Ablative Richtmyer–Meshkov Growth in ICF Targets on OMEGA

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45th Annual Meeting of the American Physical Society
Division of Plasma Physics
Albuquerque, NM
27–31 October 2003
Ablation-front oscillations due to dynamic overpressure have been observed

- Analysis of the data shows phase inversion of the ablation-front ripples.
- Observed areal-density modulations are in good agreement with theory and simulations during the shock transit.
- The data obtained from two independent experiments match very well.
- The experimental results are used to validate numerical codes for ICF hydrodynamic simulations (see V. Goncharov, LO.001).
Experimental verification of the effect of “dynamic overpressure” is important to implosion stability studies in direct-drive ICF

**Motivation**

- Dynamic overpressure sets the initial conditions for the Rayleigh–Taylor (RT) growth.

- The magnitude of dynamic overpressure stabilization during the Rayleigh–Taylor phase can be estimated:

\[
g = \sqrt{k^2 V_a V_{bl} - 2 k V_a}
\]

- The cutoff wavelength for RT growth in cryogenic targets is set by the dynamic overpressure term.
Dynamic overpressure is the main physical mechanism stabilizing ablative Richtmyer–Meshkov growth

- Classical RM growth: $h \sim k c_s h_0 t$
- With ablation: $h \sim h_0 \cos(w t)$
- Oscillations are observable only before the onset of RT growth.\(^2\)

- For short-wavelength modes, more oscillations are registered during shock transit.

\(^1\)V. N. Goncharov, Phys. Rev. Lett. 82, 2091 (1999).
Through-foil x-ray radiography is used to measure the evolution of the target $\rho R$ perturbations.

<table>
<thead>
<tr>
<th>$\lambda$ ((\mu)m)</th>
<th>$d$ ((\mu)m)</th>
<th>$a_0$ ((\mu)m)</th>
<th>$I$ (TW/cm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>40, 60</td>
<td>1.65</td>
<td>200 to 400</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
<td>2.75</td>
<td>400</td>
</tr>
</tbody>
</table>
A streaked image of a driven planar CH target acquired with the PJX provides a continuous record in time.

Spatial profiles taken at two different times clearly show phase inversion in the data. Streaked image of a planar CH target with 60-μm thickness and single-mode (l = 20 μm) surface modulations on the front.

Evolution of the peak and valley of R perturbations.
Numerical simulations are in good agreement with experimental data

\[ \lambda_1 = 20 \, \mu m \]

\[ \lambda_2 = 30 \, \mu m \]

\[ t_{rb} \sim 1.3 \, ns, \ U_s \sim 63 \, \mu m/ns, \ d = 60 \, \mu m \]

- In the numerical code, thermal transport with a flux limiter \( f = 0.06 \) models well the evolution of different modes.
PJX data agree very well with previous framing camera results

Evolution of single-mode perturbations, 20-μm wavelength

Perturbation amplitude (optical depth) vs. Time (ns)

- d = 30 μm
- d = 20 μm
- d = 45 μm
- d = 60 μm
- PJX-KB
Laser intensity affects evolution of modulation amplitude.

Evolution of single-mode perturbations, 20-μm wavelength

Perturbation amplitude (optical depth)

Time (ns)

400 TW/cm²

200

50
Summary/Conclusions

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