-diam, 27-μm shell, shaped 21-kJ PS-26 pulse

![Diagram showing normalized yield (YOC) vs CD offset (μm)]

- Expt. data
- Single-beam nonuniformity
- Beam imbalance
Cooling due to mix reduces the neutron yield, but raises the neutron-averaged ion temperature

- 20-µm, 900-µm diameter shell, 1-ns pulse
- 27-µm, 900-µm diameter shell, shaped PS-26 pulse
Mix reduces the dependence of secondary DT neutron yield on the offset and thickness of the CD layer

- 27-μm, 900-μm CH shell, 21-KJ, PS-26 pulse

![Graph showing the dependence of secondary DT yield on CD offset and thickness. The graph includes data points for different conditions: No mix, Beam nonuniformity, and Beam imbalance. The legend indicates the symbols used for each condition: - - - No mix, - Beam nonuniformity, - - - Beam imbalance, and Expt. data.]
Mix reduces the dependence of secondary DT neutron yield on the offset and thickness of the CD layer

- 20-µm, 900-µm CH shell, 1-ns pulse
Mix modifies the distinct energy spectra of secondary neutrons originating from the fuel and shell

- 27-µm, 900-µm diameter shell, shaped PS-26 pulse
- IRIS Monte-Carlo post-processor
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