Empirical Scaling of Hot Electrons with the Two-Plasmon-Decay Common-Wave Gain

D. H. Edgell
University of Rochester
Laboratory for Laser Energetics

OMEGA hydro-equivalent curve

In-flight aspect ratio

Ablation pressure (Mbar)

Common-wave gain

\( f_{\text{hot}} (\%) \)

10

10

10

10

Current hydro-equivalent design

CBET mitigation

Current stability threshold

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\( G = 2.3 \)

Standard cryo

CBET mitigation
Summary

Two-plasmon–decay (TPD) common-wave scaling makes it possible to predict hot-electron production for experimental designs

- Hot-electron production from TPD in OMEGA and OMEGA EP experiments scales empirically with the TPD common-wave gain
- If cross-beam energy transfer (CBET) must be mitigated to achieve ignition hydrodynamic equivalence on OMEGA then TPD mitigation will likely be required
- The scaling predicts that TPD mitigation with mid-Z layers will sufficiently reduce the hot-electron production
Collaborators


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The common-wave gain provides a useful empirical scaling that unifies the different experimental geometries.

The common-wave gain can be used as a scaling metric for target design.
A hydrocode postprocessor calculates maximum common-wave gain on the quarter-critical surface

- Linear theory shows that a resonant electron plasma wave (EPW) is shared by multiple beams in the region bisecting the wave vectors of the beam*

- Three-dimensional ray tracing finds the common-wave gain from all groups of three or more beams group at each point on the surface

- To predict hot-electron yields, the maximum gain over the entire surface is assumed to dominate

\[ G_c \approx \frac{I_\Sigma (W/cm^2) L_n (\mu m)}{T_e (keV)} \times 10^{-16} \]

CBET mitigation strategies based on reduced beam size are being evaluated for implementation on OMEGA

- Typically in CBET, the edge seed of outgoing beams takes energy from the center of ingoing beams.
- Reducing the beam radius increases absorption and the target drive as well as the maximum common-wave gain caused by the higher intensities.

\[
\frac{R_b}{R_t} = 0.6
\]

<table>
<thead>
<tr>
<th>Shot 63311, SG4’s, 900-(\mu)m CH on Mo, SG1018, 29.4 kJ</th>
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<tbody>
<tr>
<td>(R_b/R_t \approx 1.0)</td>
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<tr>
<td>(G_{\text{max}} = 2.8)</td>
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<tr>
<td>(f_{\text{hot}} = 0.08%)</td>
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<tr>
<td>Absorption = (~55%)</td>
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</tbody>
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<thead>
<tr>
<th>Shot 70010, PPD-DDPs, 866-(\mu)m CH, SG1018, 29.6 kJ</th>
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<tbody>
<tr>
<td>(R_b/R_t = 0.6)</td>
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<tr>
<td>(G_{\text{max}} = 4.2)</td>
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<tr>
<td>(f_{\text{hot}} = 0.9%)</td>
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<td>Absorption = 63%</td>
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Reduced-beam-size CBET mitigation schemes on OMEGA will likely require TPD mitigation.

Multilayer mid-Z targets have shown promise for TPD mitigation.

D. H. Froula et al., NO4.00013, this conference.
Experimental tests of multilayer targets produced many fewer hot electrons than CH targets.

- A mid-Z layer (Si) embedded in the target shell is designed to increase the coronal temperature at quarter critical to reduce the two-plasmon–decay produced hot electrons.
Mid-Z multilayers are predicted to significantly reduce hot-electron production.

Standard cryo design
SG4s, 26 kJ

**G**<sub>max</sub> = 2.3

\( f_{\text{hot}} \rightarrow 0.035\% \)

Multilayer cryo design
SG4s, 25 kJ

**G**<sub>max</sub> = 1.6

\( f_{\text{hot}} \rightarrow 10^{-4}\% \)

- CH + Si (7.4%) 4 \( \mu \)m
- Si 0.8 \( \mu \)m
- Be 2 \( \mu \)m
- DT 50 \( \mu \)m
Summary/Conclusions

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