Interplay of Raman Scattering and Two-Stream Flux Inhibition in Hohlraum Dynamics (new)

Talk CO5.9

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Special thanks to G. B. Zimmerman, H. Scott
Inner-beam “glint\(^1\) recently appreciated as possible significant energy loss from NIF hohlraums

“Inline” LPI models\(^2\) in hydro codes:

- **Cross-Beam Energy Transfer (CBET)**
  - Outer \(\rightarrow\) Inner + ion acoustic wave
- **Stimulated Raman scattering (SRS)**
  - Langmuir wave heating
  - SRS light absorption (minor)

**Hohlraum energetics:**

- Laser coupled to hohlraum = Incident – Backscatter – Transmitted
- Transmitted = “Glint” = (1-absorption)\(^*\)(inner power after LPI)
- Inner power after LPI = Incident + CBET from outers – BS – Langmuir and SRS heating

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Summary: “two-stream” thermal flux limit reduces CBET to inner beams and enhances glint

- Glint = (1-absorption) * (inner power after LPI)
- Inner power after LPI = Incident + CBET from outers – (Langmuir and SRS heating)

Langmuir heating or two-stream
- Hotter electrons, but different places
- Less CBET
- Less absorption
- More glint

<table>
<thead>
<tr>
<th>Compared to Base case</th>
<th>Langmuir heating</th>
<th>Two-stream</th>
<th>Both – closest to drive, shape data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron Temp.</td>
<td>Up in LEH</td>
<td>Up throughout fill</td>
<td>Way up in LEH</td>
</tr>
<tr>
<td>CBET to inners</td>
<td>Down</td>
<td>Down</td>
<td>Way down</td>
</tr>
<tr>
<td>Glint</td>
<td>Down a bit</td>
<td>Way up</td>
<td>Up</td>
</tr>
<tr>
<td>X-ray bangtime</td>
<td>+140 ps</td>
<td>+1100 ps</td>
<td>+640 ps, ~ experiment</td>
</tr>
</tbody>
</table>
We model with Lasnex NIF shot N121130: early “high-foot” plastic symmetry capsule

- $E_{\text{laser}} = 1270 \text{ kJ}$  $P_{\text{laser}} = 350 \text{ TW}$
- $(\lambda_{23}, \lambda_{30}) - \lambda_{\text{out}} = (8.5, 7.3) \text{ Ang.}$
- CBET to inners: tune polar P2 shape
- CBET to 23’s: tune azimuthal M4 shape
- Fill 1.45 mg/cc He
- Gold hohlraum: “575 scale”
Inputs to runs: measured SRS power and maximum wavelength

23° inner cone

Incident SRS, SBS, SRS+SBS

30° inner cone

50° outer cone

SRS spectra

Power [TW]

Time [ns]

Wavelength [nm]
Lasnex two-stream flux limit: crude return current instability model

- Spitzer-Harm heat flux carried by e- with (2-4)$v_{Te}$
- Zero net current $\rightarrow$ bulk electrons drift vs. ions

Ion acoustic drift instability if:
- $v_D >$ sound speed
- Growth rate exceeds ion Landau damping $\rightarrow Z T_e / T_i \gg 1$

$q = e^{-}$ heat flux $= \min(f^* n_e T_e v_{Te}, q_{SH})$

$f$ = flux limit

$f_0 = \text{user-specified} = 0.15 \text{ here}$

$f^{-1} = f_0^{-1} + \frac{a^2}{1 + a^2 \left( \frac{Z m_e}{m_i} \right)^{1/2}}$  \(TS\)

$f = \left( \frac{Z m_e}{m_i} \right)^{1/2}$

$a = \frac{Z T_e}{T_i} \gg 1$

$\Rightarrow q = n_e T_e c_{\text{sound}}$
Two-stream flux limit increases fill temperature – especially with Langmuir heating

Electron temperature [keV] at 13 ns – mid peak power

Langmuir heating

Langmuir + two-stream

12 keV!

High $T_e$ reduces CBET and laser absorption

Langmuir heating and two-stream both reduce CBET to inners – strong synergy
Two-stream flux limit reduces laser absorption: “enhanced glint”

**Enhanced Glint**

Hotter → less inverse brem. absorption

Un-absorbed light: “glint”

**Glint: escaping laser power [TW]**

Two-stream

Base case

Langmuir heating

L. J. Suter sees similar enhanced glint with low flux limit:
O. S. Jones: UI3.3 - Thursday 3:00 pm
Two-stream flux limit: enhanced glint reduces total drive

Radiation temperature on capsule

x-ray bangtime: experiment – simulated [ps]
Base case: +650
Langmuir heating: +510
Both: +10 matches experiment!
Two-stream: -450
Capsule shape combines CBET, Langmuir heating, and glint

Simulated x-ray radiograph: “2D Convergent Ablator”

Measured x-ray self emission: “Pancaked”, $P_2/P_0 = -0.12$

Langmuir heating

Hohlraum axis

Base case

Two-stream

Both – pancaked, like data!
Conclusion: two-stream flux limit increase fill temperature, reduces CBET to inners, enhances glint, reduces x-ray drive

Future work
• Glint in SBS data – blueshifted light: reflect off inward-moving wall
• \( T_e \) data: “micro-dot” (M. Barrios, CO5.1 this session), optical Thomson Scattering (~FY17)

• Improved model for return current instability
• Other flux inhibitors:
  • Nonlocal electron transport (J. Brodrick, CO5.11 this session)
  • MHD (W. Farmer, CO5.7 this session)
  • And their interplay

• SRS Langmuir waves \( \rightarrow \) suprathermal or “hot” electrons:
  • Instead of fluid heating
  • SRS-driven currents and B fields