Three-Dimensional Simulations of Flat-Foil Laser-Imprint Experiments at the National Ignition Facility

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Time = 1.5 ns

HYDRA simulation

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NIF* experiments were performed to measure imprint-seeded nonuniformities in planar foils driven with and without 45-GHz SSD applied to the laser pulse

- Excellent high-resolution x-ray radiography data with a clearly visible imprint signature were obtained
- Three-dimensional HYDRA simulations were used to capture 3-D physics of 1-D smoothing by spectral dispersion (SSD) and resolve all single-beam imprint modes
- Simulations predict a higher level of imprint, faster Rayleigh–Taylor (RT) growth rate, and early saturation time relative to experiments
- X-ray preheat from the backlighter is hypothesized to cause target preheat and reduce imprint

*NIF: National Ignition Facility
Collaborators


University of Rochester
Laboratory for Laser Energetics


Lawrence Livermore National Laboratory

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Single-beam smoothing is required for high-performance direct-drive implosions on the NIF

Calculated time-integrated inner-cone (23.5°) beam intensity

One-dimensional multi-FM SSD* (multifrequency modulation smoothing by spectral dispersion) has been validated** on a single quad (Q24B) of the NIF


NIF planar experiments used single-beam drive with no SSD and the NIF standard 45-GHz SSD

- 20-μm CH planar foil target
- 2-TW power single beam and $10^{14}$ W/cm² on-target intensity
- 15-μm-diam pinholes versus 30 and 40 μm in previous experiments
Excellent data were obtained with a clearly visible imprint signature

Imprint modulation features are persistent in time.

Each frame is an overlap of four camera frames.
The 3-D code HYDRA* is used to simulate the impact of SSD

- Simulations use HYDRA’s spherical laser-deposition model and resolve speckle size (~6 μm)

Simulations reproduce similar features as seen in the experimental radiographs but with much higher optical depth.

15-μm pinhole and framing-camera blurring were applied to simulated images.

Time = 1.5 ns

SSD active direction
Simulations predict a higher level of imprint, faster Rayleigh–Taylor growth rate, and early saturation time compared to experiments.
X-ray preheat is hypothesized to be the cause of the lower than predicted level of imprint observed in experiments.

The experiments are being considered to be repeated using a delayed backlighter pulse.

*J. J. MacFarlane, J. Quant. Spectrosc. Radiat. Transf. 81, 287 (2003).*
Summary/Conclusions

NIF* experiments were performed to measure imprint-seeded nonuniformities in planar foils driven with and without 45-GHz SSD applied to the laser pulse

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