Analysis of Modulations Observed in X-Ray Self-Emission Images of OMEGA Direct-Drive Inertial Confinement Fusion Implosions

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Summary

Nonuniform emission modulations observed in x-ray self-emission images show greater contrast than in simulations

- Modulations are generated from the laser beam port geometry on OMEGA spherical direct-drive implosions using small-spot distributed phase plates
  - the nonuniform emission patterns in the images arise from the x-ray self-emission around the ablation-front region
- State-of-the-art 3-D ASTER simulations show qualitatively similar patterns in the self-emission images
  - inclusion of imprint in the simulations did not resolve the discrepancy
- The results suggest the beam-mode–induced hydrodynamic perturbations may be underestimated
Collaborators

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Observations of emission modulations in x-ray self-emission images late in the implosion time

Omega shot 91828

Time difference in two images: 230 ps
Extraction of intensity profiles from the intensity modulations in the self-emission image
X-ray self-emission images from ASTER also show emission modulations.

ASTER x-ray self-emission images show smaller contrast compared to the data.
Two-dimensional slices of electron temperature and effective charge in the simulated implosion core also show similar modulations.

Two-dimensional slice of electron density in the simulated implosion core shows modulations.

Ablation-front radius: 182 μm
A radiation transport model is used to understand the source of the emission. Due to soft x-rays, the model shows that the modulations arise from the surface closest to the view.

Intensity-weighted photon energy: \( \sim 1000 \text{ eV} \)

Due to soft x rays, the model shows that the modulations arise from the surface closest to the view.
Plasma conditions for maximum and minimum emissions are predicted to differ

Difference in plasma conditions around ablation front region causes emission modulations in the x-ray self-emission image
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Emission from the shell along the line-of-sight shows much higher emission

Intensity weighted photon energy:

\[ I_{av} = \frac{\sum_{i=1}^{n} h v_i \cdot I_i}{\sum I_i} \]

\[ \approx 1000 \text{ eV} \]

At ~ 1000 eV intensity:

CH left ~ 1.5e^2 abs. units
D ~ 1.3e^2 abs. units
CH right ~ 1.0e^{16} abs. units
Different plasma conditions around ablation front region cause emission modulations in the x-ray self-emission image

Plasma conditions are different only in the ablation front region (see red dotted circles)
Diagram showing a spherical coordinate system with axes X, Y, and Z. The core is at the center, and the shell is marked with an angle $\theta$. The diagram illustrates the geometry of a spherical coordinate system.