Modeling Hot-Electron Measurements in Multibeam Two-Plasmon–Decay Experiments

Fraction of incident laser energy converted into hot electrons

- Overlapped intensity ($\times 10^{14}$ W/cm²)
- Hot-electron temperature

- $F_{hot}^{50}$
- $T_{hot}$ (keV)

Experiment
Simulation

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Summary

Three-dimensional two-plasmon–decay (TPD) simulations were used to calculate hot-electron production in multibeam planar-target experiments on OMEGA

- Numerical TPD calculations were combined with hydrodynamic simulations to predict hot-electron production
- Simulations show good agreement with the temporally resolved hot-electron measurements and with the scaling of hot-electron production as a function of drive-beam intensity
Collaborators


University of Rochester
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Hard x-ray detectors were used to measure the hot-electron distribution

Experimental configuration

- **HXRD** (x-ray time history)
- **300 μm (FWHM**)**
- **30 μm CH**
- **30 μm Mo**
- **30 μm CH**
- **HXIP** (absolute x-ray spectrum)
- **3ω (351-nm) drive beams**
  0.4 to 1 kJ in 1 ns ($I_{\text{overlap}} = 3$ to $9 \times 10^{14}$ W/cm²)

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*HXRD: hard x-ray detector  
**FWHM: full width at half maximum  
†HXIP: hard x-ray image-plate spectrometer
**LPSE** solves a pair of equations that model the coupling between the envelope of high-frequency-electrostatic perturbations and low-frequency-density perturbations*.

Electron plasma wave propagation in an inhomogeneous plasma

\[ \nabla \cdot \left[ 2i\omega_{pe} (\partial_t + \nu_e) + 3v_{te}^2 \nabla^2 - \frac{\omega_{pe}^2 \delta N}{n_0} \right] \vec{E} = \frac{\omega_{pe}^2}{n_0} \nabla \cdot \left( \frac{\delta n}{n_0} \vec{E} \right) + \frac{e}{4m_e} \nabla \cdot \left[ \nabla (\vec{E}_0 \cdot \vec{E}^*) - \vec{E}_0 \nabla \cdot \vec{E}^* \right] + S_E \]

Hybrid-particle evolution

Coupling to ions

Coupling to drive beams

\[ \left[ \partial_t^2 + 2\nu_i \nabla_t - c_s^2 \nabla^2 \right] \delta n = \frac{\nabla^2 |\vec{E} + \vec{E}_0|^2}{16\pi m_i} \]

ion-acoustic wave propagation

Ponderomotive force

\[ \nabla^2 \left( \vec{E} + \vec{E}_0 \right) \]

LPSE geometry

Thermal fluctuations

Polarization vectors

Drive-beam wave vectors

\[ \text{*J. F. Myatt, NO5.00002, this conference.} \]
Two-dimensional hydrodynamic simulations were used to calculate the input parameters for the LPSE simulations.
To make a direct comparison between hot-electron measurements and simulations, it is necessary to account for spatial and temporal variations present in the experiment.
Predicted hot-electron fractions were generated using plasma conditions from \textit{DRACO} simulations.

Plasma parameters at $n_c/4$ (from \textit{DRACO} simulations):

- $I_{14}$ at $n_c/4$ ($\times 10^{14}$ W/cm$^2$)
- $L_n$ at $n_c/4$ ($\mu$m)
- $T_e$ at $n_c/4$ (keV)

Spatially and temporally varying $F_{\text{hot}}$ prediction.
The predicted spatially averaged hot-electron production is in good agreement with time-resolved HXRD measurements.

\[
\left\langle F_{\text{hot}} \right\rangle_r = \frac{\int F_{\text{hot}}(r,t)I(r,t)rdr}{\int I(r,t)rdr}
\]

Measured and predicted hot-electron–production time histories

- Pulse
- TS*: Thomson scattering
- HXRD
- LPSE

*TS: Thomson scattering
LPSE reproduces the observed scaling in hot-electron temperature and fraction

\[
\langle F_{\text{hot}} \rangle = \frac{\int dt \int F_{\text{hot}}^{LPSE}(r, t) I(r, t) r dr}{\int dt \int I(r, t) r dr}
\]

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