Modeling of Target Offset in Warm Implosions on OMEGA

K. S. Anderson
University of Rochester
Laboratory for Laser Energetics

Yield over clean vs. Target Offset ($\mu$m)

- CBET/Nonlocal
- No CBET/VFL
- Experiment

60th Annual Meeting of the American Physical Society
Division of Plasma Physics
Portland, OR
5 – 9 November 2018
Simulations of direct-drive implosions that include target offset require a 3-D cross-beam energy transfer ray trace to model $\ell = 1$ accurately.

- Implosions that are simulated including the effect of cross-beam energy transfer (CBET)* show less sensitivity to initial target offset than when modeled without.
- **DRACO** simulations with CBET show improved agreement in yield compared to experiment.
- Simulated x-ray core offsets match experimental data better when CBET effects are included.

CBET reduces the $\ell = 1$ mode perturbation induced by target offset.

---

Collaborators


University of Rochester
Laboratory for Laser Energetics

M. Gatu Johnson
Massachusetts Institute of Technology
Plasma Science and Fusion Center

S. Laffite
Commissariat à l’Energie Atomique, DAM
No clear correlation exists in OMEGA cryogenic experiments between YOC versus target offset for $2.5 \leq \alpha \leq 3.5$ and $14 \leq CR \leq 19$.

- Other sources of nonuniformity appear to dominate YOC in cryogenic implosions.
- Simulations, however, have shown neutron yields have high sensitivity to target offset.

\[\alpha: \text{adiabat}\]
\[\text{CR: convergence ratio}\]
\[\text{XRPHC: x-ray pinhole camera}\]
\[\text{YOC: yield over clean}\]

---

Warm target experiments with prescribed target offsets were conducted to compare experimental with simulated data.

- Target offsets were nominally 40 μm
- Simulated both with CBET* + nonlocal heat transport and with variable flux limiter
- Compared data between simulation and experiment
  - yields
  - compressed core offsets
  - neutron-averaged core flows**

Warm targets allow for more control of the target positioning, and no ice layer to complicate analysis.

---

**See O. M. Mannion et al., BO6.00010 (next talk).
Simulations with CBET and nonlocal thermal transport more accurately predict yield degradation from target offset.

Values for the variable flux limiter (VFL) were chosen to match shock and shell trajectories with CBET + nonlocal transport.

VFL shows 2× more yield degradation than CBET + nonlocal transport.

*Experimental yield is normalized to the best-shot, no-offset experiment; simulated yield is normalized to the no-offset simulated yield for the same shot.
Simulations with CBET and nonlocal thermal transport more accurately predict yield degradation from target offset.

*Experimental yield is normalized to the best-shot, no-offset experiment; simulated yield is normalized to the no-offset simulated yield for the same shot.*
Simulations with CBET and nonlocal thermal transport more accurately predict yield degradation from target offset.

*Experimental yield is normalized to the best-shot, no-offset experiment; simulated yield is normalized to the no-offset simulated yield for the same shot.*
Target offset causes an $\ell = 1$ mode in the laser illumination pattern

- Beam centers strike the target closer together on one side than the other
- This results in a dominant $\ell = 1$ mode
As the plasma forms, more over-the-horizon light reaches the “hot” side of the target. More over-the-horizon light seeds higher CBET losses in hot-side beams. CBET is higher on the hot side of the target, effectively mitigating the $\ell = 1$ drive asymmetry from target offset. $\ell = 1$ drive asymmetry from power imbalance is not mitigated by CBET; this is a geometric effect of target offset.
Scattered-light diagnostics in *DRACO* show CBET scatters more light from the hot-side beams.

CBET increases the scattered light only on the hot side (north pole).
The power deposited by the laser in the $\ell = 1$ mode is dramatically decreased by CBET

- During the picket and beginning of the foot, the mode amplitude is similar.
- As the plasma scale length increases, CBET losses dramatically reduce the $\ell = 1$ mode.

![Graph showing mode 1 amplitude over time with different curves for VFL, CBET/Nonlocal, and laser power x 0.1.](image)
The simulated shift of the compressed core away from target chamber center agrees better with experiment when CBET is included.

Experimental x-ray core shift from TCC $\approx 61 \pm 2 \mu m$

Simulated x-ray photon count

Core shift$_{VFL} \approx 71 \mu m$

Core shift$_{CBET} \approx 63 \mu m$

TCC: target chamber center

Simulations of direct-drive implosions that include target offset require a 3-D cross-beam energy transfer ray trace to model $\ell = 1$ accurately.

- Implosions that are simulated including the effect of cross-beam energy transfer show less sensitivity to initial target offset than when modeled without.

- DRACO simulations with CBET show improved agreement in yield compared to experiment.

- Simulated x-ray core offsets match experimental data better when CBET effects are included.

CBET reduces the $\ell = 1$ mode perturbation induced by target offset.