Integrated Two-Dimensional DRACO Simulations of Cryogenic DT Target Performance on OMEGA

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Integrated DRACO simulations examined the perturbations in cryogenic DT implosions on OMEGA

- Laser imprint and target perturbations were examined for a variety of cryogenic DT target implosions at ignition-relevant implosion velocities ($V \sim 3.8 \times 10^7$ cm/s) on OMEGA using DRACO
- Integrated DRACO simulations have reproduced most of the experimental observations for the mid-adiabat ($\alpha \approx 4$) implosions
- For low-adiabat ($\alpha \approx 2$) implosions, the nonuniformity sources included cannot fully explain the reduction in target performance
Collaborators


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Perturbation effects on cryo DT target performance can be examined by multidimensional simulations

- The 2-D radiation hydrocode *DRACO* is used to perform the integrated simulations
- The nonuniformity sources include laser imprint (up to \( \ell = 150 \)), laser mistiming and mispointing, power imbalance, target offset, and ice-layer roughness
- The nonlocal* and cross-beam energy transfer (CBET)** effects are mimicked by a time-dependent flux limiter in 2-D simulations through matching the 1-D trajectory
- The 2-D simulation results are further post-processed with *Spect3D*† and *IRIS*‡ to extract the x-ray emission and \( \rho R \) information for comparison with experiments

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* J. A. Delettrez et al., U04.00007, this conference.
** J. A. Marozas et al., C07.00004, this conference.
† Prism Computational Sciences, Inc. Madison, WI 53711.
Mid-adiabat ($\alpha \approx 4$) cryo DT implosions are found to be less affected by perturbations.

Target offset: 6 $\mu$m
Ice roughness: $\sigma_{rms} \sim 1.4$ $\mu$m
Laser imprint: $\ell_{max} = 150$
DRACO simulations reproduced the experimental observations in neutron yield, $\rho R$, and ion temperature.
Low-adiabat ($\alpha \approx 2$) cryo DT implosions are more susceptible to laser and target perturbations.

- Target offset: 8 $\mu$m
- Ice roughness: $\sigma_{\text{rms}} \sim 1.3$ $\mu$m
- Laser imprint: $\ell_{\text{max}} = 150$
The experimental observables for $\alpha \approx 2$ implosions cannot be fully explained by the nonuniformity sources currently included in the simulations.

<table>
<thead>
<tr>
<th></th>
<th>Simulation</th>
<th>Experiment</th>
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<tbody>
<tr>
<td>Yield</td>
<td>$1.7 \times 10^{13}$</td>
<td>$1.1 \times 10^{13}$</td>
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<tr>
<td>$\langle T_i \rangle_n$ (keV)</td>
<td>2.9</td>
<td>3.0</td>
</tr>
<tr>
<td>$\langle \rho R \rangle_n$ (mg/cm$^2$)</td>
<td>190</td>
<td>110</td>
</tr>
<tr>
<td>Burn width (ps)</td>
<td>79</td>
<td>150</td>
</tr>
</tbody>
</table>
The x-ray image from the DRACO–Spect3D simulation is smaller than experiments for the $\alpha \approx 2$ implosion.

**DRACO**: $R_{17\%} = 20.1 \, \mu m$

Experiment: $R_{17\%} = 33.3 \pm 0.4 \, \mu m$

*Gated monochromatic x-ray imager*
Hot-spot pressure and burnwidth comparisons also indicate the degraded low-adiabat implosions*

<table>
<thead>
<tr>
<th></th>
<th>Pressure</th>
<th>Simulation</th>
<th>Experiment</th>
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<tbody>
<tr>
<td>S68951 ((\alpha \approx 4))</td>
<td>35.0 Gbar</td>
<td>31.5 Gbar</td>
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</tr>
<tr>
<td>S69236 ((\alpha \approx 2))</td>
<td>41.0 Gbar</td>
<td>18.0 Gbar</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Burnwidth</th>
<th>Simulation</th>
<th>Experiment</th>
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</thead>
<tbody>
<tr>
<td>S68951 ((\alpha \approx 4))</td>
<td>80 ps</td>
<td>80 ps</td>
<td></td>
</tr>
<tr>
<td>S69236 ((\alpha \approx 2))</td>
<td>79 ps</td>
<td>150 ps</td>
<td></td>
</tr>
</tbody>
</table>

*V. N. Goncharov, GI3.00001, this conference (invited).
Possible sources for the performance reduction of low-adiabat implosions are being investigated

- The accuracy of laser-imprint simulations in DRACO is being examined with OMEGA high-resolution VISAR (OHRV) measurements
- Preliminary analysis suggested that the simulation underestimates the laser-imprint effect
- The thermal conductivity and opacity models have also been re-examining with first-principle quantum molecular dynamics (QMD) calculations
- The QMD calculations showed 3 to 5 times higher thermal conduction in the boundary between hot-core and cold-fuel shells, which may change the hot-spot formation dynamics
- Surface defects,* radiation preheat...

*I. V. Igumenshchev et al., Phys Plasmas 20, 082703 (2013).*
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