Precision Equation-of-State (EOS) Measurements Using Laser-Driven Shock Waves On the OMEGA Laser

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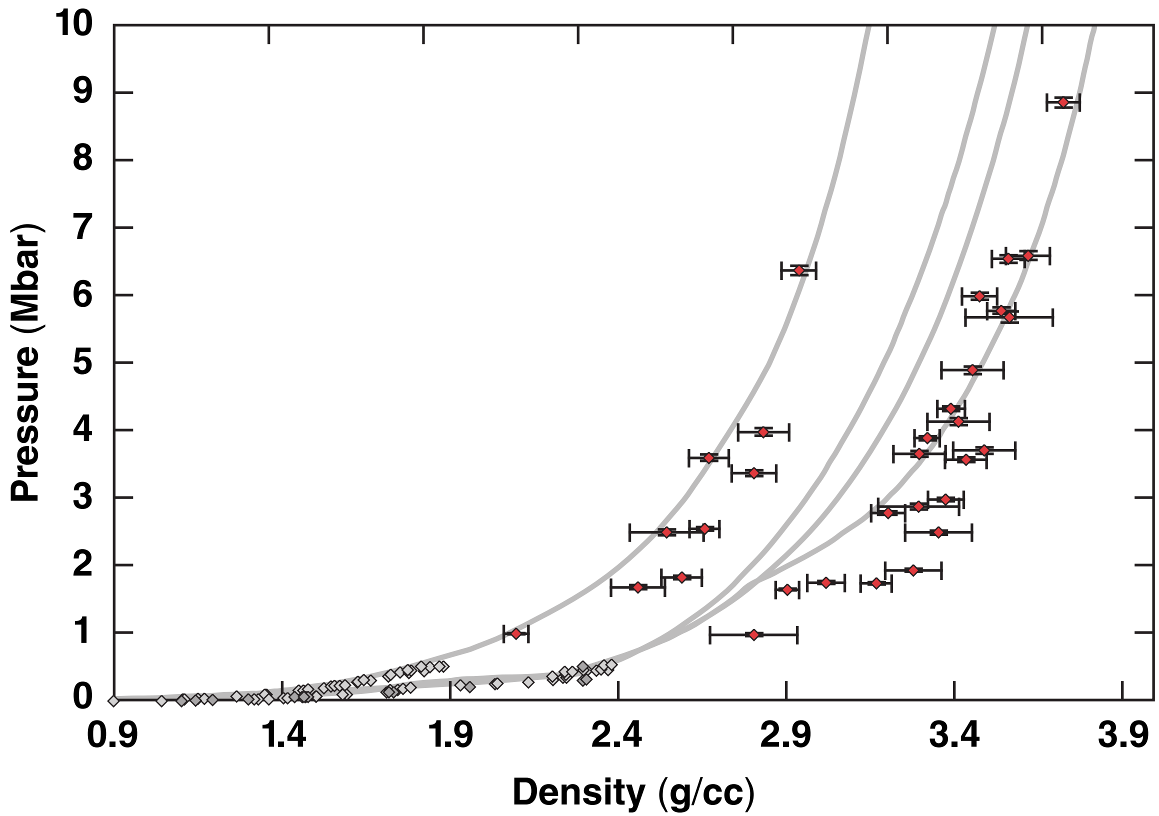

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Summary

Precision equation-of-state (EOS) measurements are obtained using quartz as a standard

- The impedance-matching (IM) technique has been used for decades to obtain EOS measurements, mainly using opaque standards.

- Both random *and* systematic errors, inherent in IM, must be addressed.

- Transparent standards (quartz) allow one to measure the shock velocity (U_s) within the standard, reducing random errors.

- This high-precision technique was applied to CH and CH_2.

Collaborators

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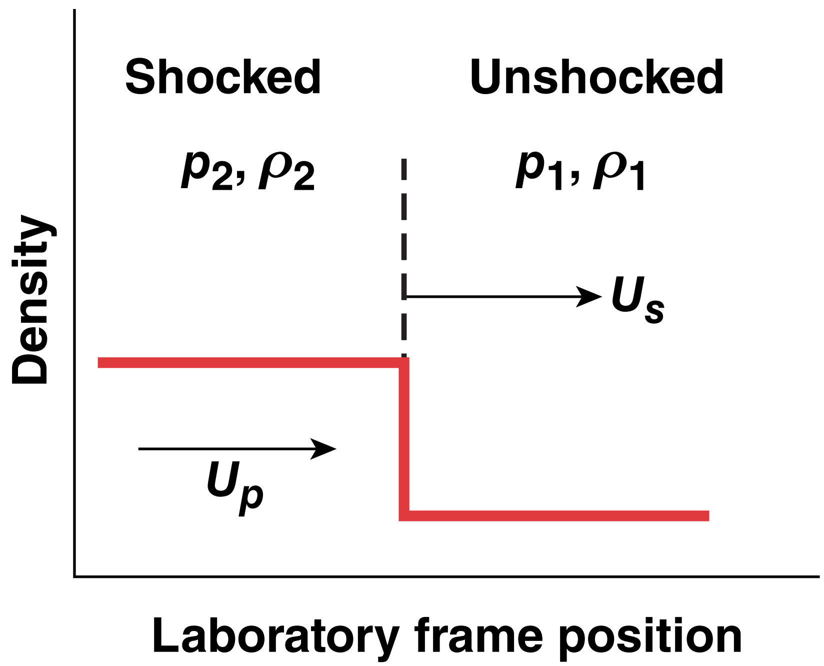
Laser-driven shocks are used to study materials at high pressure



Rankine–Hugoniot equations

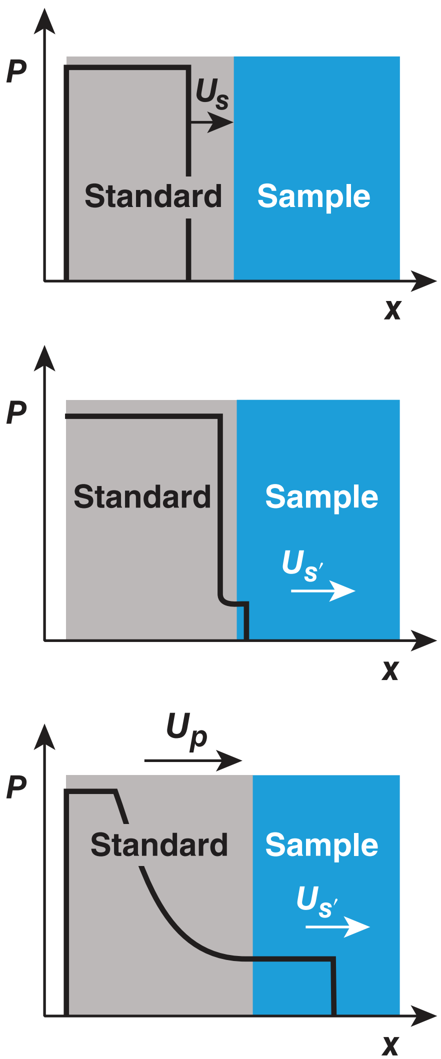
$$\rho_0 U_s = \rho_1 (U_s - U_p)$$

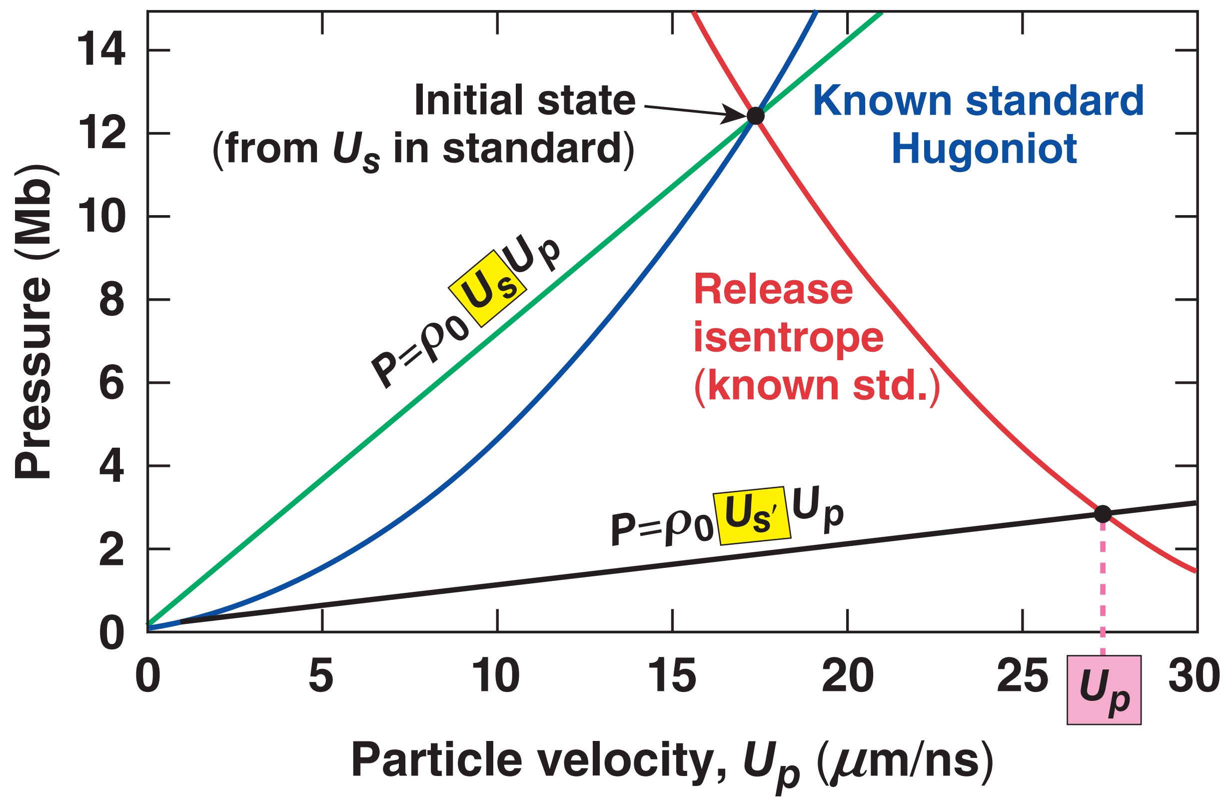
$$P_1 - P_0 = \rho_0 U_s U_p$$

The measurement of two variables is needed to close these equations; e.g., $U_s = F(U_p)$.

Impedance Match $U_s = F(U_p)$

The particle velocity and pressure are conserved across a contact interface





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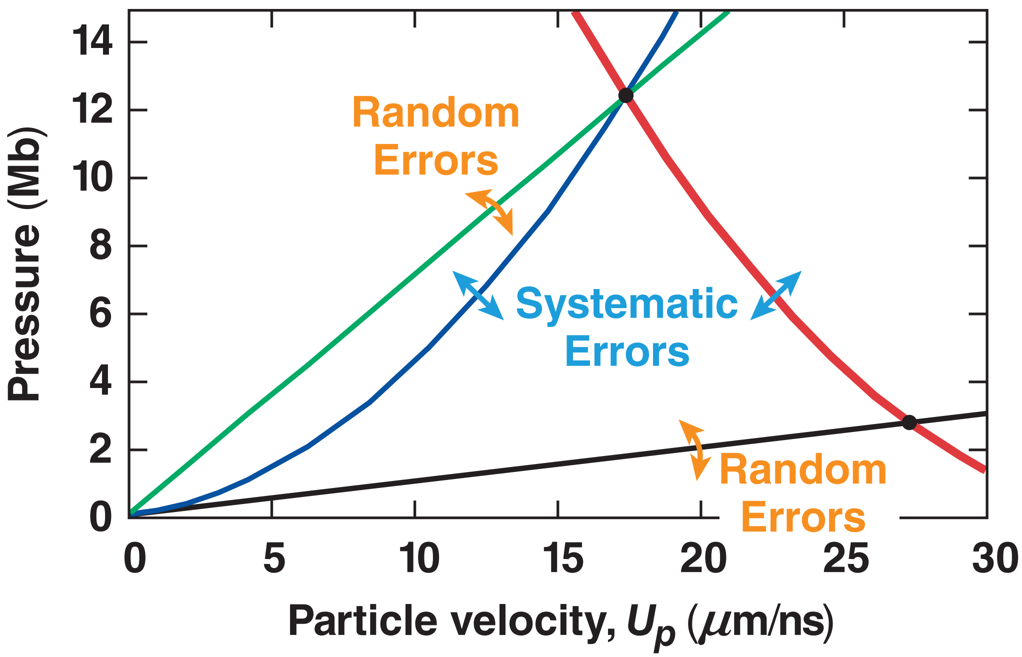
Need to minimize experimental error and address systematic errors for precision EOS measurements



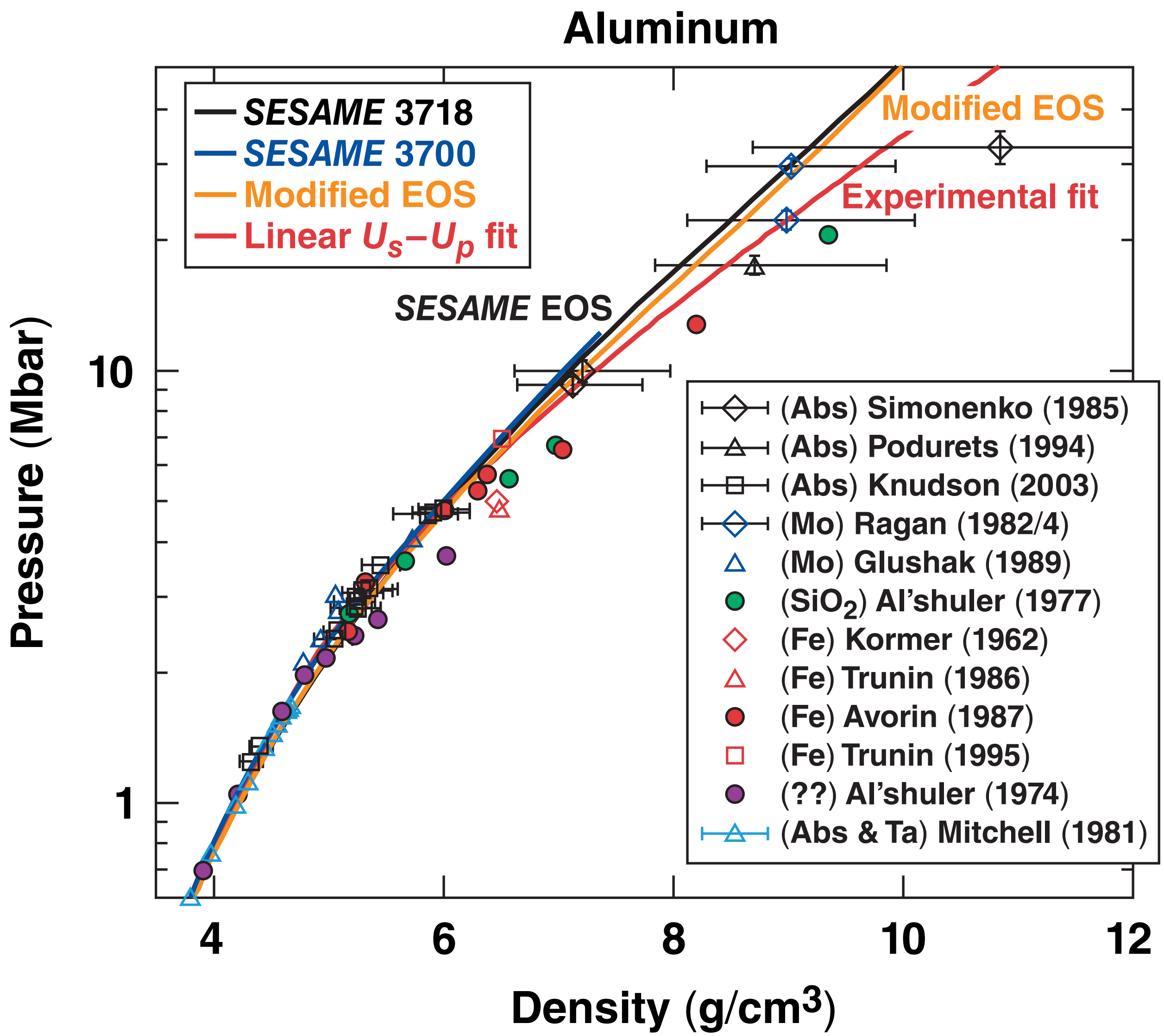
- Measurement accuracy depends on knowledge of standard.
- Most IM studies quote only random errors.
- Cannot propagate systematic errors using theoretical EOS.

- Random errors

$$\frac{\delta\rho}{\rho} \simeq (\eta - 1), \quad \eta = \frac{\rho}{\rho_0}; \quad \eta \simeq 4-6 \rightarrow \frac{\delta\rho}{\rho} \propto (3-5) \times \delta u_s$$

E13920b

At high pressures inconsistencies exist between EOS models and data for aluminum



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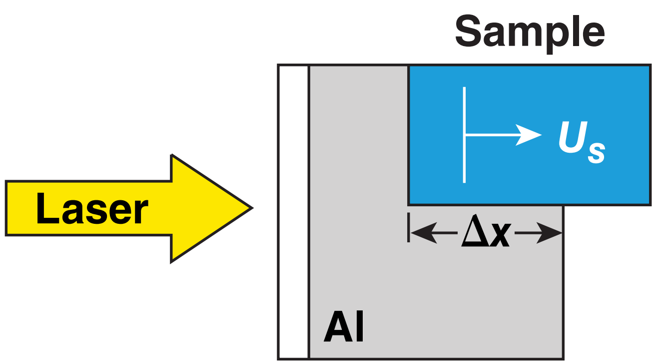
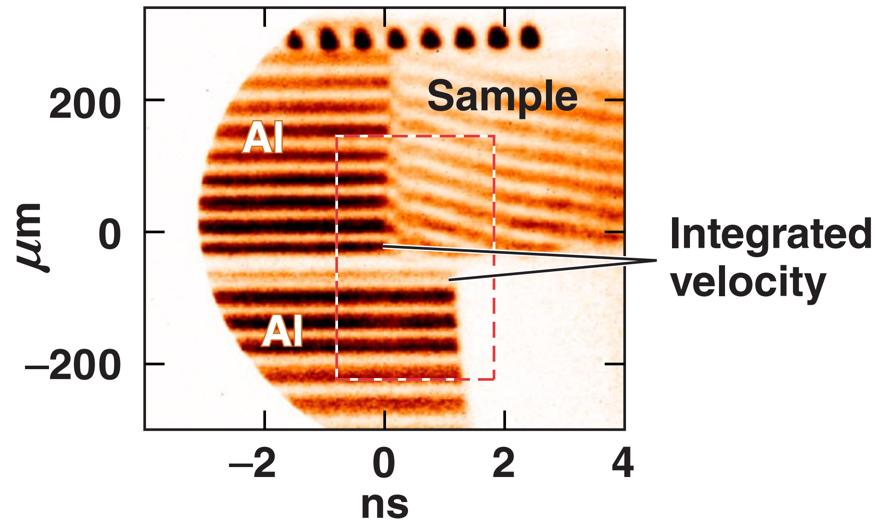
Random Errors

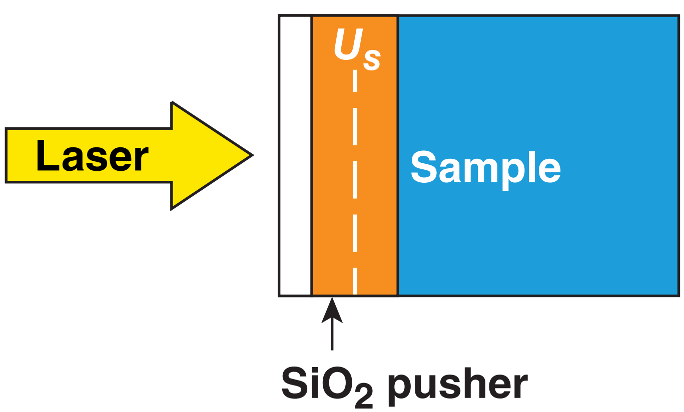
Higher precision is achieved using a transparent standard



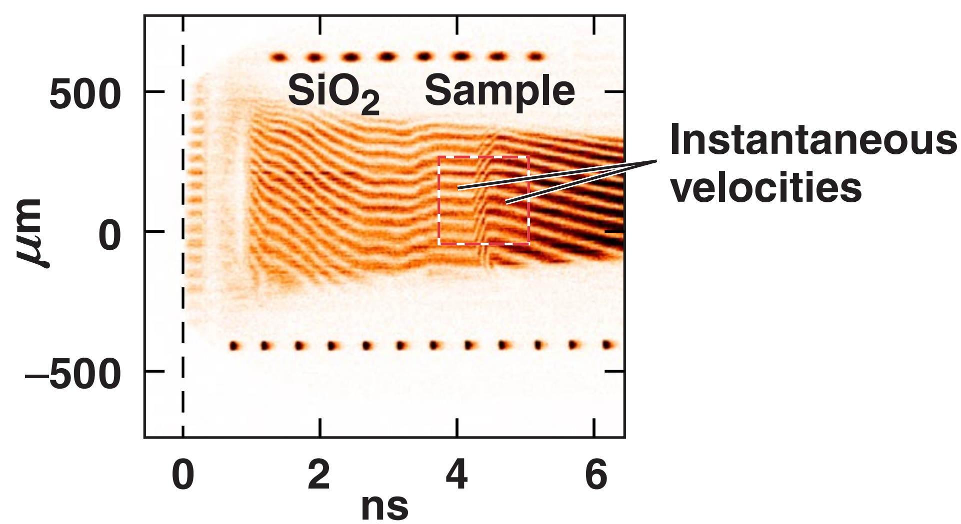
U_s is inferred from transit times

VISAR-1 shot 29425





VISAR-1 shot 52118



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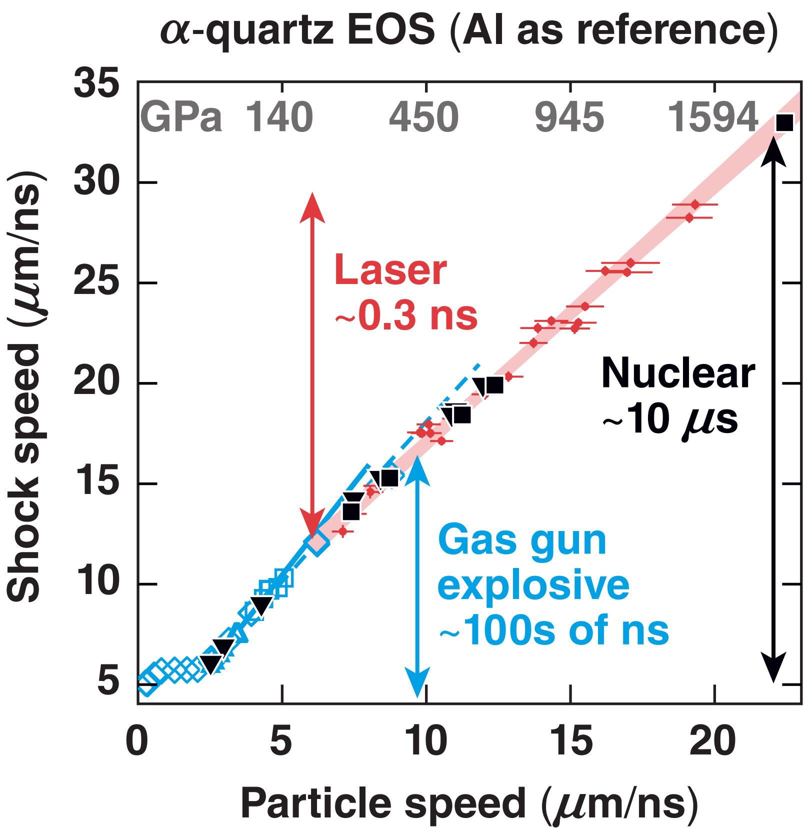
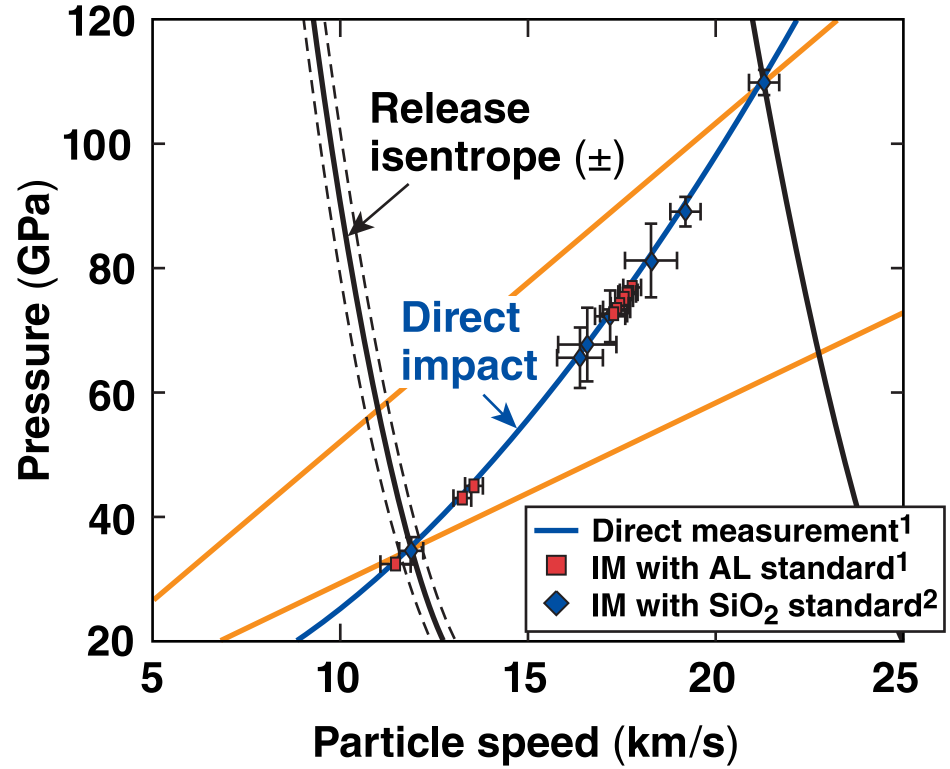
Quartz validity as a standard is established through ample study of its EOS and agreement with previous results





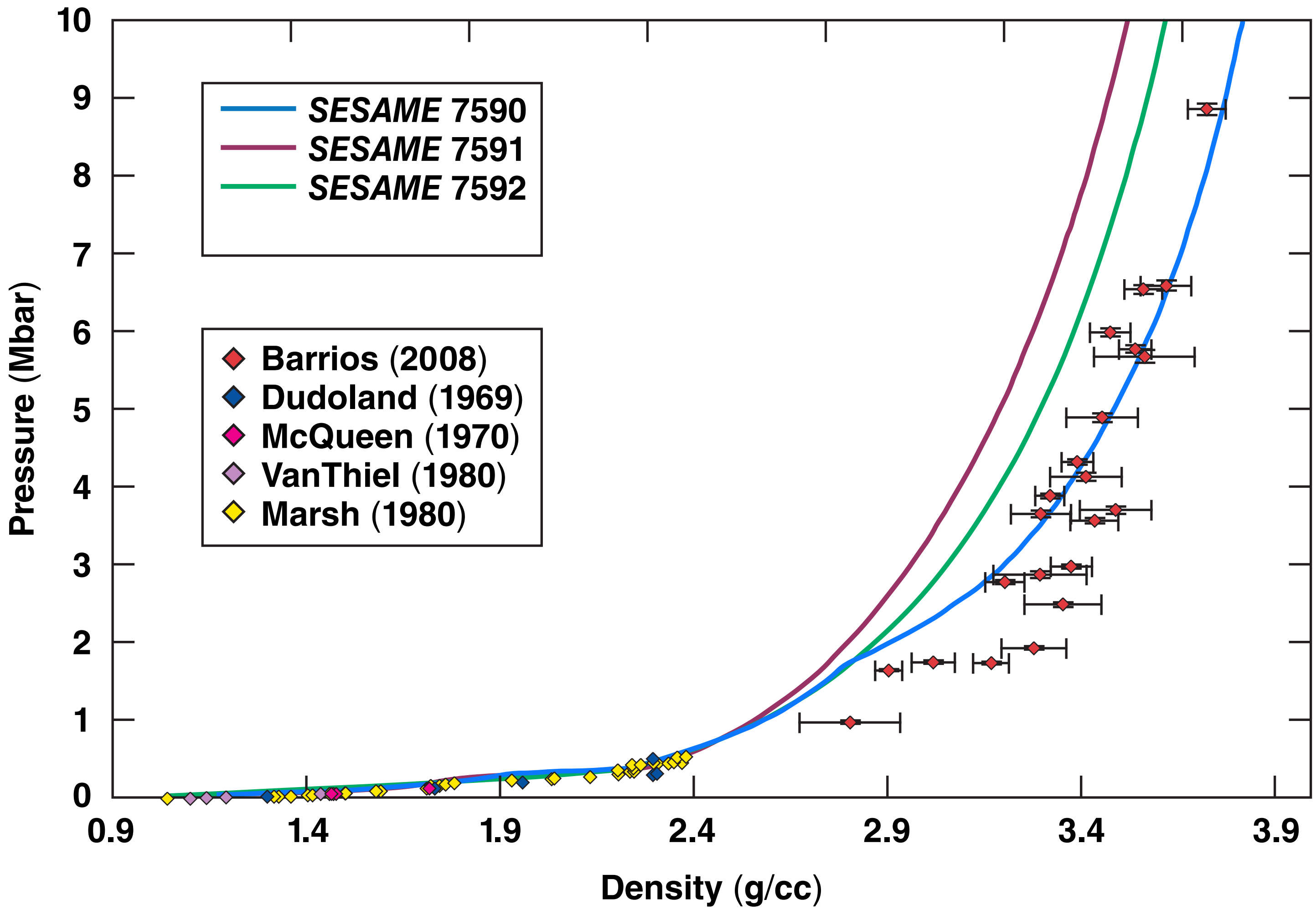
D. G. Hicks *et al*., Phys. Plasmas 12, 082702 (2005).

[1]M. D. Knudson *et al*., J. Appl. Phys. 97, 073514 (2005).

[2]T. R. Boehly *et al*., in *Shock Compression of Conducted Matter–2007*, Vol. 955, p 19–22.

E17325

Precision EOS data more tightly constrain polystyrene (CH) EOS



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Precision EOS data more tightly constrain polystyrene (CH) EOS and polypropylene (CH_2) EOS

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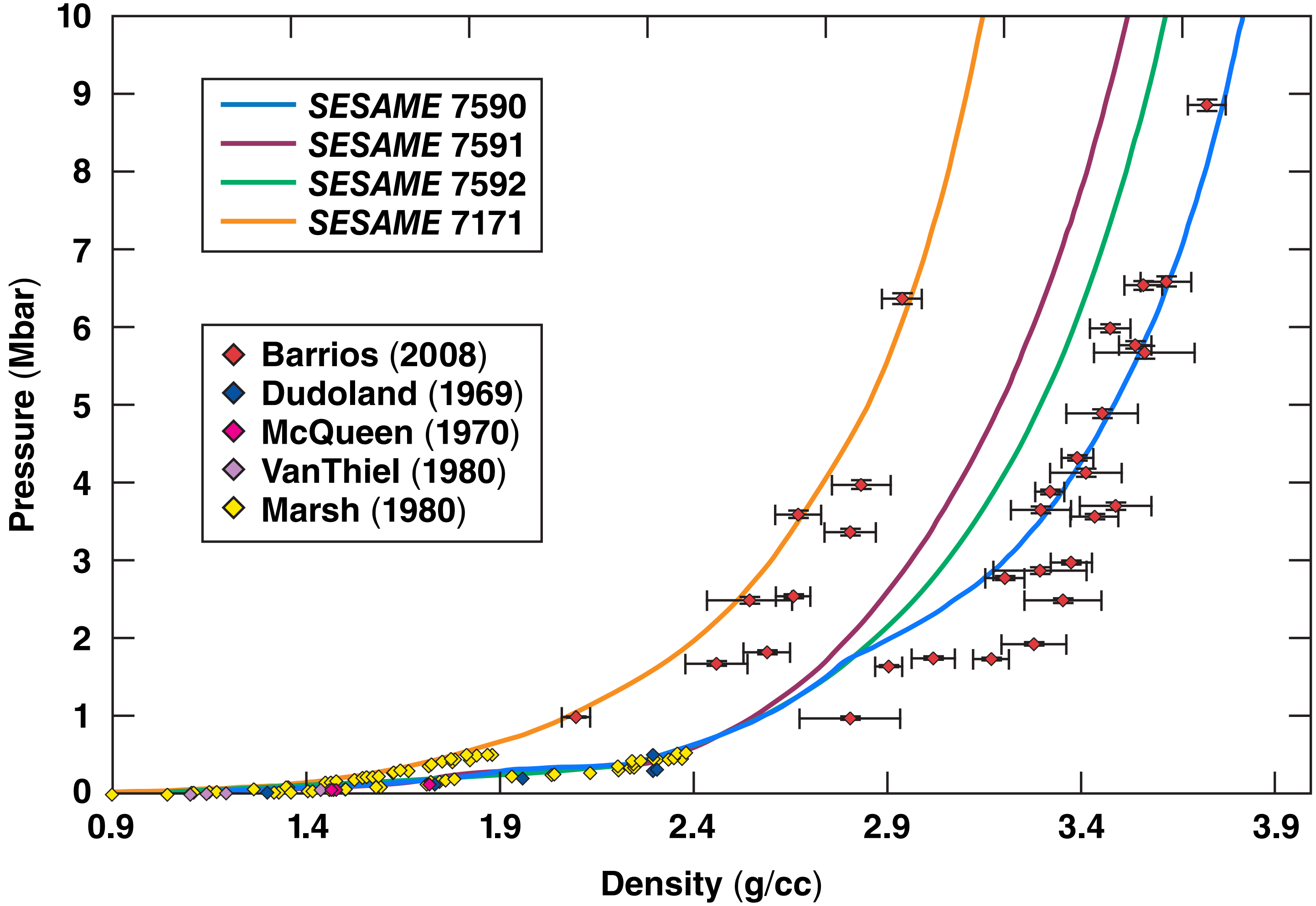

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Summary/Conclusions

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