3D Low Mach Simulations of Convective Urca Process in White Dwarf

Brendan Boyd

What is the Urca Process?

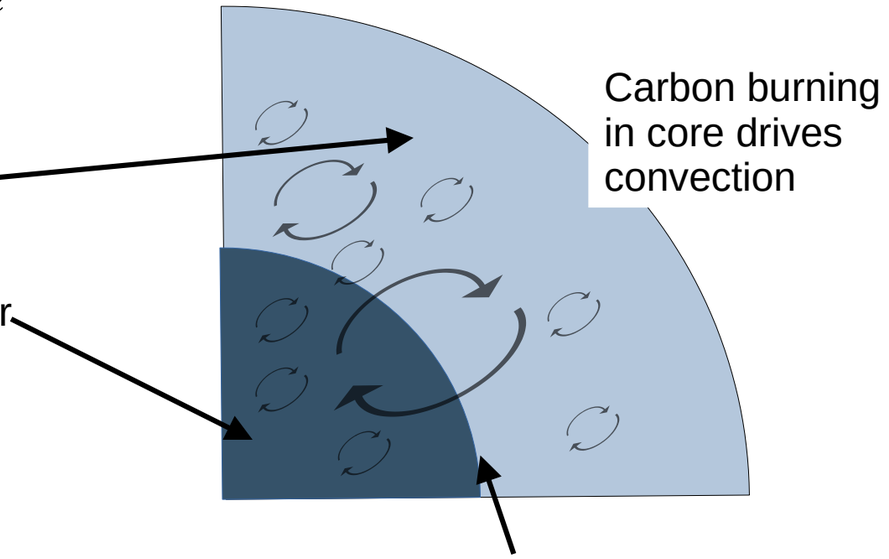
- Pairs of beta decay ↔ electron capture reactions. E.g.

$$^{23}\mathrm{Ne} \rightarrow {}^{23}\mathrm{Na} + \mathrm{e}^- + \bar{\nu}_e$$

$$^{23}\mathrm{Na} + \mathrm{e}^- \rightarrow {}^{23}\mathrm{Ne} + \nu_e$$

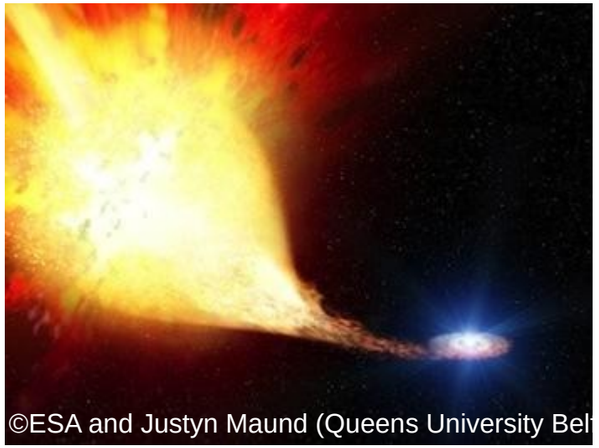
- Beta decay at low density (far from core of WD)
- Electron capture at high density (near core of WD)
- Can be important in white dwarfs
  - Remnant of a star, mostly made of Carbon and Oxygen

Convecting White Dwarf



Why do we care?

Type Ia Supernovae



- Incredibly bright and useful distance indicators
- Exploding white dwarf(s)
  - Undetermined how the white dwarf is exploding
- Structure of white dwarf impacts explosion
  - Urca process changes structure

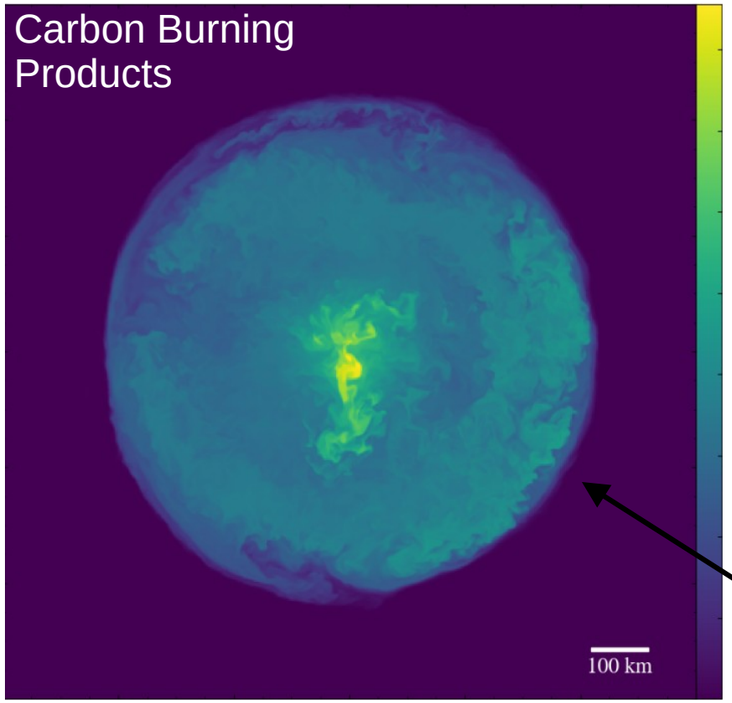
3D Low Mach Simulations of Convective Urca Process in White Dwarf

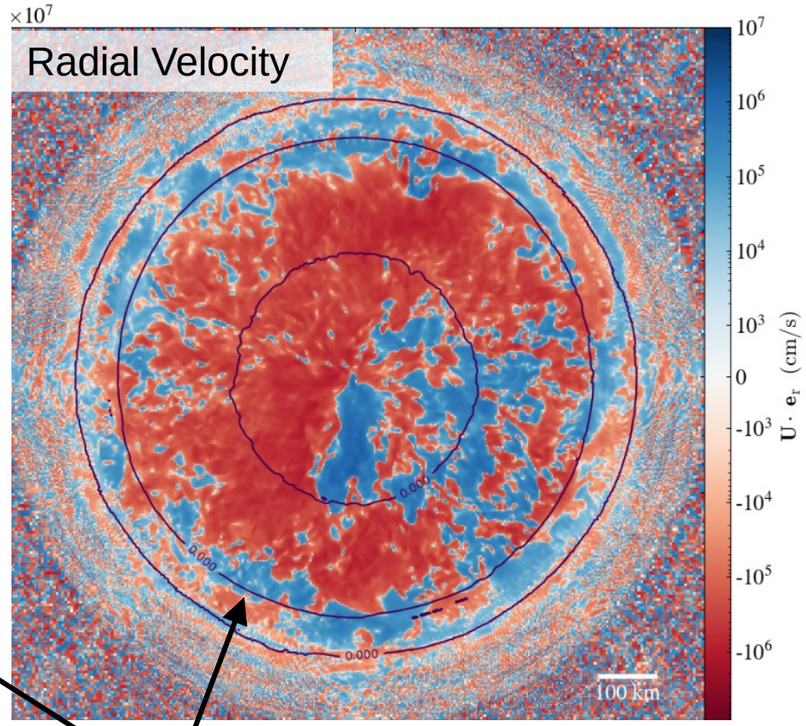
Brendan Boyd

Stony Brook University

MAESTROeX Code

- A Fortran/C++ hydrodynamic grid based code
  - Parallelization w/ MPI and OpenMP
  - GPU support w/ CUDA
  - Scales well over 10,000 cores
- Evolve fluid equations (w/ a low mach constraint) and nuclear reactions
- Low mach code. For slow moving fluids:
  - Run longer, more accurate simulations than standard hydrodynamic codes





Simulation Results

- Preliminary findings indicate convection limitted to **urca shell**
  - Restricted convection can influence products of supernova explosion
- Future work to include more urca pairs (^{25}Mg / ^{25}Na). Test under different white dwarf conditions (temperature and density), and eventually blow up the models!

Scan for MAESTROeX