The Release of Shocked CH

CH release $P$ versus $U_P$

- LEOS 5111 Release (5.6 Mbar)
- LEOS 5111 Release (7.5 Mbar)

C. McCoy
University of Rochester
Laboratory for Laser Energetics

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Summary

The release of a shocked material depends on the amount of entropy added by the shock wave

- Shocked material releases along a characteristic isentrope, determined by the shock pressure and the equation of state (EOS)
  - weak shocks: $U_{\text{release}} \approx 2 \ U_p$
  - strong shocks: ($\geq 0.4 \ \text{Mbar}$): $2 \ U_p < U_{\text{release}} < 4 \ U_p$

- Shock release is studied using momentum-transfer analysis

- Initial results indicate EOS models underestimate the entropy added by shock waves
Motivation

• Release physics is important for
  – understanding early stages of an inertial confinement fusion (ICF) implosion
  – impedance-match measurements
  – shockless compression (ICE) experiments

• Characterizing the shock release may allow EOS measurements in regions with pressures much lower than shock measurements
Collaborators

T. R. Boehly, P. M. Nilson, T. J. B. Collins, T. C. Sangster, and D. D. Meyerhofer

Laboratory for Laser Energetics
University of Rochester

D. E. Fratanduono, P. M. Celliers, and D. G. Hicks

Lawrence Livermore
National Laboratory
The impedance-match method relies on the shock and release behaviors of a known standard.

\[ P = \rho_0 U_s U_p \]

Initial state (from \( U_s \) in Al)

Aluminum hugoniot (known standard)

Intersection yields \( P \) and \( U_p \) in the sample

Release isentrope (known standard)

Possible shock states in the sample

Pressure (Mbar) vs. Particle velocity, \( U_p \) (\( \mu \)m/ns)
Upon release, shocked material accelerates as it rarifies into a vacuum.
For strong shocks, the added entropy becomes large compared to the compressive work.
Release follows an isentrope determined by final shock pressure at breakout

$P$ versus $U_P$ for CH from SESAME 7590

- Shock hugoniot
- Reflected hugoniot
- Release isentrope

$P$ (Mbar)

$U_P$ ($\mu$m/ns)

$U_{p1}$, $U_{p2}$, $2U_{p1}$, $2U_{p2}$, W
Target design enables low pressure regions of the CH release isentrope to be examined

Witness film: silicon nitride (50 nm)

Silicon nitride (50 nm) (s64755)
Laser energy = 846.7 J

OMEGA

CH

C_{50}H_{48}Br_2

CH ablator

Si_3N_4 film (50 nm)

Gap

Visar/SOP

Reflectivity change

Fringe movement

Shock breakout

Time (ns)

Position (µm)

Courtesy D. Fratanduono (LLNL)
Conservation of momentum is used to determine the release into vacuum

Measure $V_{\text{wit}}$ using VISAR and get $V_{\text{release}}$ from transit time. Iterate momentum over time accounting for mass increase and displacement of witness.

$P_{\text{wit},N} = \sum_{n=0}^{N} P_{\text{rel},N} + P_{\text{wit},0}$

Thin foil initially at rest

CH release

$V_1 > V_2 > V_3 > V_N$

$m_1 < m_2 < m_3 < m_N$
Release measurements indicate that LEOS 5111 is underestimating the release velocity.
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