Numerical Investigation of the Effects of Cross-Beam Energy Transfer (CBET) on the Drive Uniformity of OMEGA Implosions

SG4 and CBET laser-beam profiles
Low-adiabat, cryo implosion

Mass density at peak burn (DRACO)

Normalized laser intensity

Beam radius (mm)

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Summary

Target uniformity is more susceptible to the effects of CBET as the adiabat of the implosion is lowered

- Effective laser-beam profiles were calculated with the CBET model implemented in 1-D LILAC
- Time-independent laser-beam profiles, representing a “worst-case” scenario, were used in 2-D DRACO simulations to evaluate the effects of CBET on target performance for a range of implosion adiabats
- CBET was found to have little or no effect on high- to medium-adiabat implosions
- Simulations indicate that CBET does act to reduce target performance in low-adiabat implosions

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Collaborators


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Simulations using the CBET model better reproduce the experimental FABS scattered-light spectrum*

- Red-shifted “fingers” are reproduced more accurately with the CBET model

*D. H. Edgell (JO5.00014).
Effective beam profiles are used to emulate the CBET in 2-D DRACO simulations

- The CBET model is implemented into the 1-D code LILAC*

- Ray intensity along its trajectory**

\[
I^{(1)} = I_0^{(1)} \exp \left( \int L^{-1} d\ell \right),
\]

\[
L^{-1} \int \frac{n/n_c}{1 - n/n_c} \frac{I^{(2)}}{f(Z)T}
\]

*S. V. Igumenshchev (JO5.00015)

An initial investigation of CBET shows that the effective beam profile changes during the implosion.
Time-independent effective beam profiles were selected for each considered implosion.

- CBET profiles were rescaled to have the same energy as SG4 to reproduce the drive.
An analysis of the effective laser-beam profiles shows an increase in medium-wavelength illumination nonuniformities.

- SG4 laser-beam profile was designed to minimize $\sigma_{rms}$

$$I(r) = I_0 e^{-\left(\frac{r}{r_0}\right)^n}$$ – beam-intensity profile

$n$ – order of super-Gaussian
A high-adiabat implosion shows a negligible increase in stagnated shell nonuniformity.

Shot 54881 target

Mass density at peak burn (DRACO)

24 kJ SG1018 laser pulse
A medium-adiabat implosion shows an unimportant increase in \( l = 16 \) perturbation due to CBET.

Shot 41089 target

- **D\(_2\) gas**
- **CH**
- 27 \( \mu \)m
- 430 \( \mu \)m
- 403 \( \mu \)m

20.5 kJ LA1501 laser pulse

Laser power (TW)

Time (ns)

Mass density at peak burn (DRACO)

- SG4
- CBET
- YOC 99.8%
- YOC 98.7%

\( \rho \) (g/cm\(^3\))

0

90
A low-adiabat, D\textsubscript{2} cryo target implosion shows much higher nonuniformities and performance degradation.

Shot 47206 target:
- D\textsubscript{2} gas
- D\textsubscript{2} ice
- CD

16.5 kJ HE363001P laser pulse

Mass density at peak burn (DRACO):
- SG4
- CBET
- YOC 98.4%
- YOC 81.5%

Laser power (TW):
- 11

Time (ns):
- 0 to 4

Density (g/cm\textsuperscript{3}):
- 0 to 190
Target uniformity is more susceptible to the effects of CBET as the adiabat of the implosion is lowered.

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- CBET was found to have little or no effect on high- to medium-adiabat implosions.
- Simulations indicate that CBET does act to reduce target performance in low-adiabat implosions.

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