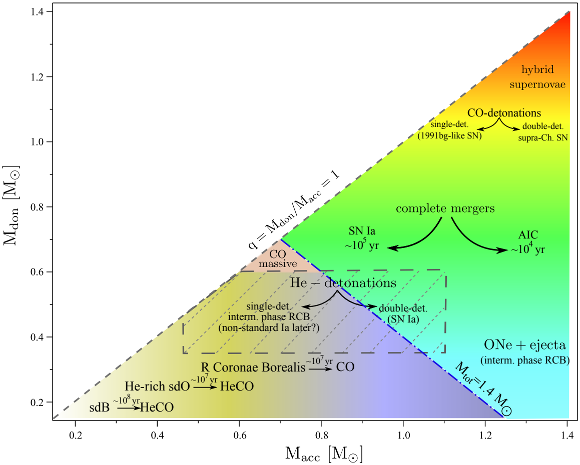
The Long-Term Outcomes of Double White Dwarf Mergers

UC Berkeley, Ph.D. (May 2016)

Josiah Schwab

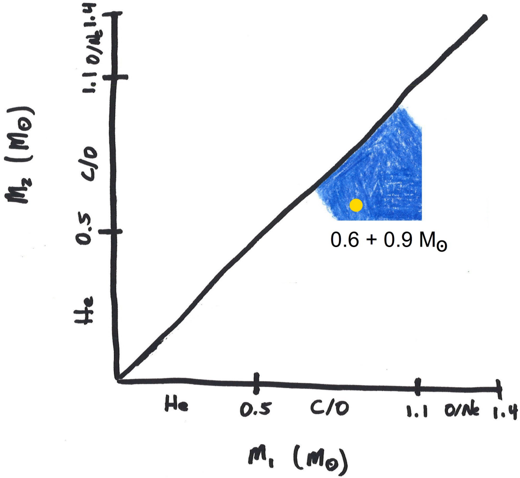
05 January 2016

The merger of two white dwarfs (WDs) gives rise to a variety of post-merger outcomes.



e.g., Webbink (1984), ... ; Fig. from Dan et al. (2014)

Today, I will focus on the merger of two CO WDs, with a total mass above the Chandrasekhar mass.



The primary WD remains relatively undisturbed;
The secondary WD is disrupted, forming a disk.

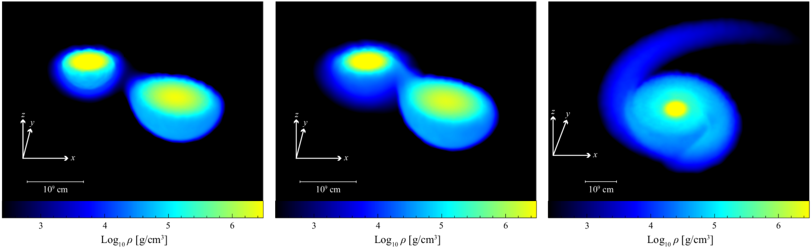


Fig. from Dan et al. (2011)

The evolution can be divided into three phases with well-separated timescales.

Dynamical Time (min)

Completion of merger

Viscous Time (hr)

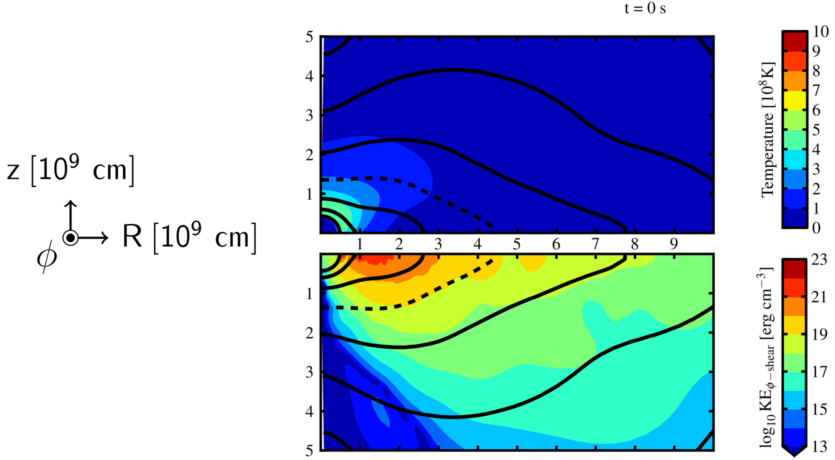
Redistribute ang. mom.

Thermal Time (kyr)

Radiate away energy

Shen et al. (2012); Schwab et al. (2012)

The remnant is unstable to the MRI and evolves viscously before cooling significantly.



Schwab et al. (2012)

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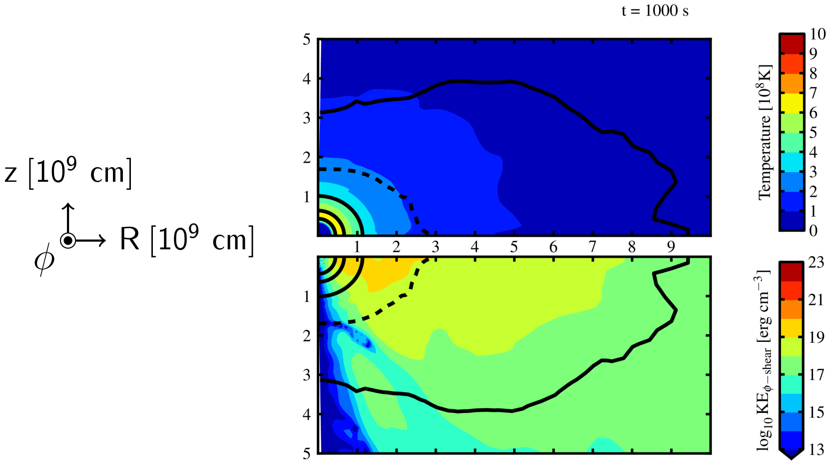

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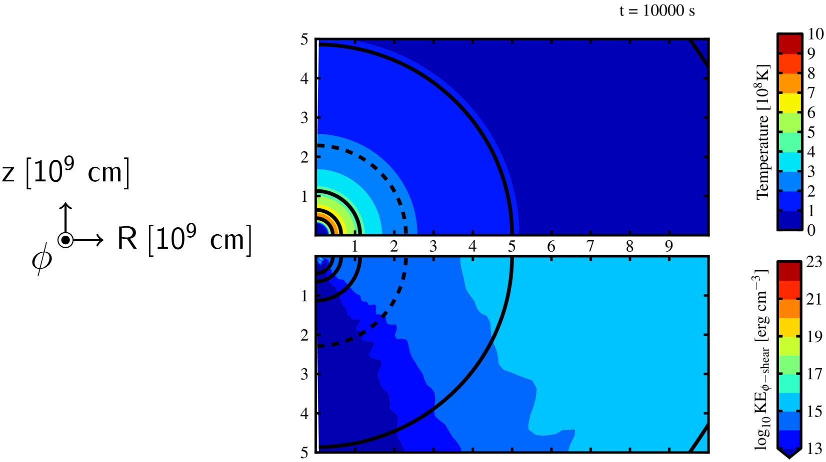
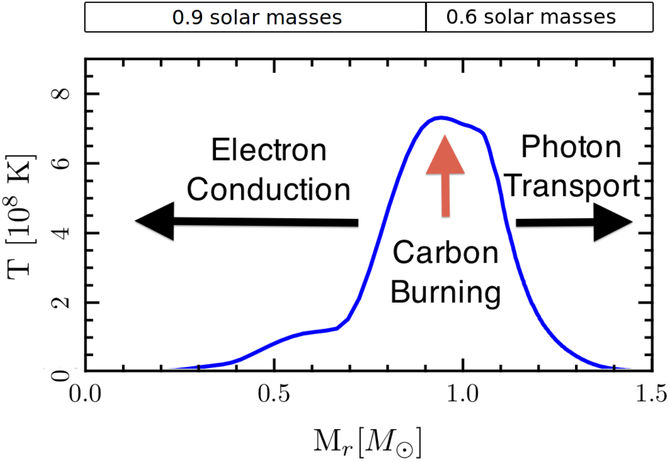


Schwab et al. (2012)

Energy generation and heat transport will drive the next phase of evolution.



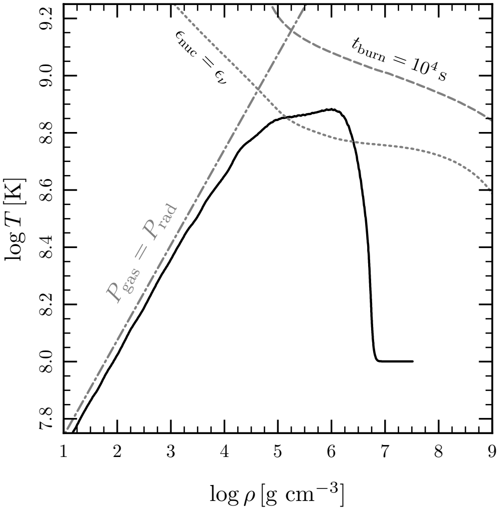
Introduction to WD+WD Mergers

The viscous evolution of WD merger remnants

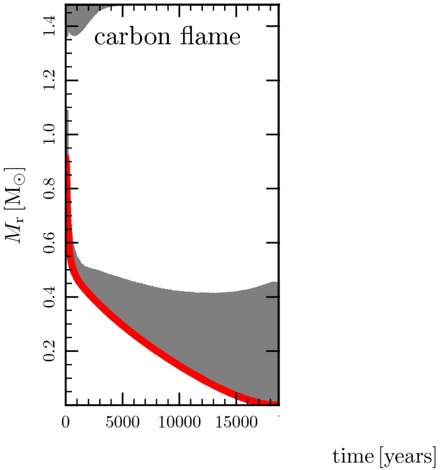
The thermal evolution of WD merger remnants

Summary and Conclusions

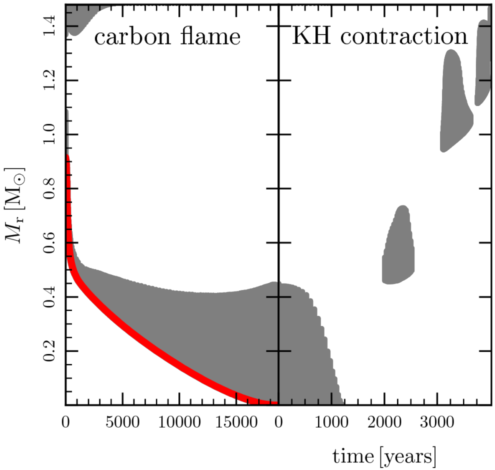
I map the output of the hydro simulations into the MESA stellar evolution code.



A convectively-bounded carbon deflagration propagates inward, converting material to O & Ne.



The carbon flame lifts the degeneracy;
the remnant begins to cool & contract.



The KH contraction is neutrino-cooled and leads to off-center neon ignition.

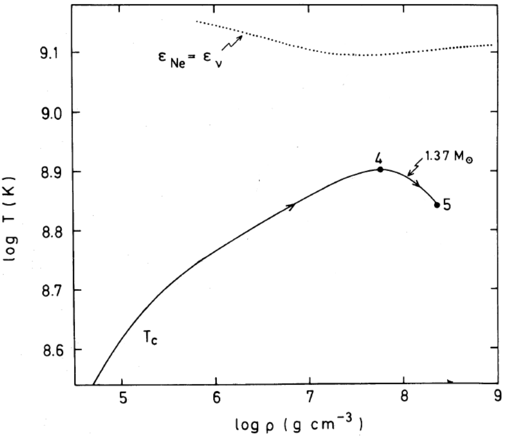


Fig. adapted from Nomoto (1984)

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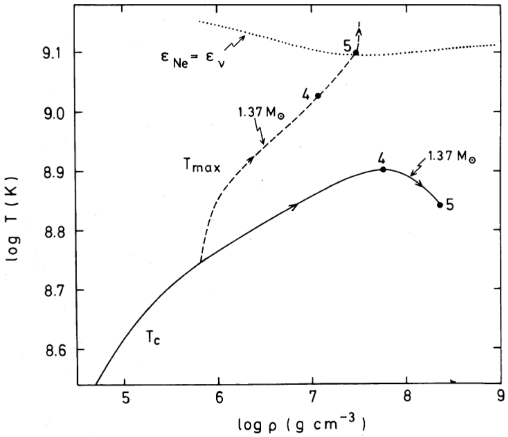

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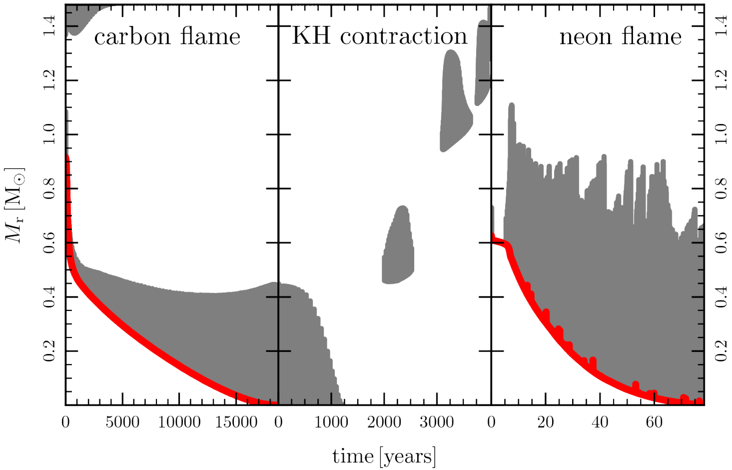
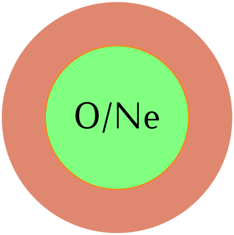


The way the remnant collapses to a neutron star depends on the central composition

Electron-capture (AIC)



Schwab et al. (2015)

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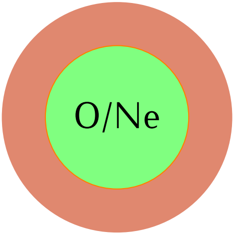
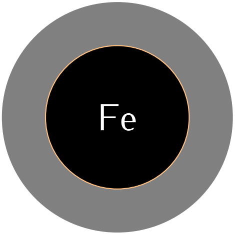


Schwab et al. (2015)

Core-collapse



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  - **dynamical** phase (merger)
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- Connecting simulations of each phase enables studies of the long-term evolution.
- For super-Chandrasekhar WD mergers, the likely fate is collapse to a neutron star; the evolution towards collapse appears to be more complicated than previously understood.