Shock-turbulence interaction with plasma viscosity

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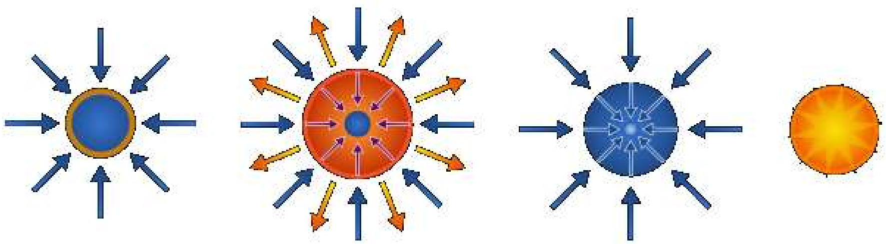
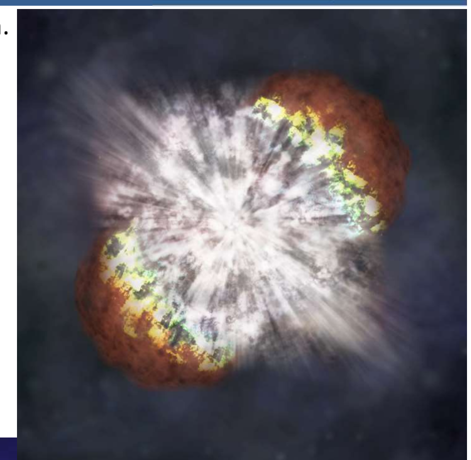
Is turbulence viscously dissipated in both ICF and supernovae?



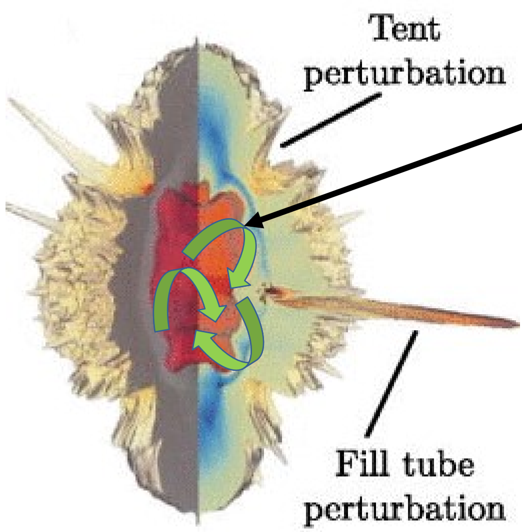
Stages of ICF. Credit: https://www.interstellarresearchcentre.com/blog/shock-ignition-icf

Supernova illustration. Credit: NASA/CXC/M.Weiss



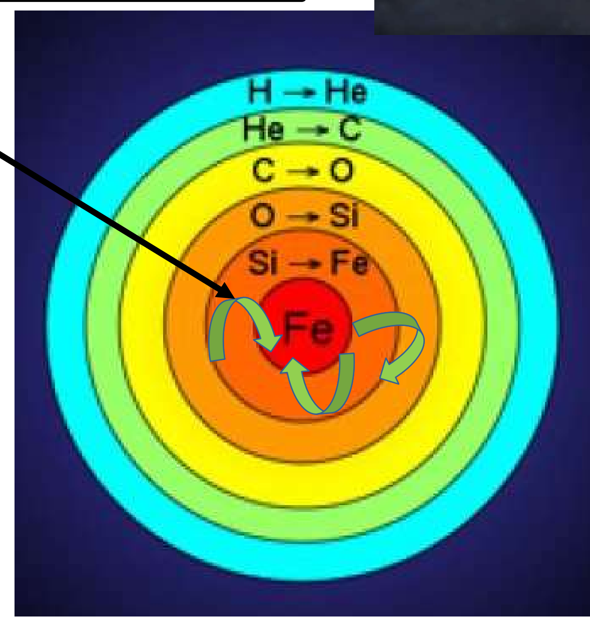
Are these plasma regimes potentially viscous enough for a shock to dissipate turbulence?

Turbulence?



ICF capsule and hotspot during stagnation phase.
C. R. Weber et al., Phys. Plasmas **22** 032702 (2015).

To estimate this, we see how turbulence and the Reynolds number change across the shock



Before core collapse of a supernova. Credit: Swinburne University of Technology

Estimates of dissipation obtained via analytic calculations and simulation

Analytic estimate of change in Reynolds number

Plasma Viscosity

$$\mu \propto T^{5/2}$$

$$Re = \frac{\rho u l}{\mu}$$

Rankine-Hugoniot relations compute temperature jump across shock (1 post-shock, 0-pre-shock)

$$R = \frac{Re_1}{Re_0} = \frac{\rho_1}{\rho_0}\left(\frac{T_0}{T_1}\right)^{5/2}\frac{u_1}{u_0}\frac{l_1}{l_0}$$

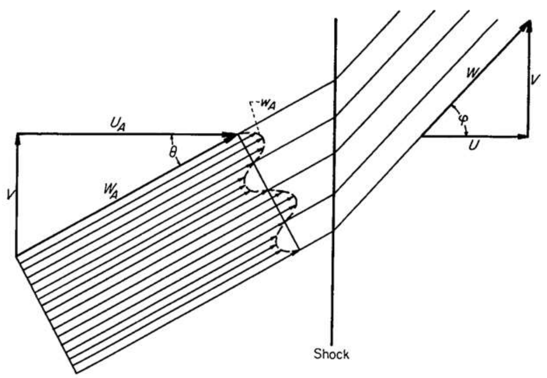


FIGURE 2.—Transformation to equivalent steady-flow problem by superposition of velocity V.

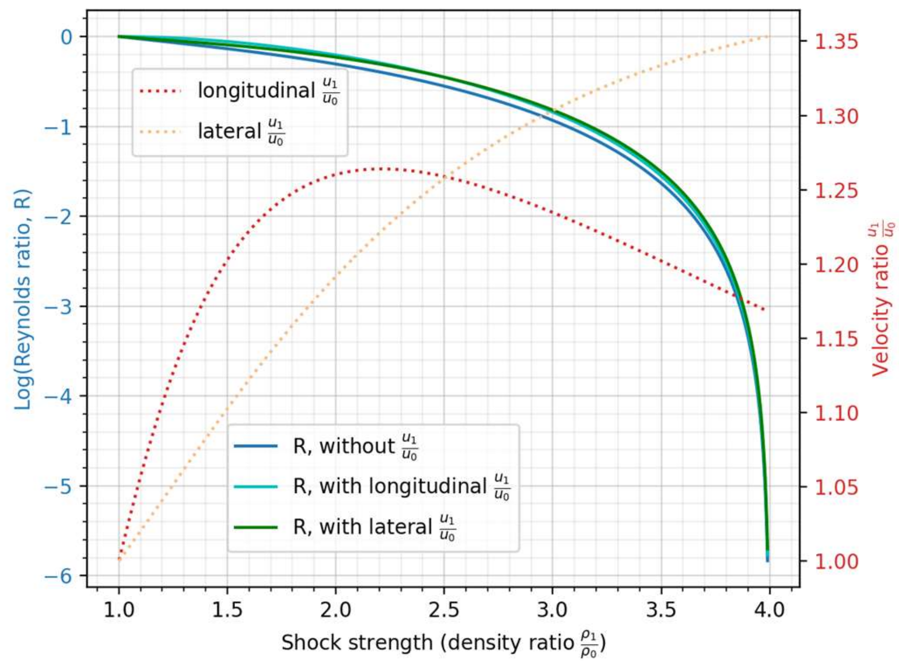
Ribner's Linear Interaction Analysis gives turbulent velocity amplification across shock.

Credit: Ribner HS. Convection of a Pattern of Vorticity Through a Shock Wave. NACA Rep. 1164, 1954.

Simulations of turbulence passing through a shock in pyranda will allow for direct comparison of viscosity jump

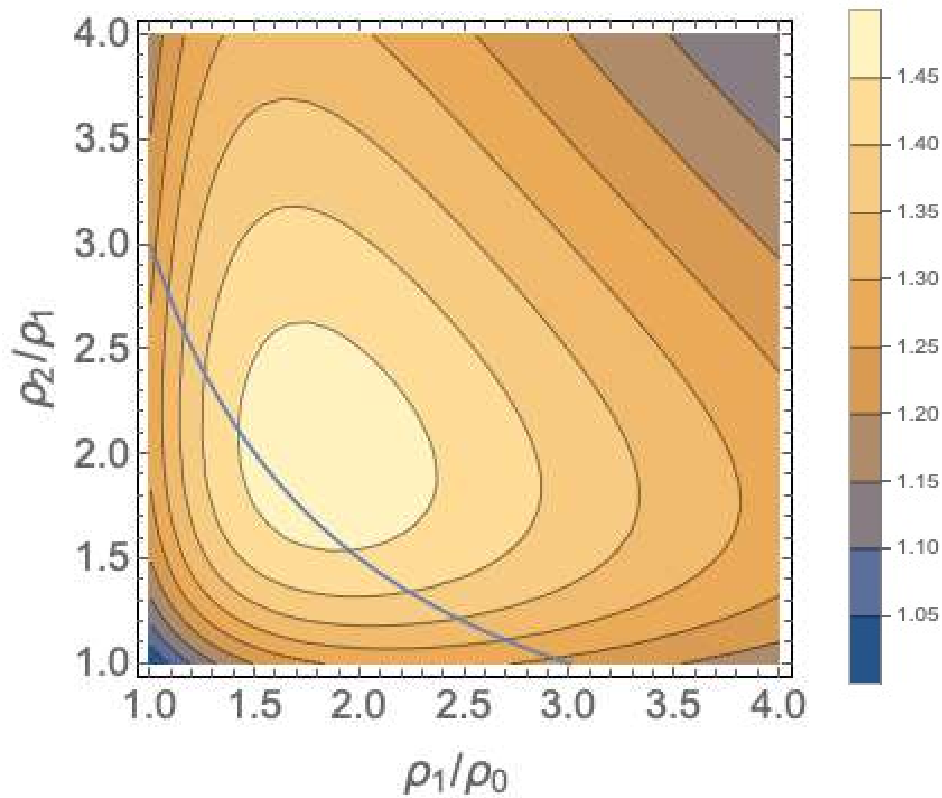
Significant decrease in Reynold's number predicted for stronger shocks

Decrease in Reynolds number across a shock, R, is greater for stronger shocks



Amplification of longitudinal and lateral turbulence across a shock, $\frac{u_1}{u_0}$, is anisotropic and non-monotonic with shock strength

Amplification of longitudinal turbulence for two shocks is impacted by the order of shocks of different strengths



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