Angular Dependence of the Two-Plasmon Decay in Multibeam Direct-Drive Irradiation Geometries

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Summary

The transition of collectively driven TPD from convective to absolute occurs at very large gains and is likely to be overshadowed by nonlinear effects.

- Experiments on OMEGA have shown that TPD is driven by the collective intensity of several overlapping laser beams.
- A group of beams can drive a common central plasma wave that is expected to produce most of the hot electrons.
- The angular distribution of this wave will determine the anisotropy of the hot electrons produced and, therefore, their preheating efficiency.
- Hot electrons should primarily be directed inward toward the target core.
TPD is observed to depend on the overlapped intensity for multiple-beam experiments.

Planar experiments x-ray signal

\[ \sim \exp \left( \frac{I_{14}}{0.7} \right) \]

![Graph showing the relationship between overlapped intensity and x-ray signal]

<table>
<thead>
<tr>
<th>Beams</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
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<td>Low</td>
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The anisotropy of multibeam TPD interaction can be studied using two beams

- Each pump wave drives a common plasma wave and a satellite; the common wave is of greatest interest
The common plasma wave can deviate from the centroid of the beams or from the density gradient.
Fourier analysis of the time-dependent TPD equations results in a set of first-order linear equations that can be integrated numerically

\[
\frac{du}{dk_x} = e^{i\psi_+} \left( \frac{k^2 - k_{d1}^2}{kk_{d1}} \right) L \left| v_{01} \right| (\hat{e}_1 \cdot k) u_{d1}
\]

\[
+ e^{i\psi_-} \left( \frac{k^2 - k_{d2}^2}{kk_{d2}} \right) L \left| v_{02} \right| (\hat{e}_2 \cdot k) u_{d2}
\]

\[
\frac{du_{d1}}{dk_x} = -e^{-i\psi_+} \left( \frac{k^2 - k_{d1}^2}{kk_{d1}} \right) L \left| v_{01} \right| (\hat{e}_1 \cdot k) u
\]

\[
\frac{du_{d2}}{dk_x} = -e^{-i\psi_-} \left( \frac{k^2 - k_{d2}^2}{kk_{d2}} \right) L \left| v_{02} \right| (\hat{e}_2 \cdot k) u
\]

\[
\psi_{\pm} = -\frac{3v_e^2 k_0 L}{\omega_p^2} \left\{ \cos (\theta_0 \pm \theta_n) k_x^2 + 2k_r [\cos (\theta_0 \pm \theta_k) - \cos \theta_0] k_x \right\}
\]
Spatial growth can be obtained by numerical integration of the Fourier-transformed equations:

\[ u_{d1}(k_x < 0) \]
\[ u_{d1}(k_x > 0) \]
\[ u(k_x > 0) \]
\[ u(k_x < 0) \]
\[ u_{d2}(k_x < 0) \]
\[ u_{d2}(k_x > 0) \]
The absolute instability threshold can also be determined from the behavior of the spatial growth.

- The convective gain can be found by integrating these equations over $k_x$ from $-\infty$ to $\infty$.

\[
\text{The gain is represented as max} \left\{ \left| \frac{u_{\text{out}}^2}{u_{d1}^2 + u_{\text{in}}^2 + u_{d2}^2} \right| \right\}
\]

- The spatial gain may diverge with increasing input intensity. This represents the onset of absolute instability.
The instability transitions from convective to absolute at large gains

\[ T_e = 2.0 \text{ keV} \]
\[ L = 100 \mu \text{m} \]
\[ \theta_0 = 23^\circ \]
\[ \theta_n = 0^\circ \]
Small deviations from the density gradient have little effect

\[ I = 2.0 \text{ keV} \]
\[ L = 100 \ \mu\text{m} \]
\[ \theta_0 = 23^\circ \]
\[ \theta_n = 30^\circ \]
At larger angles, the convective gain is reduced and the onset of absolute instability is not clear.

\[ T_e = 2.0 \text{ keV} \]
\[ L = 100 \mu m \]
\[ \theta_0 = 23^\circ \]
\[ \theta_n = 60^\circ \]
For a fixed intensity, the gain falls off rapidly with angle from density gradient.

Hot electrons should be primarily directed inward toward the target core.
The transition of collectively driven TPD from convective to absolute occurs at very large gains and is likely to be overshadowed by nonlinear effects.

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