Two-Plasmon–Decay Electron-Divergence Measurements in Direct-Drive Implosions on OMEGA

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X-ray pinhole camera

absolutely calibrated Mo Kα yield

XRS

Kα

E_{\text{coupled}}

E_{\text{TPD}}

Mo diameter (µm)

No divergence

Isotropic (2π) ~R²

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Summary

Measurements indicate that only 20% of the hot electrons produced by TPD are coupled to the fuel

- Calculations of the hot-electron preheat require knowledge of the two-plasmon decay (TPD) source and the angular divergence of the electrons
- Direct-drive ignition-relevant plasma conditions are created on OMEGA EP
- The fraction of laser energy converted to hot electrons saturates near ignition conditions
- Experiments indicate that the $f_{\text{hot}}$ and $T_{\text{hot}}$ are linked and independent of the target geometry
- The TPD-generated electrons are measured to be isotropic on OMEGA
Collaborators

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Two plasmon decay (TPD) generates hot electrons that can couple energy to the imploding, shell raising the adiabat and potentially quenching ignition

- Calculating the energy coupled to the fuel (preheat) requires:
  - electron source \((T_{\text{hot}}, f_{\text{hot}})\)
  - electron angular divergence \((\theta)\)
  - energy lost to the sheath \((\Delta E)\)

Direct-drive ignition requires that less than \(~0.1\%\) of the laser energy be coupled to the unablated fuel.
A series of targets were designed to study TPD in both planar and spherical geometries.

OMEGA EP planar (ignition scale lengths)
1-mm-diam spots 10 kJ/2 ns
30 μm CH
30 μm Mo

Spherical (source)
30-μm-thick CH
30-μm Mo shell

Spherical (coupling)
860 μm CH shell
200 μm solid Mo ball

Monte Carlo calculations are used to determine the total hot-electron energy given the Kα yield and hot-electron temperature.

*B. Yaakobi et al., Phys. Plasmas 19, 012704 (2012).*
Direct-drive ignition-relevant plasma conditions are created in planar geometry on OMEGA EP.

The increased power available on OMEGA EP produces ignition-relevant longer-scale-length plasmas.

\[
G_{TPD} \propto \left( \frac{I_0 L_n}{T_e} \right)
\]

\[
I_{overlap} = 7 \times 10^{14} \text{ W/cm}^2
\]
Extending the intensity to ignition conditions indicates that \(~1\%\) of the laser energy is converted to hot electrons with a characteristic temperature of 85 keV.

Planar targets, OMEGA EP

This target platform accounts for all electrons generated by TPD source; the energy coupled to the direct-drive shell ("preheat") will be reduced.

The hot-electron fraction is reduced in spherical geometry for a given overlapped intensity.
A multibeam gain model shows that the laser-beam configuration must be taken into account.

In polar drive, the gain is not driven by the overlapped intensity of all the beams.

\[
G_c = \left( f_g N^\text{sym}_\Sigma \right) \left( \frac{I_{14}^{\text{SB}} L_n (\mu m)}{47 T_e (\text{keV})} \right)
\]
The fraction of hot electrons reaching the cold shell is measured using small Mo balls. These results indicate that only 20% of the hot electrons generated by TPD will contribute to preheat on OMEGA.
TPD can be reduced in direct-drive plasmas by changing the ablator material

- Part of this reduction is a result of hydrodynamics
  - increased electron temperature
  - reduced scale length
- TPD has been shown through simulations to be reduced by
  - increased electron–ion collisions*
  - reduced ion-acoustic wave damping**

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**J. F. Myatt, TO5.00005, this conference.
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