Three-Dimensional Hot Spot Reconstruction from Cryogenic DT Polar-Direct-Drive Implosions on OMEGA

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Summary

A 3-D hot-spot model* has been developed to study and interpret the symmetry of implosions at OMEGA

- A technique was developed to reconstruct the 3-D intensity profile using a Spherical Harmonic Gaussian function
- This technique was validated by reconstructing synthetic data produced by the hydrodynamic code DEC3D**, and then applied to experimental data
- Causal effects from the laser drive show the expected change in hot-spot shape from prolate to oblate, indicated by the change in sign of the inferred $A_{2,0}$ coefficients
  - The magnitudes of the inferred $A_{2,0}$ coefficients are in agreement with the magnitudes of laser drive asymmetries

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* K. M. Woo et al., ZO04.00006, this conference.
Collaborators


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PDD implosions can be used to generate large asymmetries, and make a useful platform for testing aspects of 3-D reconstruction.

Precise characterization of these asymmetries could help us to improve implosion performance.

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PDD: polar-direct-drive
Magnitude and orientation of the low-mode shape can be inferred from x-ray images along different lines of sight

The 3-D shape of the hot-spot emission can be reconstructed using data from several quasi-orthogonal lines of sight.
A 3-D hot-spot intensity model* was developed to reconstruct the hot-spot emission profile of direct-drive implosions on OMEGA.

Spherical harmonic Gaussian function:

\[
\ln I(r, \theta, \phi) = \sum_{n=0}^{\infty} \sigma_n r^n \sin^n \theta \cos^n \phi = \sum_{n=0}^{\infty} \sigma_n R^n \left[ 1 + \sum_{l=0}^{\infty} \sum_{m=-l}^{l} A_{lm}(R) Y_{lm}(\theta, \phi) \right] \]

**Calculate error between experimental data and model**

**Compare with experimental data**

**Estimate for solution**

**2-D projection in detector planes**

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This approach has been tested against forward-simulated data from DEC3D*, and shows good agreement on major and minor radii.

Reconstruction of experiment 96581 shows a prolate-shaped hot-spot, indicated by a negative $A_{2,0}$ coefficient.

Spherical harmonic coefficients:

<table>
<thead>
<tr>
<th></th>
<th>$M = -3$</th>
<th>$M = -2$</th>
<th>$M = -1$</th>
<th>$M = 0$</th>
<th>$M = 1$</th>
<th>$M = 2$</th>
<th>$M = 3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L = 1$</td>
<td></td>
<td>0.02 ± 0.01</td>
<td>0.03 ± 0.01</td>
<td>0.04 ± 0.01</td>
<td></td>
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<tr>
<td>$L = 2$</td>
<td></td>
<td>−0.21 ± 0.01</td>
<td>0.1 ± 0.01</td>
<td>−0.47 ± 0.03</td>
<td>0.033 ± 0.003</td>
<td>−0.24 ± 0.02</td>
<td></td>
</tr>
<tr>
<td>$L = 3$</td>
<td>0.02 ± 0.01</td>
<td>0.08 ± 0.03</td>
<td>−0.05 ± 0.01</td>
<td>0.03 ± 0.01</td>
<td>−0.07 ± 0.01</td>
<td>−0.09 ± 0.02</td>
<td>0.23 ± 0.03</td>
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A better understanding of the fitting process and uniqueness is needed.
Experiment 96578 shows the expected change to an oblate hot-spot, indicated in the change in sign of coefficient $A_{2,0}$.

The magnitude of the $A_{2,0}$ coefficient is reduced by a factor of 2 in accordance with the reduction in laser drive asymmetry by a factor of 2.

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<td></td>
<td>$-0.13 \pm 0.01$</td>
<td>$0.18 \pm 0.01$</td>
<td>$-0.13 \pm 0.01$</td>
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<td></td>
<td></td>
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Future work will consider uniqueness, the highest mode that is resolved by existing data, and the potential value of improvements in resolution and additional lines of sight

*K. M. Woo et al., Z004.00006, this conference.