Title:

Hugoniot Measurements at Multiple Pressures in Tin Using of 800 MeV Proton Radiography

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Hugoniot Measurements at Multiple Pressures in Tin Using of 800 MeV Proton Radiography

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Collimator

Identity Lens

Object Location

Identity Lens

Image Locations
Proton Interactions

Proton Radiography

- Energy Loss (Electron Attraction)
- Nuclear Interaction
- Coulomb Scattering from Nucleus
Image and Contrast

Quadrupole Identity Lens

- Scattering from object maps to radial position at Fourier plane
- Transmission through a collimator provides image contrast and information about object thickness

No object

Object

Fourier Point

Image

After Object

After Collimator

Scattering from object maps to radial position at Fourier plane.
Transmission through a collimator provides image contrast and information about object thickness.
Temporal Resolution

- 19 images at first station
- 22 images at second station
- Total 41 possible image times
- Typically 50 ns exposure times
Powder Gun-Driven
Measured and Calculated Densities - Iron

Fe Densities

<table>
<thead>
<tr>
<th>State</th>
<th>Measured</th>
<th>Calculated*</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>8.346</td>
<td>8.342</td>
<td>&lt;0.1%</td>
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<tr>
<td>P2</td>
<td>8.854</td>
<td>8.846</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

*calculated values from 1-D Multi-Phase EOS for Fe model
Taylor Wave-Driven Tin

- Explosive-driven “Taylor Wave” shock
- Multiple pressures, densities over time
- Stainless steel membrane

Dynamic transmission radiographs
Trimmed density reconstruction

Technique that subtracts overburden and release effects from areal density radiographs
Position and Density

1.8 μsec  Time  6.9 μsec

Shock Position (cm)

0 1 2 3 4 5 6
0 0.5 1.0
-1.0

Density Jump (fraction)

0 1 2 3 4 5 6
1.0 1.06 1.10 1.14 1.18

Los Alamos

Unclassified LA-UR-09-xxxx
Single experiment, Multiple Measurements

- Single experiment measures many Hugoniot points
- Agreement with LASL Hugoniot data
- Equation of state measured from peak shock velocity to near sound velocity
Conclusions & Future Work

• Measured points on the Hugoniot from peak shock velocity down to nearly sound wave velocities

• 19 images in single experiment equates to 19 points on the Hugoniot

• Agreement between present measurement and known Hugoniot with 1% density and 0.2mm/μsec shock velocity uncertainty

• More experiments planned, ex. Al, Cu, Sn, Fe, Ga

• Strategic materials possible