High-Pressure Equation-of-State Studies
Using Laser-Driven Decaying Shocks

48th Annual Meeting of the American Physical Society
Division of Plasma Physics
Philadelphia, PA
30 October–3 November 2006

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Summary

Decaying-shock measurements have observed possible missing energetics in the Al$_2$O$_3$ SESAME model

- Decaying shocks are used to produce a wide range of conditions for EOS measurements on a single experiment.

- Simultaneous measurements of shock velocity, reflectivity, and radiance are made to relate shock temperature to wave properties.

- Measurements deviate around 10 Mbar from the current SESAME sapphire model.
Collaborators

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The kinematic EOS of sapphire has been measured over many Mbar.
A previous study of the thermal properties of silica was used to identify phase transitions.

Near metalization, the shock-front reflectivity is characterized by a Drude-like behavior.

\[ R = \frac{(n - n_{00})^2 + \kappa^2}{(n + n_{00})^2 + \kappa^2} \]

\[ n + i\kappa = \sqrt{\varepsilon_B \left[ 1 - \frac{\omega_p (E_G)^2}{\omega^2} \right] \frac{1}{1 - i/\omega \tau(E_G, \gamma)}} \]
Simultaneous kinematic and thermal measurements are obtained with VISAR* and a two-channel SOP**

$$T_{GB} = \frac{T_0}{\ln[1 + (1 - R) \cdot A/I]}$$

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*Velocity Interferometer System for Any Reflector
**Streaked Optical Pyrometer
Sapphire

Shock velocity, temperature, and reflectivity are simultaneously measured as the shock decays.

OMEGA drive $\sim 10^{14} \text{ W/cm}^2$
1-ns pulse
**Sapphire**

*SESAME* deviation at high pressures may indicate unaccounted for energetics.

Possible unaccounted for energetic sink at ~10 Mbar.
Decaying-shock measurements have observed possible missing energetics in the Al₂O₃ SESAME model.

- Decaying shocks are used to produce a wide range of conditions for EOS measurements on a single experiment.

- Simultaneous measurements of shock velocity, reflectivity, and radiance are made to relate shock temperature to wave properties.

- Measurements deviate around 10 Mbar from the current SESAME sapphire model.
Shock velocity, reflectivity, and self-emission are measured using time-resolved VISAR* and SOP**

* Velocity interferometer system for any reflector (designed and implemented by LLNL)
** Streaked optical pyrometer (designed and implemented by LANL, modified to current state by LLNL)
The SOP spectral response was absolutely calibrated to relate SOP output to brightness temperature. *Using the NIST-Traceable Standard OL-550*