Evaluation of Wavelength Detuning to Mitigate Cross-Beam Energy Transfer Using the NIKE Laser

P. W. McKenty
University of Rochester
Laboratory for Laser Energetics

56th Annual Meeting of the American Physical Society
Division of Plasma Physics
New Orleans, LA
27–31 October 2014
**Summary**

The NIKE laser will be employed to examine the effects of laser wavelength detuning to mitigate cross-beam energy transfer (CBET)

- CBET has been shown to have deleterious effects on shell drive and stagnation-phase assembly
- Wavelength detuning is predicted to recover the necessary implosion velocities required for ignition platforms
- The NIKE platform is well suited for these studies, providing a well-diagnosed system over a wide range of detunings (±6Å)
- Various ablator systems will be studied, including basic glass and CH, as well as doped and/or graded shells
Collaborators

J. A. Marozas and F. J. Marshall
University of Rochester
Laboratory for Laser Energetics

J. Weaver, S. Obenschain, and A. Schmitt
Naval Research Laboratory
The effects of CBET in direct-drive implosions have been well documented on both OMEGA and the National Ignition Facility (NIF).

- N120328 was a 125-kJ, 1540-mm-diam glass target: Peak $I = 1.6 \times 10^{15} \text{ W/cm}^2$

\[
\begin{align*}
\text{DRACO/Spect3D}\,* \\
(f = 0.06) \\
N120328 \text{ gated x-ray detector (GXD)} \\
\text{DRACO/Spect3D}\,* \\
(iSNB,** CBET)
\end{align*}
\]

\[
\begin{align*}
r_{\text{avg}} & = 339 \ \mu\text{m} \\
r_{\text{avg}} & = 341 \ \mu\text{m} \\
r_{\text{avg}} & = 343 \ \mu\text{m}
\end{align*}
\]

*Prism Computational Sciences, Inc., Madison, WI 53711.
**D. Cao et al, UP8.00084, this conference.
Absorption reduction caused by CBET can be mitigated in three different domains that can be combined.

- **Spatial domain** (reduction of the interaction volume)
  - dynamic spot-shape changes; “zooming”
  - static spot-shape design tailored to the target, e.g., spot masking

- **Spectral domain** (wavelength detuning)
  - detuning causes a resonance shift to lower interaction volumes

- **Temporal domain**
  - time-multiplexed pulses reduce interaction time overlap

M. Hohenberger, CI1.00001, this conference; P. B. Radha et al., JO4.00013, this conference; D. H. Froula et al., NO4.00013, this conference.
Wavelength detuning affects CBET in two modes in direct-drive implosions

CBET causes rays from the beam tails to extract energy from high-intensity central rays.
Frequency detuning is predicted to recover the critical implosion velocity in polar-drive (PD)–ignition target designs.

Experimental verification of CBET mitigation with wavelength detuning is a high priority.

T. J. B. Collins et al., JO4.00001, this conference; J. A. Marozas et al., NO4.00014, this conference.
The NIKE laser is capable of significant laser detuning between the drive and backlighter beams.

Backlighter beams
\[ \Delta \lambda: \pm 3 \text{ Å KrF} \]
10 J in 400-ps (FWHM)

Drive beams
\[ \Delta \lambda: \pm 3 \text{ Å (KrF)} \]
1.8 kJ in 4 ns

---

Density

\[ \rho \text{ (g/cm}^3\text{)} \]
6.07
4.90
3.72
2.55
1.37
0.20

\[ n_e/n_c \]
7.22
2.18
0.66
0.20
0.06
0.02

\[ T_e \]
2.11
1.07
0.54
0.27
0.14
0.07

---

J. Weaver et al., NP8.00127, this conference.
Wavelength detuning is predicted to alter the intensity of the scattered signal of the probe beam.

Scattered light (mJ/cm²)

- CH ablator
- No CBET
- CBET ($I_{peak}/2$)

$d\lambda = +6$ Å (KrF)

$d\lambda = 0$

$d\lambda = -6$ Å (KrF)
The NIKE laser will be employed to examine the effects of laser wavelength detuning to mitigate cross-beam energy transfer (CBET)

- CBET has been shown to have deleterious effects on shell drive and stagnation-phase assembly
- Wavelength detuning is predicted to recover the necessary implosion velocities required for ignition platforms
- The NIKE platform is well suited for these studies, providing a well-diagnosed system over a wide range of detunings (±6Å)
- Various ablator systems will be studied, including basic glass and CH, as well as doped and/or graded shells
Once implemented, the NIKE platform can evaluate the effects of CBET for a variety of ablator systems.