Cross-Beam Energy Transfer in Simulations of NIF-Scale Strong Spherical Shock Experiments

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62nd Annual Meeting of the American Physical Society
Division of Plasma Physics
Memphis, TN
9 – 13 November 2020
DRACO simulations with a pump-depletion CBET model* match the shock trajectories and captures the shape of the shock front.

- Solid-sphere laser-coupling experiments were conducted in polar direct drive at the National Ignition Facility (NIF) investigating laser energy coupling with high laser intensity spikes**

- Simulations indicate that CBET reduced the laser absorption during the spike pulse by ~15% at $1 \times 10^{15}$ W/cm² and $2.5 \times 10^{15}$ W/cm²

- CBET changes the shape of the shock front from round to oblate

- The shock trajectories in 1-D simulations are not strongly influenced by hot electrons at the levels observed in experiment

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**S. P. Regan, et al., BO09.00014, this conference
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Shock ignition* (SI) adds a high-intensity spike at the end of the laser pulse to launch a strong shock wave, igniting the precompressed fuel.

Laser energy coupling at these high laser intensities is not well characterized.

Two experiments were performed with polar drive on the NIF to assess laser energy coupling at two different laser intensities. The experiments utilized a solid sphere driven by 184 beams. The peak intensities were 1×10^{15} W/cm^2 and 2.5×10^{15} W/cm^2.

- **Cu foil**
- **Q16T (B161-164)**
- **Au shield for DIM 90-124**
- **Q41B (B415-418)**
- **Thick target stalk**
- **Solid sphere driven by 184 beams**

The laser power-time curve shows two distinct peaks, corresponding to the two intensities:

- **E_{high} = 777.5 kJ**
- **E_{low} = 399.2 kJ**
The plasma conditions of these shots are similar to ignition designs for the NIF

<table>
<thead>
<tr>
<th></th>
<th>Lower-intensity N190204-003</th>
<th>Higher-intensity N190204-002</th>
<th>SI Point Design (NIF)* (flux-limited thermal, no-CBET)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Intensity</strong></td>
<td>1.0</td>
<td>2.5</td>
<td>3.4†</td>
</tr>
<tr>
<td><strong>Scale length</strong></td>
<td>330/400</td>
<td>400/420</td>
<td>450 (avg)</td>
</tr>
<tr>
<td><strong>Te (keV)</strong></td>
<td>3.2</td>
<td>4.5</td>
<td>8.5</td>
</tr>
</tbody>
</table>

†Maximum value of 8.0x10^{15} W/cm^2 in the center of “zoomed” spike beams
‡Simulated (DRACO) values at quarter critical, middle of spike pulse.
DRACO simulations with pump-depletion CBET match the experimental shock trajectories well.

Analysis of the Equatorial shock position was adversely affected by the stalk.
Most of the CBET effect on the shock is at the equator and on the second, high-intensity shock.

Laser focal spots were elliptical and smaller than the target.

*Both CBET and No-CBET runs performed with non-local thermal transport.*
CBET alters the shape of the imploding shock to more oblate.
The shape of the shock front is captured well in simulations with CBET.
The shape of the shock front is captured well in simulations with CBET
Hot electrons do not seem to make a significant difference in the shock trajectory

**1-D LILAC simulations**

**Lower-intensity**
- $E_{\text{hot-e}} = 7\text{ kJ (1.8\%)}$
- $T_h = 46\text{ keV}$
- Shock position vs. time graph for comparison with and without hot electrons.

**Higher-intensity**
- $E_{\text{hot-e}} = 35\text{ kJ (4.5\%)}$
- $T_h = 56\text{ keV}$
- Shock position vs. time graph for comparison with and without hot electrons.
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