Experiments to understand the interaction of stellar radiation with molecular clouds

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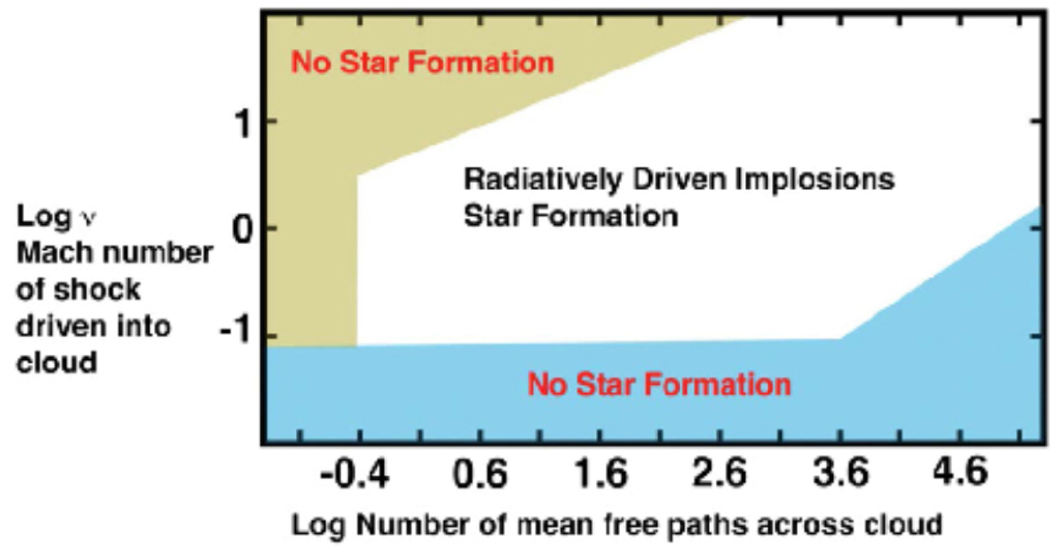
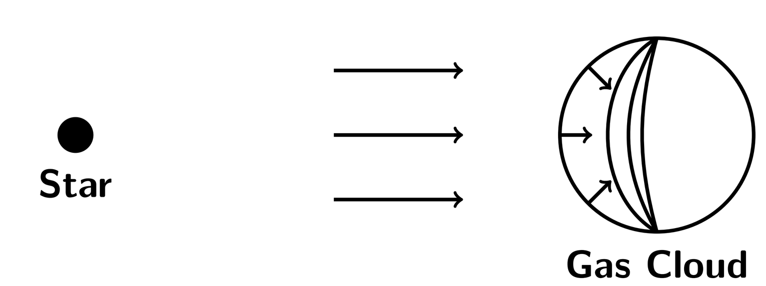
Stellar radiation compresses or explodes local gas clouds

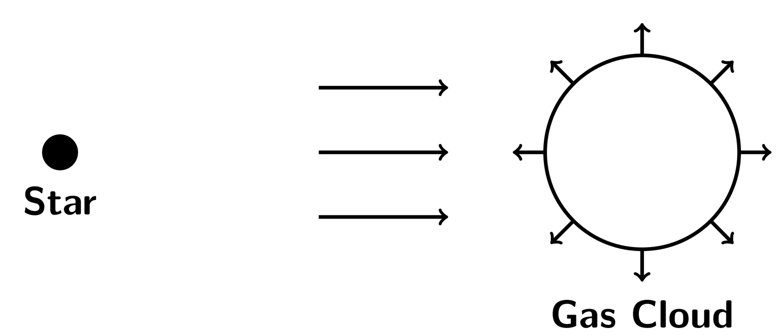


[1] P. A. Keiter et al.: "Design of laboratory experiments to study radiation-driven implosions," High Energy Density Physics, Volume 22, p. 37-40 (2017)

- Interaction dependent on photon energy, cloud thickness and density



- Optically thick: Photons absorbed at one cloud edge
  - Drives asymmetric shock into cloud



- Optically thin: Photons permeate and heat cloud
  - Cloud explodes

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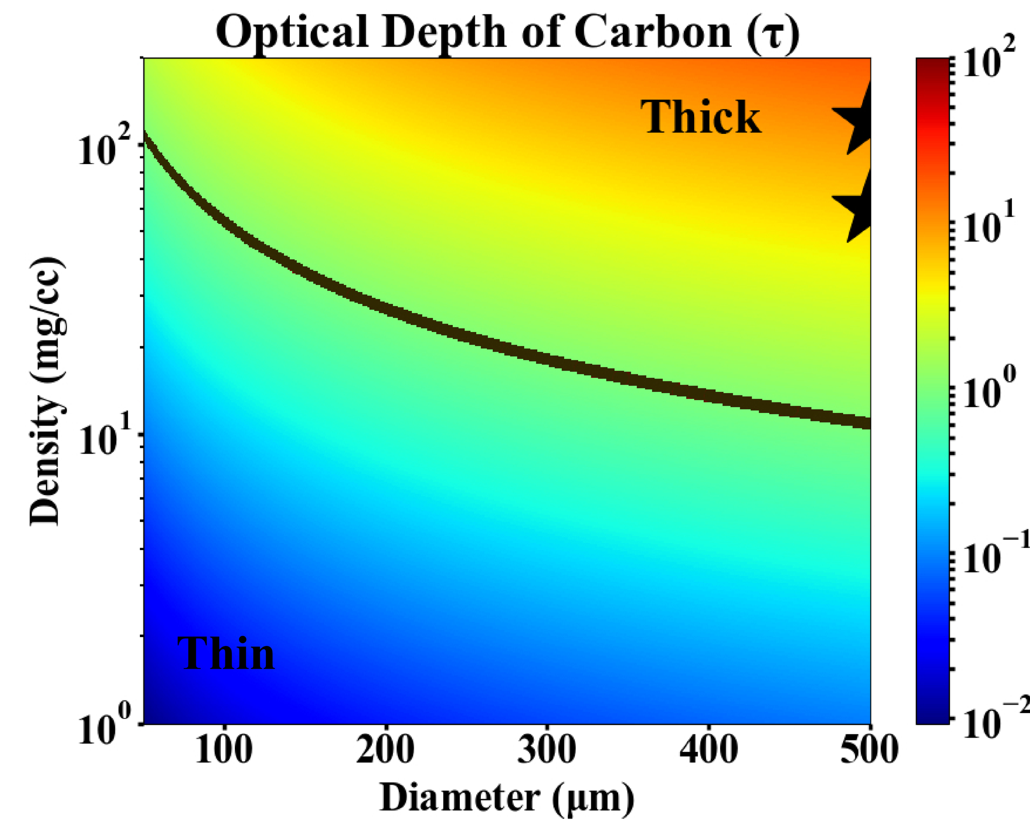
Additional references

- Drake, R. P. 2010, High-Energy-Density Physics (Springer)
- F. Bertoldi: "The Photoevaporation of Interstellar Clouds. I. Radiation-Driven Implosion," Astrophysical Journal, vol. 346, p. 735-755 (1989)

Foil temperature, foam diameter and density determine the optical depth regime

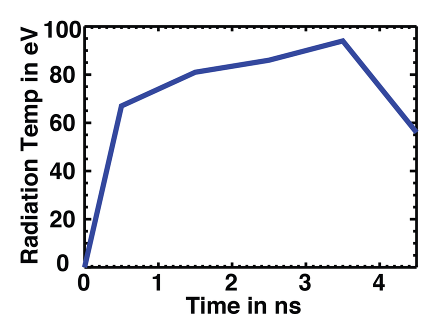
- Carbon foam
- Photon energy $\sim$ 282 eV
- $\sigma \sim 1848\ \frac{\mathrm{cm}^2}{\mathrm{g}}$ [2]
- $\lambda_{\mathrm{mfp}} = \frac{1}{\rho\sigma}$
- $\tau \sim \frac{\mathrm{D}}{\lambda_{\mathrm{mfp}}} \sim \mathrm{D}\rho\sigma$
- $\tau \sim 1$ = black line
- Black stars = experimental parameters

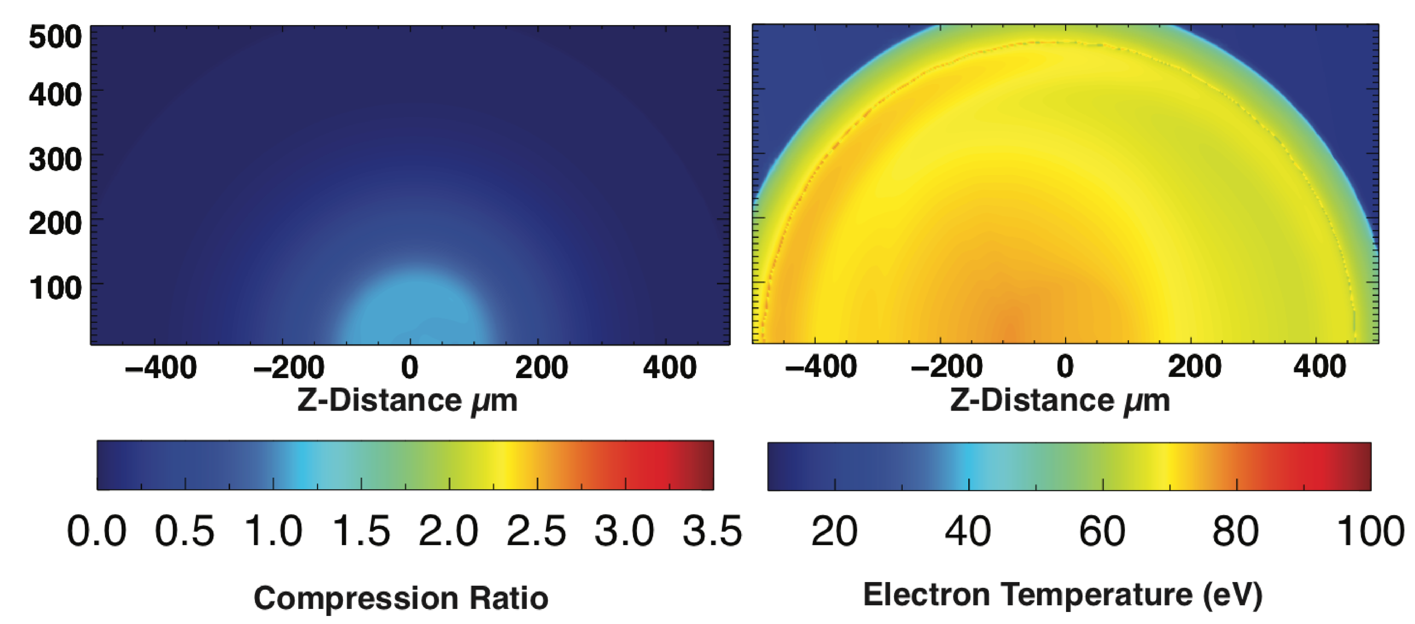


[2] Estimated from http://henke.lbl.gov/optical_constants/filter2.html

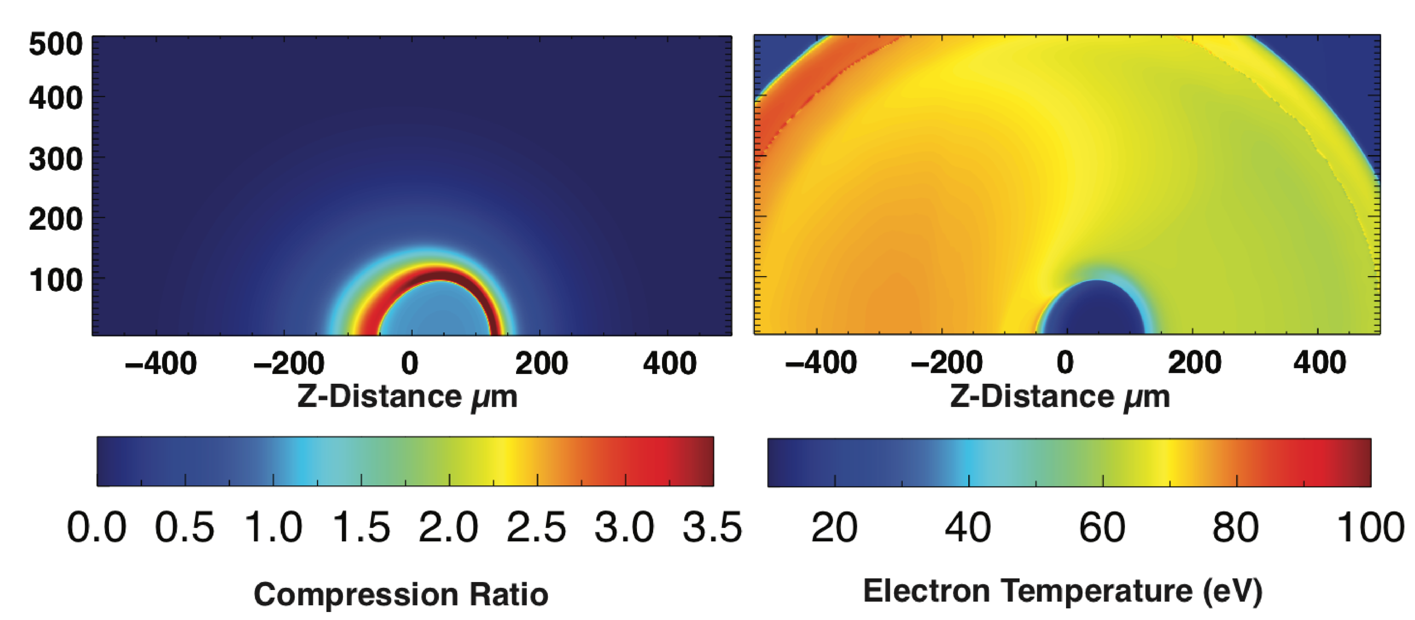
2D CRASH radiation hydrodynamic simulations show both compression and explosion limits

- Sphere diameter = 500 μm
- Foil edge to sphere center distance = 1 mm
- Simulated images below are at 2.5 ns
- Radiation source on left side of image





- Optically thin case at 10 mg/cc
- Uniform heating causes uniform explosion

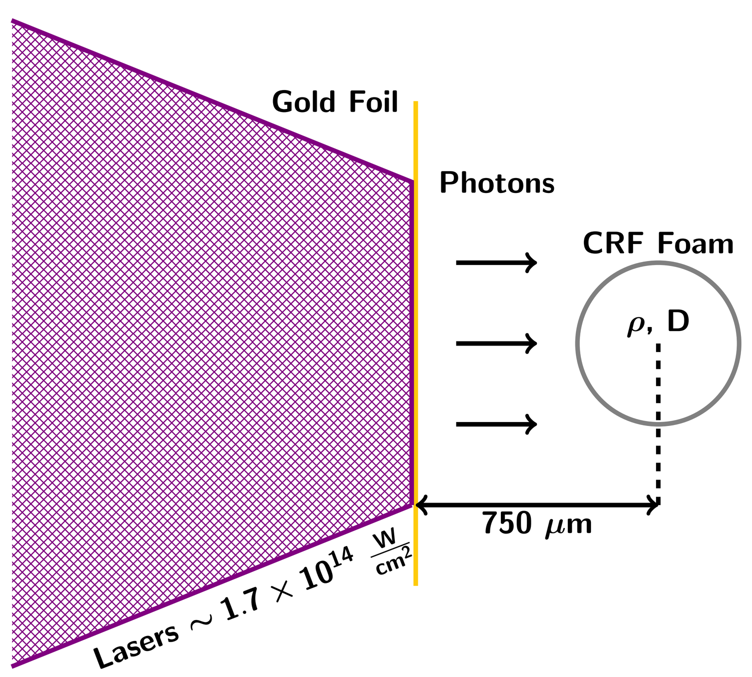


- Optically thick case at 100 mg/cc
- Asymetric ablation drives an asymetric compression

[3] B. van der Holst et al; "CRASH: A Block-adaptive-mesh Code for Radiative Shock Hydrodynamics-Implementation and Verification"

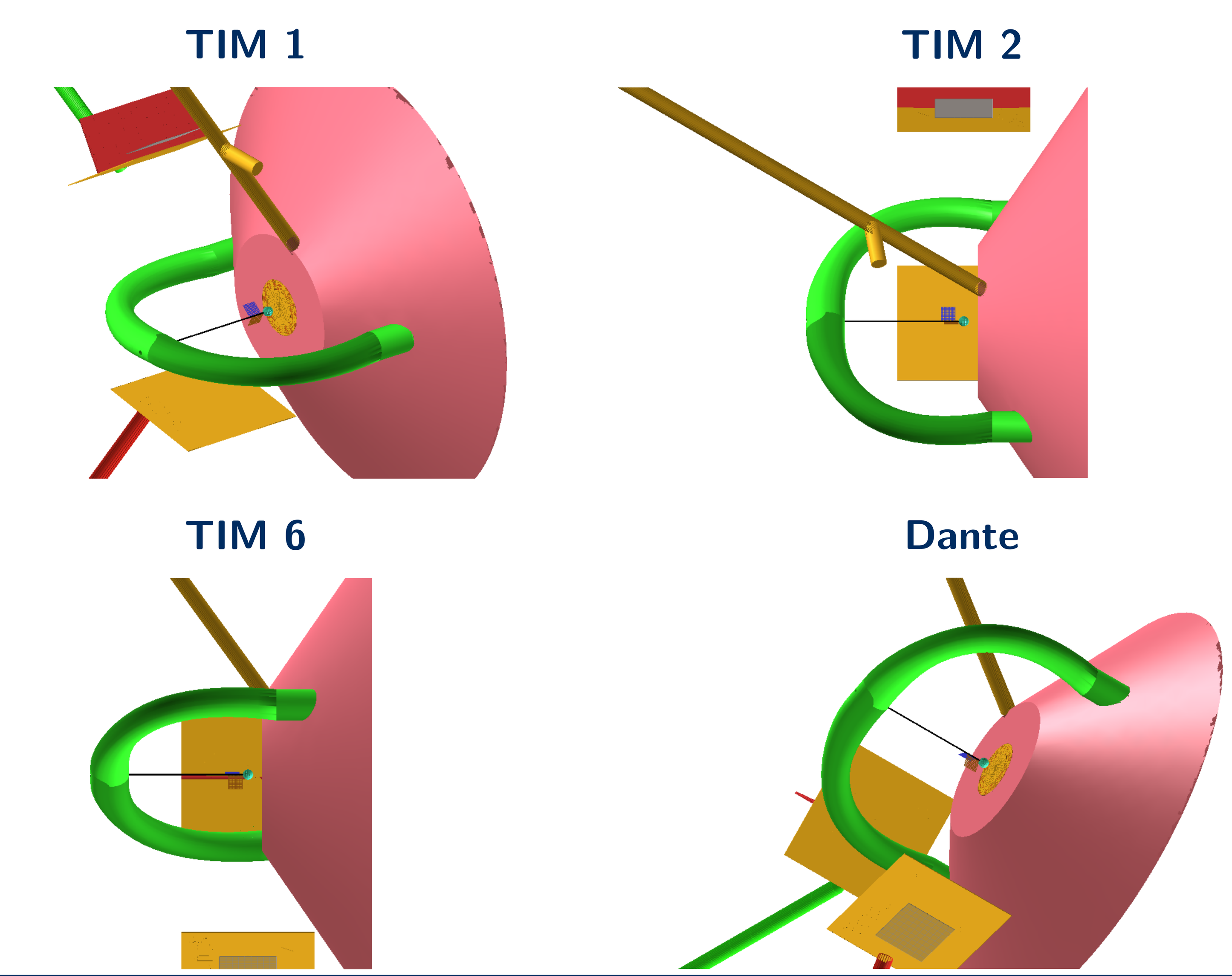
The platform driven by laser irradiated thin gold foil and a variable density foam sphere

- Sphere densities $\sim$ 60, and 120 $\frac{\mathrm{mg}}{\mathrm{cm}^3}$
- Optical depths $\sim$ 5.5 and 11
- Physics drive $\sim 1.7 \times 10^{14}\ \frac{\mathrm{W}}{\mathrm{cm}^2}$ for 7ns
- Titanium point-projection radiography
  - High densities and late times
- Chlorine point-projection radiography
  - Low densities and early times



[4] J. Davis et al.: "Measurements of laser generated soft X-ray emission from irradiated gold foils," Review of Scientific Instruments 87, 11D609 (2016)

Initial experiments focus on the $\tau \gg 1$ regime



We are developing an experimental platform to explore the range of conditions found when stars irradiate gas clouds

- Local O, B type stars cause gas clumps to explode or compress
  - Gas cloud fate dependent on initial optical depth
- Simulations show the platform can reach optically thin and thick limits by changing foam density
- First experiments started in the optically thick regime for physics and diagnostic simplicity
- Our first optically thick targets had a density $\sim$ 60, and 120 mg/cc and a diameter $\sim$ 500 μm
- Data is under analysis