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

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What is Urca Process?

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

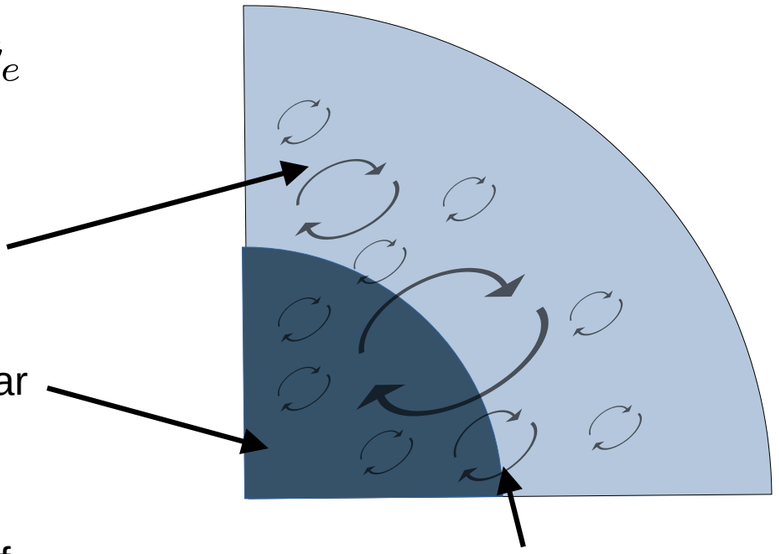
$$^{23}\mathrm{Ne} \rightarrow {}^{23}\mathrm{Na} + \mathrm{e}^- + \bar{\nu}_e$$

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

- 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

Carbon burning in core drives convection



Equilibrium zone called **Urca shell**, splits WD

- Material moving across the Urca shell, can repeatedly go through Urca process

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

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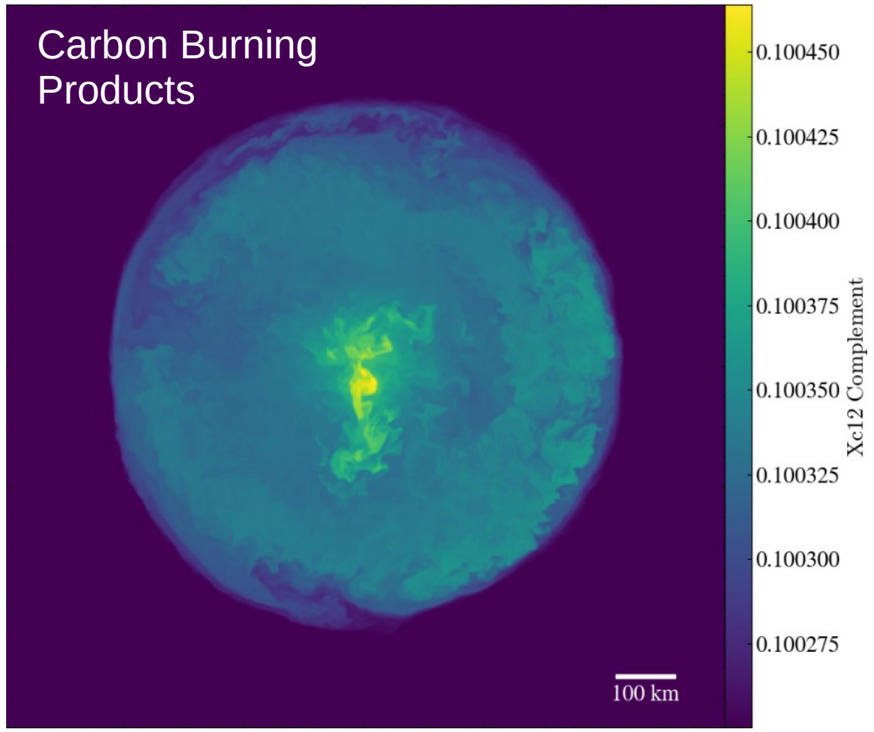
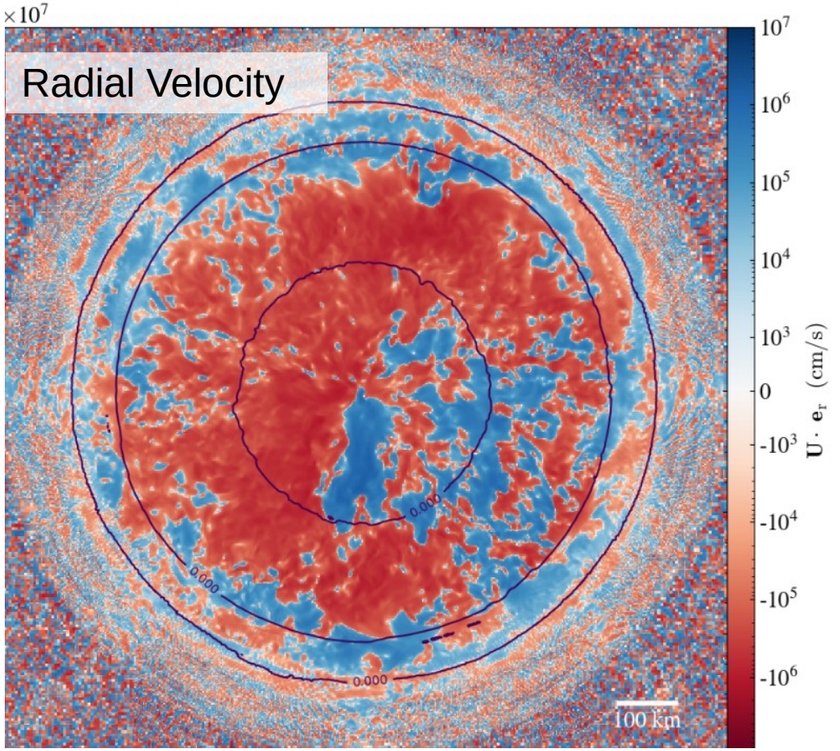
MAESTROeX Code

- A Fortran/C++ hydrodynamic grid based code
  - primarily C++
  - Parallelization w/ MPI and OpenMP
  - GPU support w/ CUDA
- Evolve fluid equations (w/ a low mach constraint) and nuclear reactions
- Low Mach code. For slow moving fluids
  - Efficiently models flows
  - 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

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