Modelling the Core Collapse Supernova Explosion Mechanism in One Dimension

Emma Jarvis

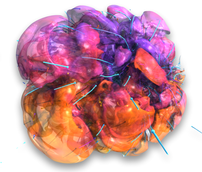
Supervisor: Almog Yalinewich

Astronomy & Astrophysics
UNIVERSITY OF TORONTO

CITA | ICAT
Canadian Institute for Theoretical Astrophysics | L'institut Canadien d'astrophysique théorique

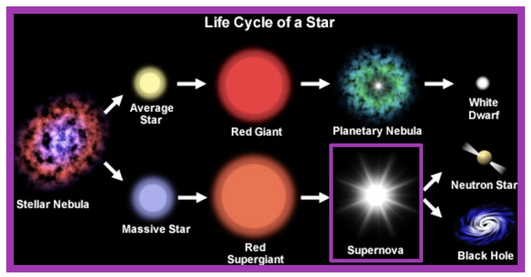
Summary

- Core collapse supernovae occur at the end of a massive star's life.
- 1D simulations of core collapse supernovae do not explode without turbulence.
- This project uses **diffusion** to model **turbulence in 1D**.
- We found that increasing the diffusion strength makes the shock explode more easily.

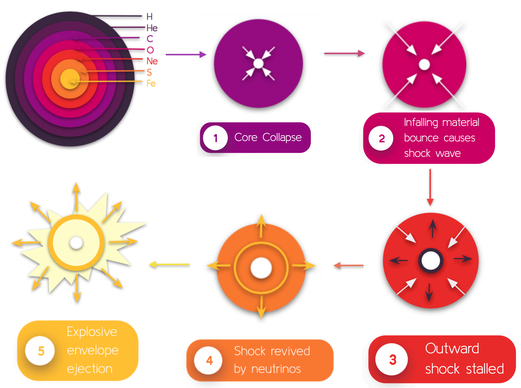


Core Collapse Supernovae

Stellar Evolution



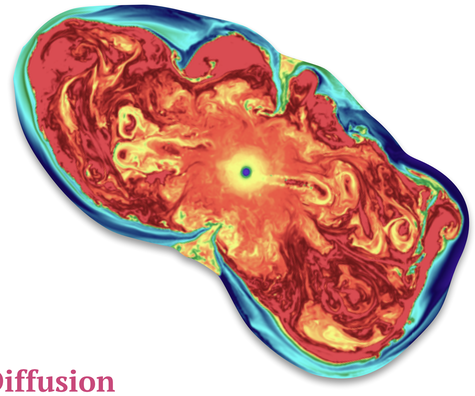
Explosion Mechanism



The Model

Hydrodynamics

- Hydrodynamic equations solved using **self similarity.**

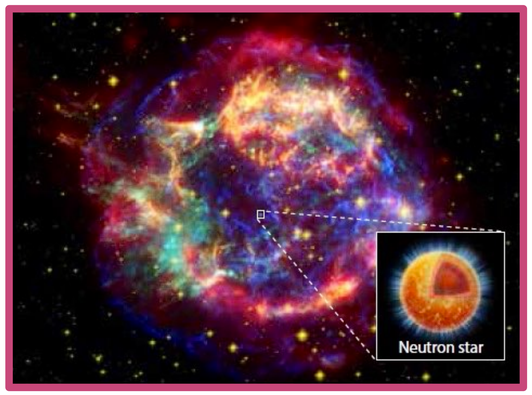


Diffusion

- Diffusion was used to model the effect of turbulence in one dimension.

Diffusion Equation: $\frac{\partial y}{\partial t} = \nabla (D \nabla y)$

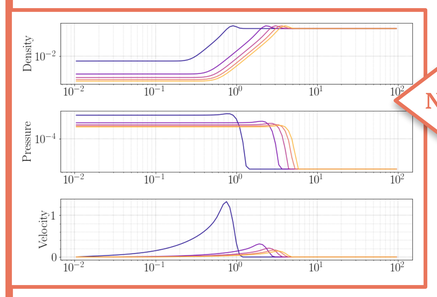
- The diffusion coefficient, D:
  - **length** of the eddies $\times$ thermal **speed**



Point Gravity

- Newtonian point gravity of the **proto neutron star**

Hydrodynamic Profiles

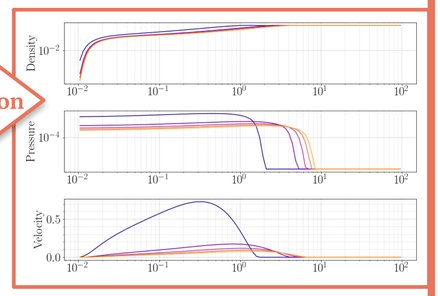


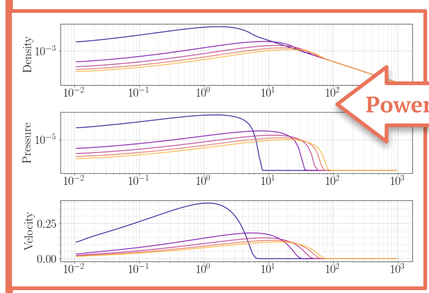
No Diffusion

$\gamma = \frac{4}{3}$

With Diffusion

$D = 1$

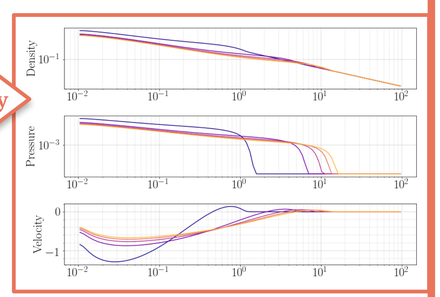




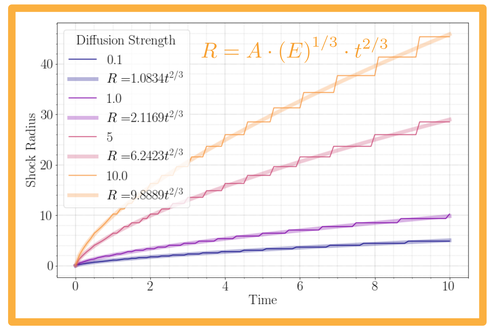
Power Law Density

$\rho \propto R^{-2}$

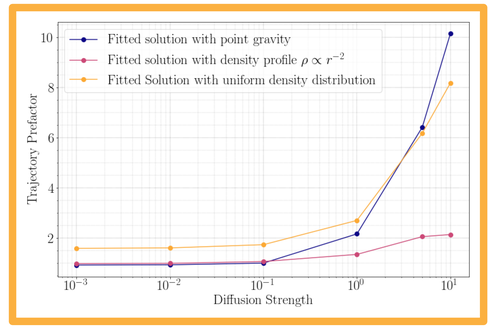
Point Gravity



Shock Trajectories



Increasing **diffusion** makes the shock travel **faster**



Trajectory prefectors, A

Faster shock ⟶ easier to **explode!**

Supernova 1987A Remnant