Modeling Cross-Beam Energy Transfer for Polar-Drive Experiments

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Predicted scattered-light normalized distribution at wall

Scattered-light calorimeters
Beam ports

Measured and predicted energy collected by calorimeters

Measured
Predicted with CBET

Scattered light (kJ/sr)

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

0 20 40 60 80

Angle from pole (°)

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Summary

Modeling suggests that cross-beam energy transfer (CBET) is significant during polar-drive (PD) implosions, but mitigation strategies exist.

- Modeling predicts that CBET will reduce absorption of the laser energy by ~10% during PD implosions on OMEGA
  - this level is similar to that in symmetric 60-beam implosions
  - the equatorial ring is affected more than the other rings

- A reduction in absorption is predicted for the PD point design on the NIF

- CBET may be mitigated by reducing the ratio of the beam/target radii
  - smaller beam profiles reduce CBET but increase illumination nonuniformity
Collaborators


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CBET is modeled using our scattered-light simulation code with a 3-D PD geometry

- Plasma parameters taken from 2-D DRACO hydrocode calculations (without CBET)

- Beam profiles are divided into many beamlets and ray tracing is used to calculate their paths and Doppler shifts

- CBET calculated* in 3-D for all beamlet crossings using all beams
  - intensity, absorption, and transfer along each beamlet solved iteratively

- Incorporation of CBET into DRACO is an ongoing effort**

- Modeling has been benchmarked using PD implosions on OMEGA

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For more details about CBET modeling, see also talk by J. A. Marozas, UO5.00003, this conference.
Integrated scattered-light distribution from OMEGA PD implosions support the CBET predictions

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Planned scattered-light calorimeters on NIF will be essential measurements for PD implosions.
CBET modeling of the time-dependent scattered light spectrum reproduces the observed features

- Details of the predicted spectra will likely match the observations even better with CBET incorporated into the hydrocode plasma profile predictions
A \(~10\%\) reduction in absorption caused by CBET is predicted for upcoming optimized PD implosions on OMEGA*

This level is similar to that in symmetric 60-beam implosions

This is consistent with observed \(~180\) ps bang-time delays in PD implosions

Equatorial third ring most affected by CBET

*P. B. Radha, NI2.00006, this conference
The PD ignition point design* for the NIF has been studied using the CBET model.

Preliminary results suggest ~20% reduction in absorption as a result of CBET for PD on the NIF

- The NIF PD implosions seem more sensitive to CBET than OMEGA
  - quads treated as single beams with quadruple intensity
  - pointing offsets are larger
    - some beams are offset azimuthally as well as toward the equator

<table>
<thead>
<tr>
<th>Ring</th>
<th>Absorption no CBET</th>
<th>Absorption with CBET</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>95%</td>
<td>88%</td>
</tr>
<tr>
<td>2b</td>
<td>95%</td>
<td>80%</td>
</tr>
<tr>
<td>3b</td>
<td>92%</td>
<td>90%</td>
</tr>
<tr>
<td>3c</td>
<td>90%</td>
<td>59%</td>
</tr>
<tr>
<td>4c</td>
<td>92% 89%</td>
<td>55% 60%</td>
</tr>
<tr>
<td>Total</td>
<td>92%</td>
<td>72%</td>
</tr>
</tbody>
</table>
CBET may be mitigated by using a smaller laser beam spot size

- In CBET the edge regions of the beam profiles steal energy from the centers
  - if we remove this edge region by making the spot smaller we may reduce the effects of CBET

- Experiments* in symmetric-drive implosions with reduced beam/target radius support this

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Using a smaller spot size recovers the 85% total absorption of the no-CBET predictions in PD

This could be an effective CBET mitigation strategy for PD, but it must be balanced with increasing illumination asymmetries and possible LPI issues with decreasing beam size.
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