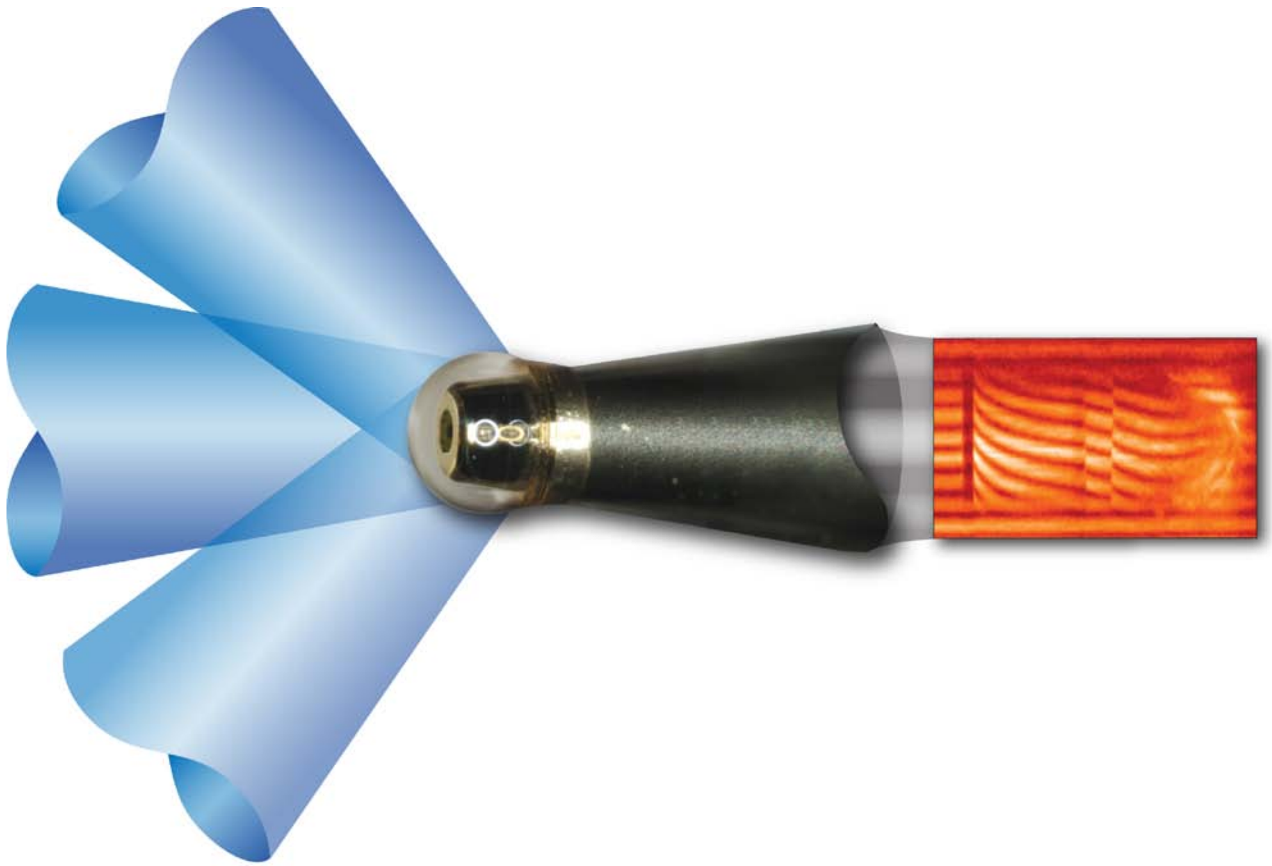
Radiative Precursors and Temperature Measurements in Shocked Deuterium



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Summary

Spherical shock-timing data were used to study deuterium at pressures of 0.5 to 25 Mb

- Simultaneous velocity and self-emission are used to infer temperature versus pressure up to ~5 Mb
- At ~6 Mbar (~10 eV), the dependence of self-emission on velocity changes; likely due to a radiative precursor
- Above the insulator–conductor transition, shock reflectivity rises with increasing velocity, suggesting changes in carrier density or relaxation time
- For shocks ~>0.5 Mb, D_2 becomes strongly coupled, warm dense matter ($\Gamma > 1$, $\Theta \sim 1$)

Collaborators

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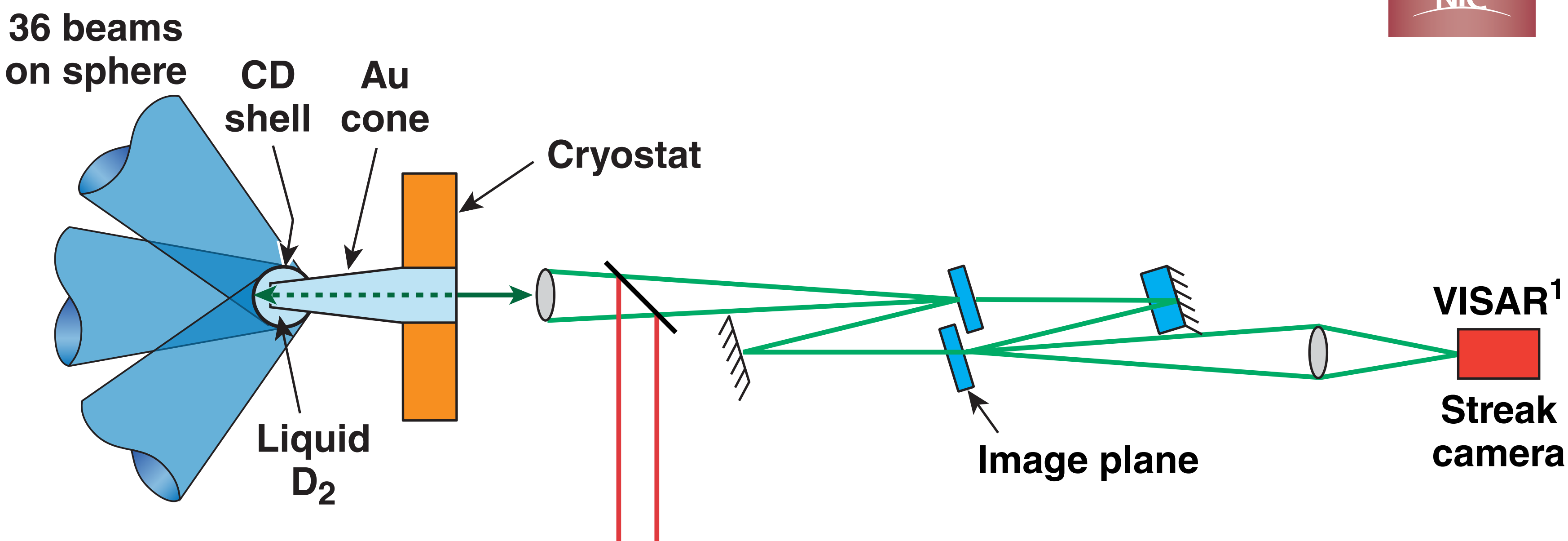
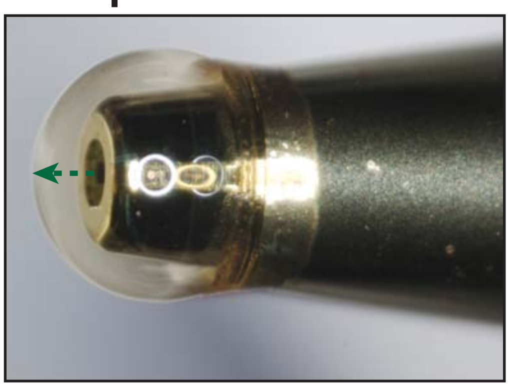
The behavior of shocked D_2 was studied using multiple spherically converging shocks



Capsule/cone detail



[1]Velocity interferometer system for any reflector
[2]Streaked optical pyrometer

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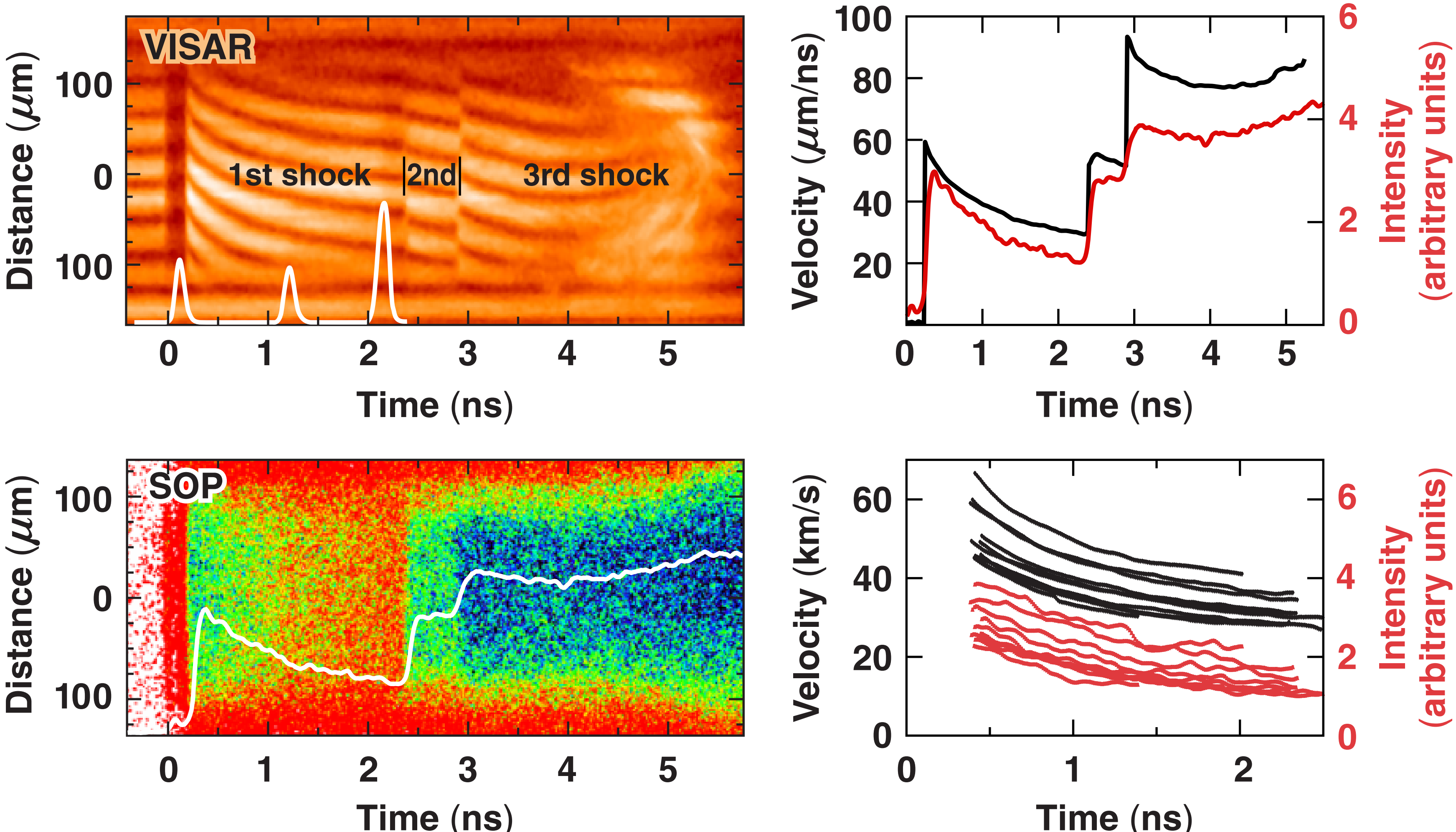
Simultaneous VISAR and SOP data provide self-emission as a function of velocity



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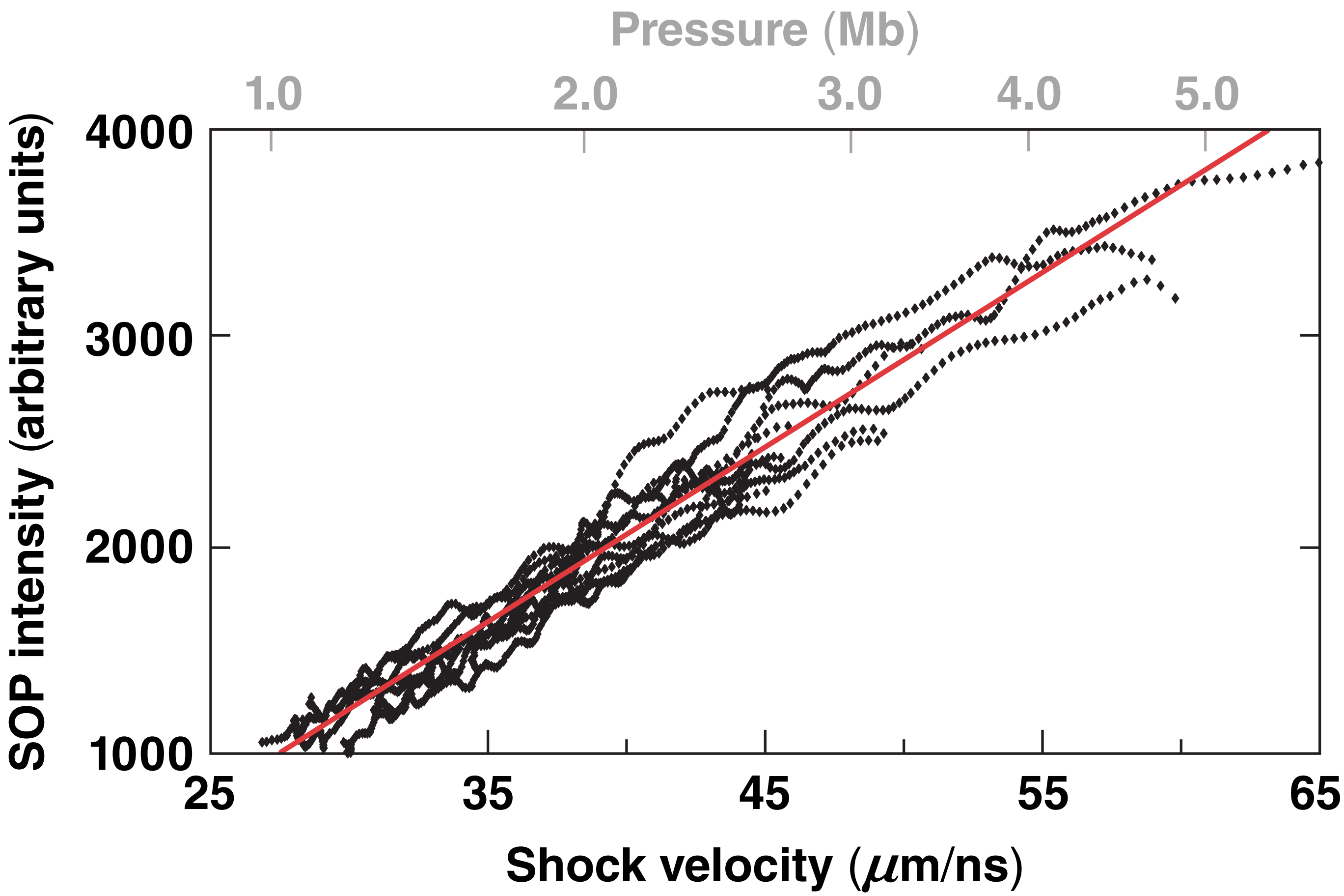
The self-emission detected from D_2 shocks depends linearly on shock velocity



Need reflectivity to convert to temperature.

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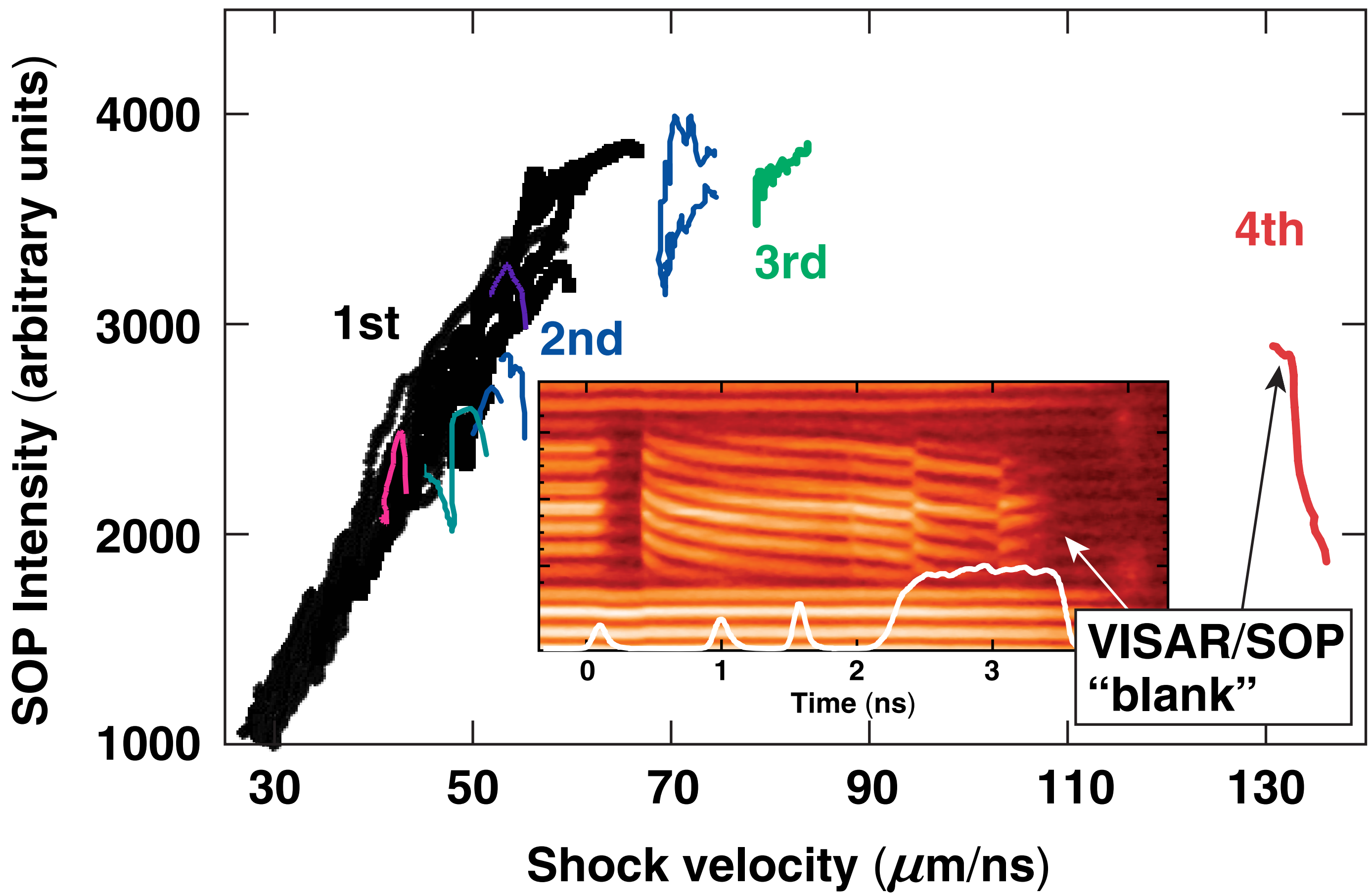
For velocities ≥70 km/s, SOP intensity stops rising, ultimately blanking at velocities >130 km/s



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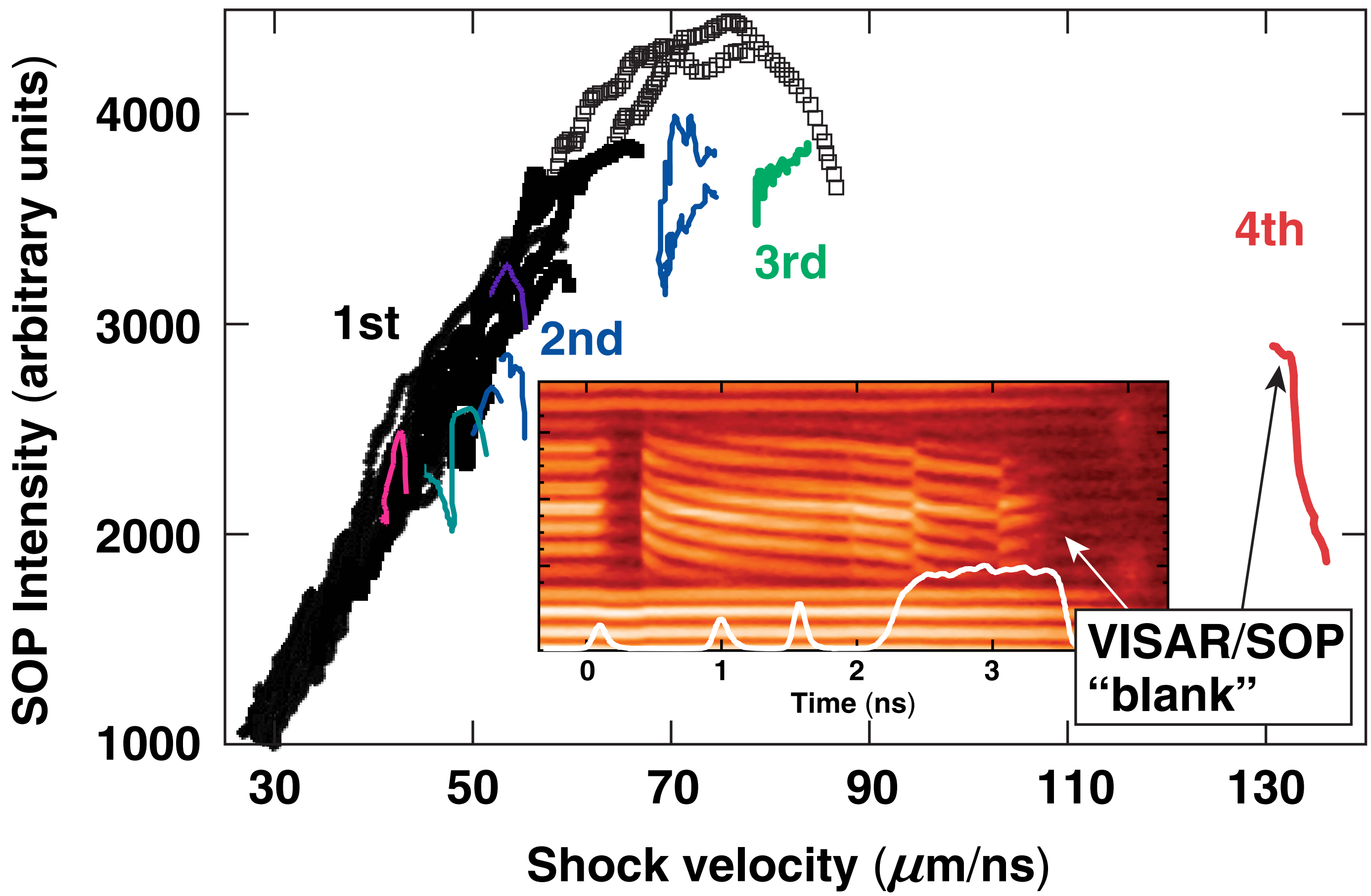
For velocities ≥70 km/s, SOP intensity stops rising, ultimately blanking at velocities >130 km/s

UR LLE

NIC



High shock temperatures produce a radiative precursor that reduces the detected SOP signal.

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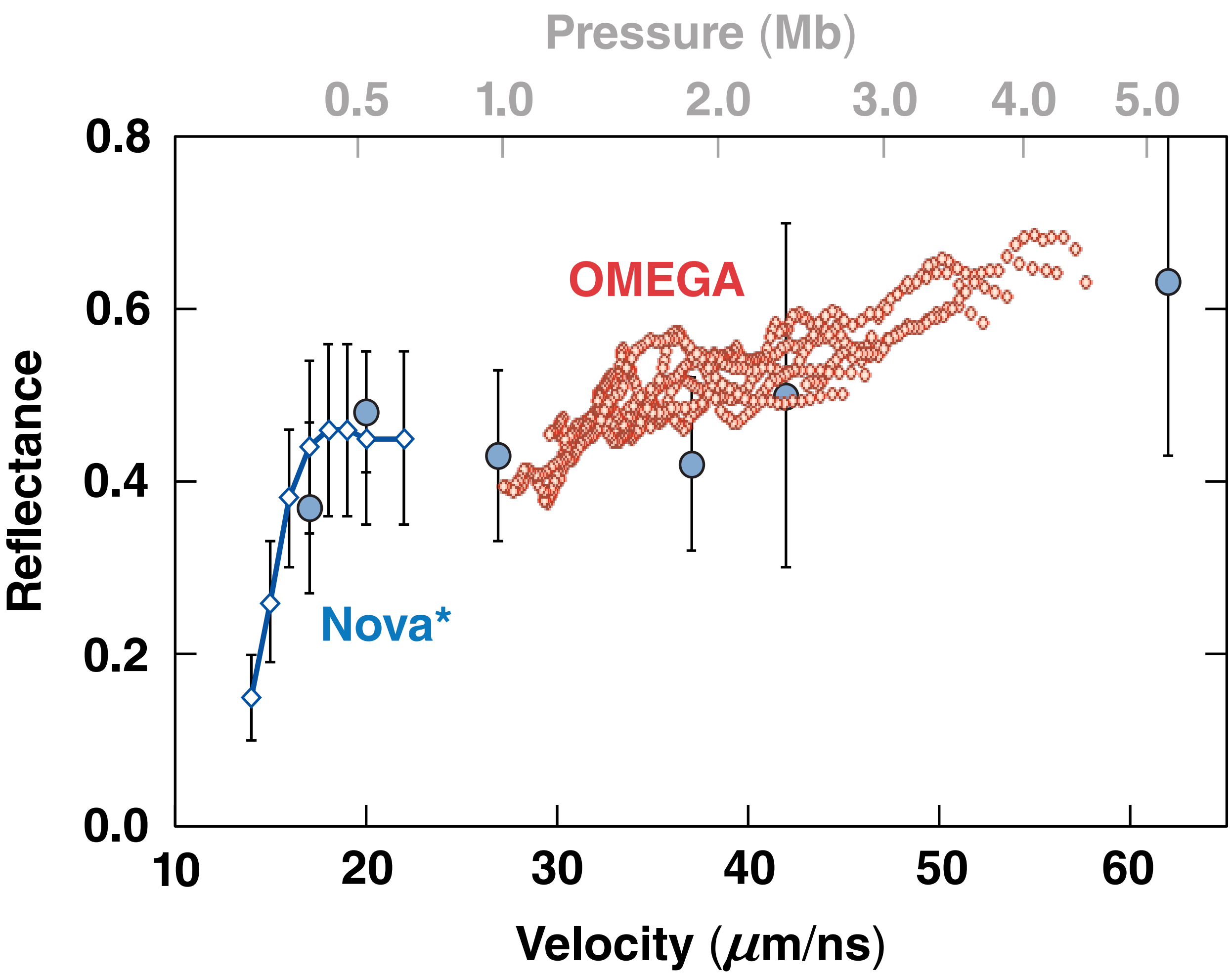
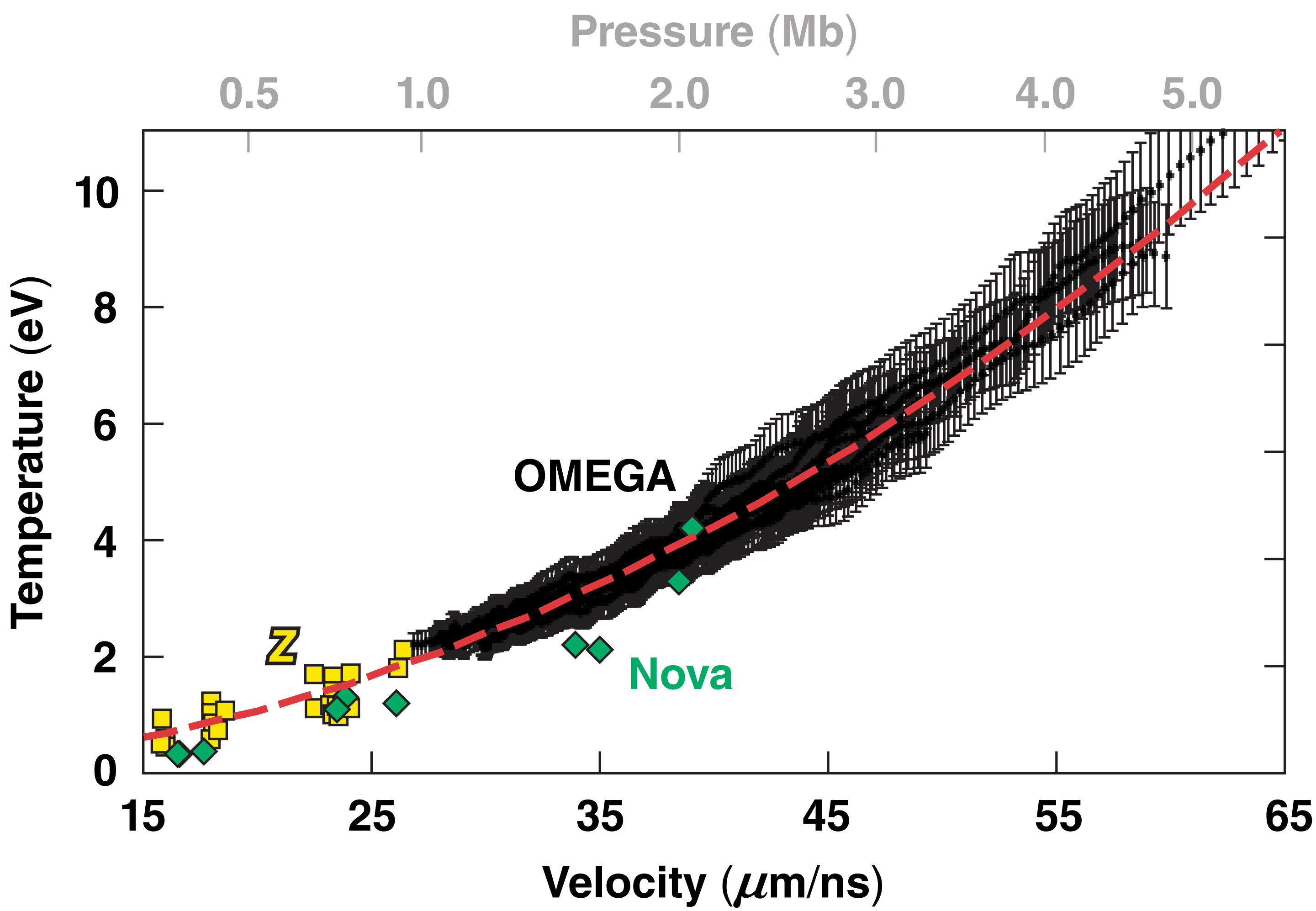
OMEGA VISAR data indicate that D_2 shock reflectivity rises linearly with velocity above ~30 km/s



E19851

*P. M. Celliers *et al*., Phys. Rev. Lett. 84, 5564 (2000).

D_2 shock temperatures show quadratic dependence on velocity and agree with previous measurements



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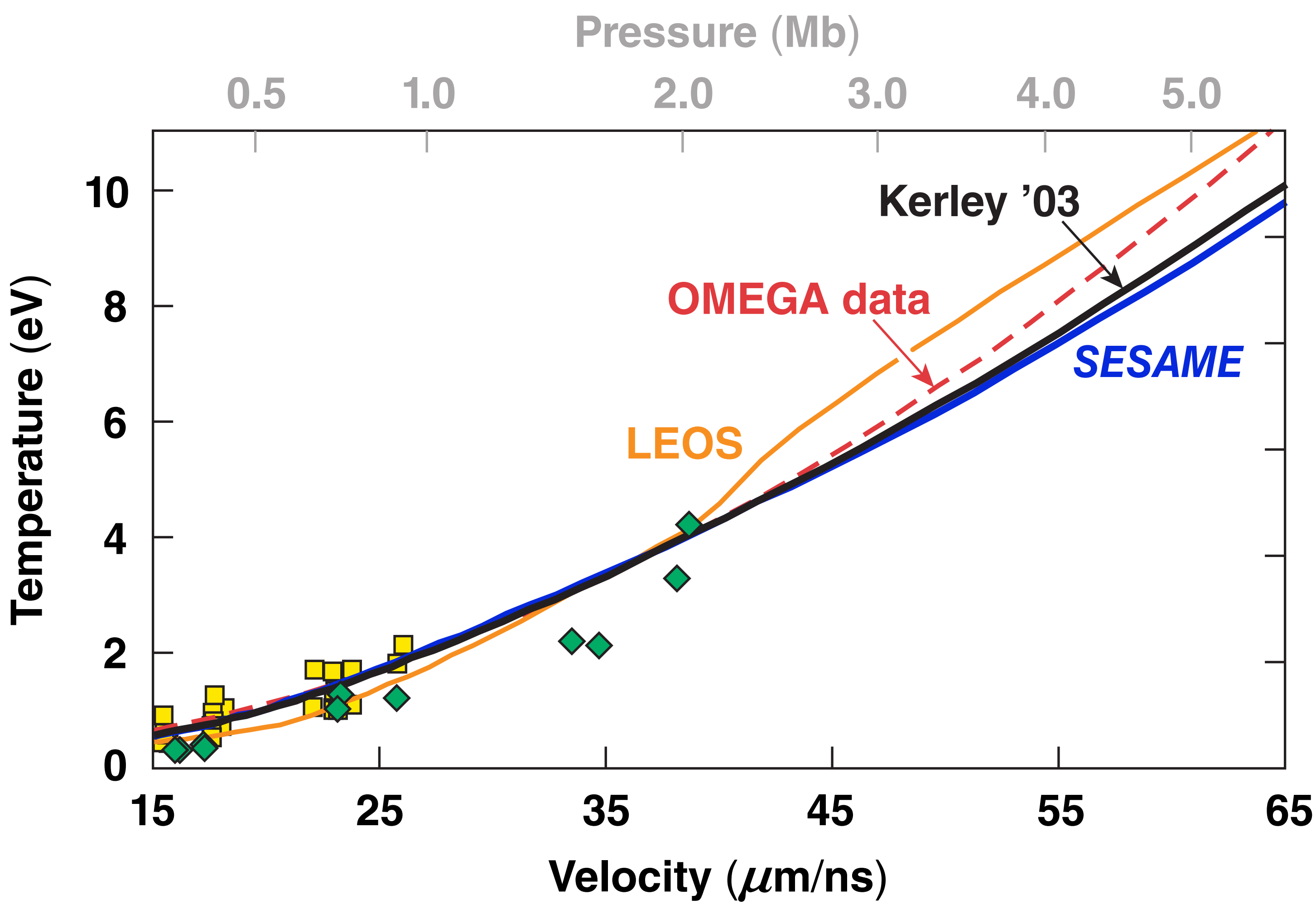
OMEGA temperature data are closer to "stiffer" EOS; reflectivity is important



E19855a

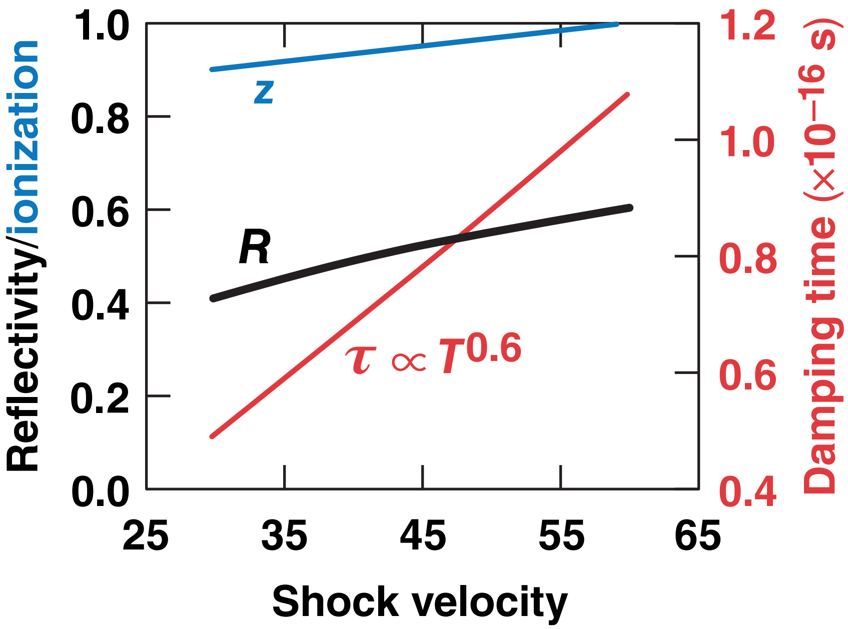
Above the insulator–conductor transition, deuterium continues to evolve

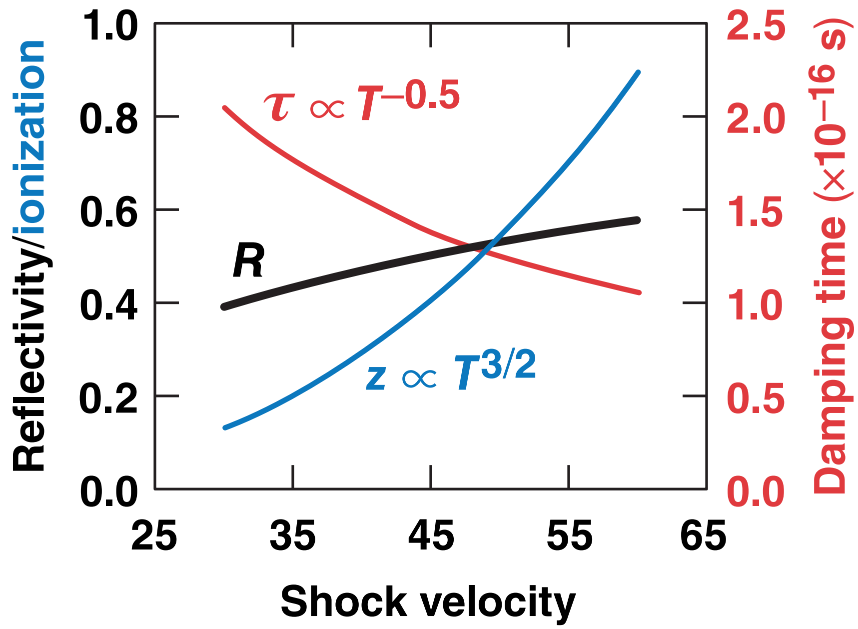
- Reflectivity depends on carrier density (ω_p) and relaxation time (τ_{ei})

$$\varepsilon_r(\omega) = 1 - \frac{\omega_p^2 \tau^2}{1 + \omega^2 \tau^2} + i \frac{\omega_p^2 \tau}{\omega\left(1 + \omega^2 \tau^2\right)}$$

- Insulator–conductor (IC) transition is assumed to involve *delocalization* of all electrons and relaxation time at the Ioffe–Regal limit, i.e., constant reflectivity
- Reflectivity that increases above the IC transition implies varying carrier density and electron relaxation times

The observed shock reflectance can be reproduced by varying carrier density or relaxation time





At these pressures, $\Gamma > 1$, $\Theta \sim 1$; shocked D_2 is strongly coupled.

E20318

Summary/Conclusions

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