NCO Ignition in Massive Helium Shells

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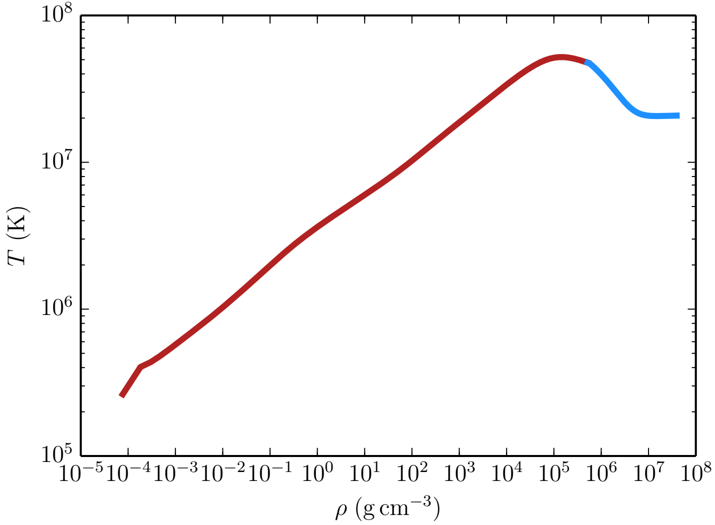
October 31, 2016

Profile of a White Dwarf Accreting Helium



A New Energy Source

$^{14}\mathrm{N}(e^-,\nu)^{14}\mathrm{C}(\alpha,\gamma)^{18}\mathrm{O}$ (Hashimoto et al. 1986)

- Helium cores created by CNO burning end up with about $1\%^{14}\mathrm{N}$ leftover.
- When the accreting white dwarf compresses this material, it reaches density for electron capture $^{14}\mathrm{N}(e^-,\nu)^{14}\mathrm{C}$.
- At typical temperatures for this scenario, $^{14}\mathrm{C}(\alpha,\gamma)^{18}\mathrm{O}$ happens quickly as soon as the $^{14}\mathrm{C}$ appears?

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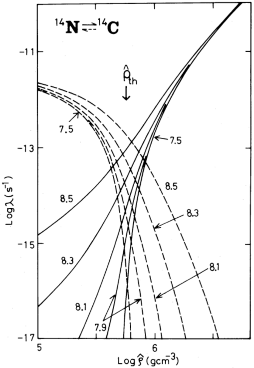
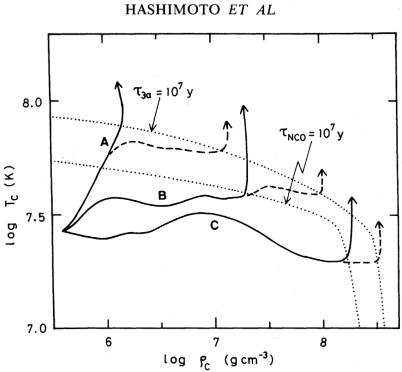
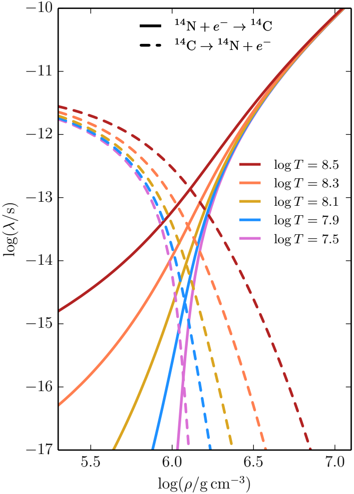




Center of an accreting Helium White Dwarf reaches NCO ignition.

The Hashimoto Scenario in MESA



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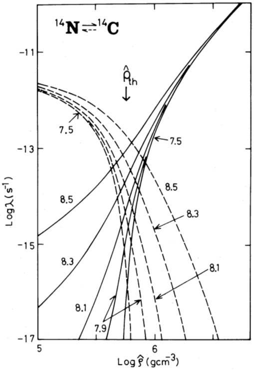

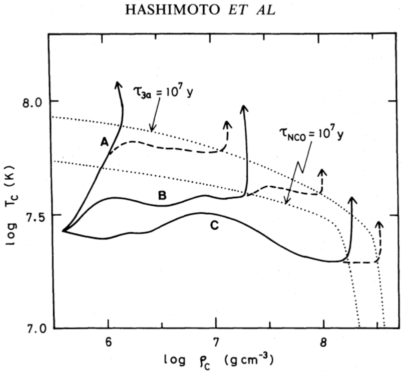

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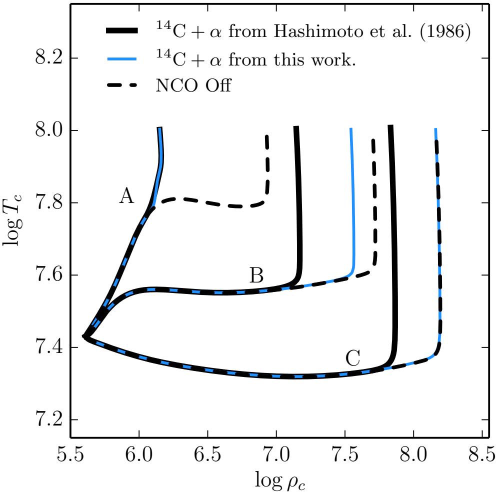
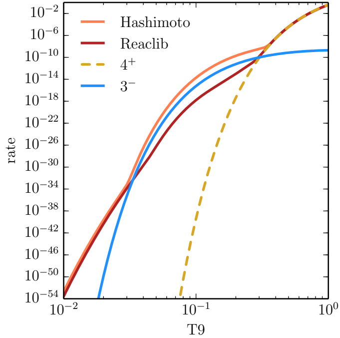
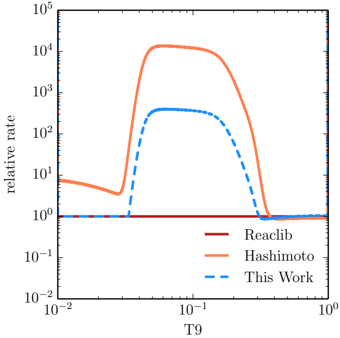


The Uncertain $^{14}\mathrm{C} + \alpha \rightarrow {}^{18}\mathrm{O}$ Rate





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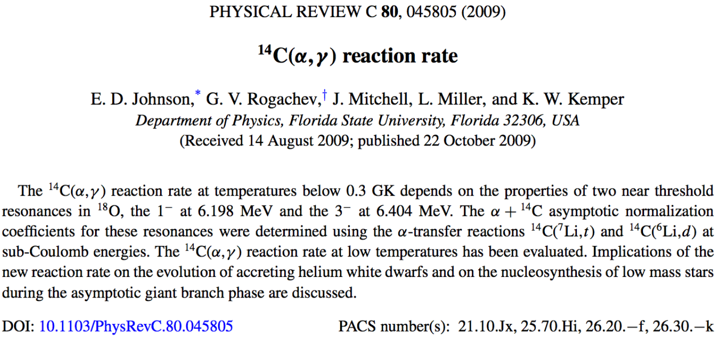

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^{14}C(α,γ) reaction rate

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(Received 14 August 2009; published 22 October 2009)

The ^{14}C(α,γ) reaction rate at temperatures below 0.3 GK depends on the properties of two near threshold resonances in ^{18}O, the 1^- at 6.198 MeV and the 3^- at 6.404 MeV. The $\alpha + {}^{14}$C asymptotic normalization coefficients for these resonances were determined using the α-transfer reactions ^{14}C(^{7}Li,t) and ^{14}C(^{6}Li,d) at sub-Coulomb energies. The ^{14}C(α,γ) reaction rate at low temperatures has been evaluated. Implications of the new reaction rate on the evolution of accreting helium white dwarfs and on the nucleosynthesis of low mass stars during the asymptotic giant branch phase are discussed.

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The Reasonably Certain $^{14}C + \alpha \rightarrow {}^{18}O$ Rate

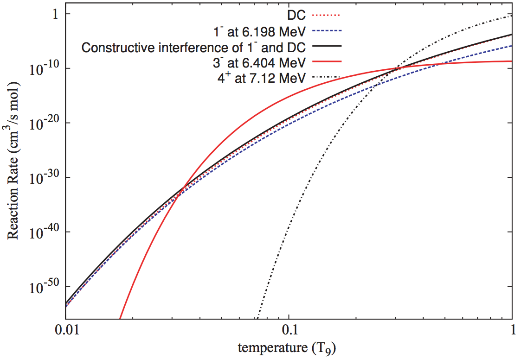

FIG. 9. (Color online) The $^{14}C(\alpha,\gamma)$ reaction rate due to resonant and nonresonant capture. Resonant capture due to the 4^+ state at 7.12 and 3^- state at 6.404 MeV are shown as the black dash-dotted and solid red curves, respectively. Direct capture is the red dotted curve; capture due to the 1^- subthreshold resonance at 6.198 MeV is the blue dashed curve.

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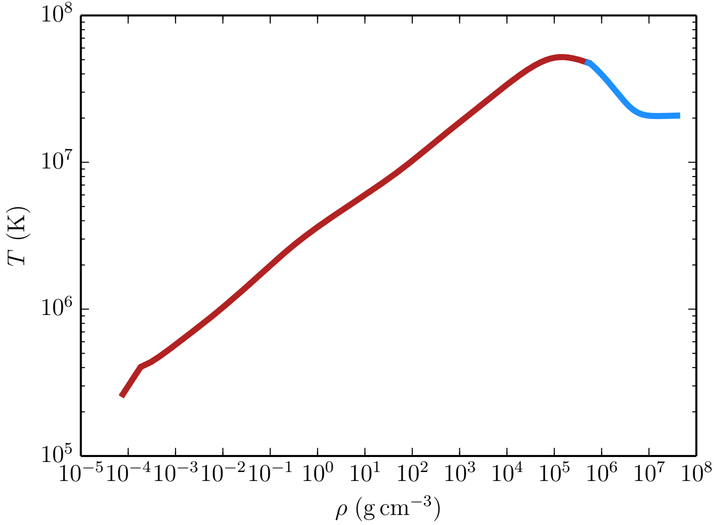
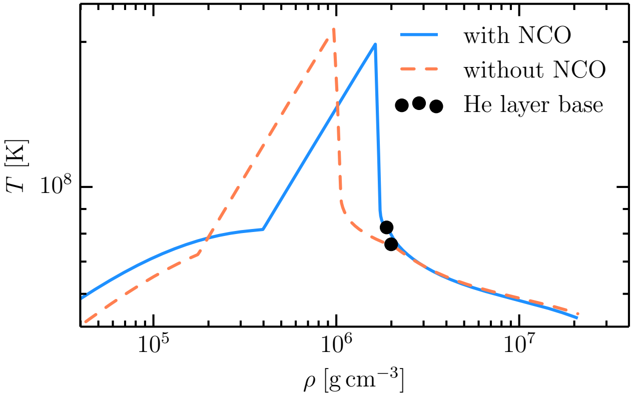


An Observed Binary: CD $-30°11223$

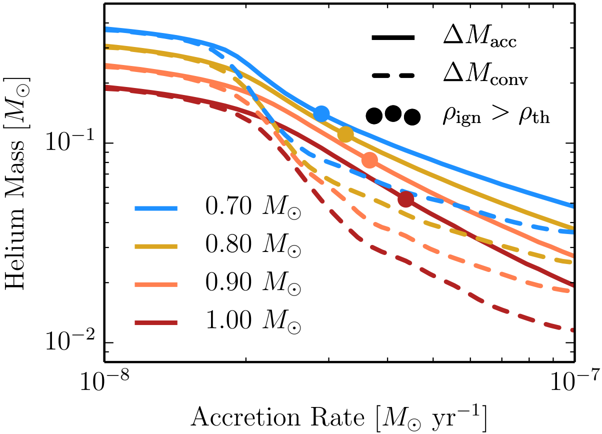
Predicted flash structure after detailed simulation of ≈ 45 million years of binary evolution.



Backups

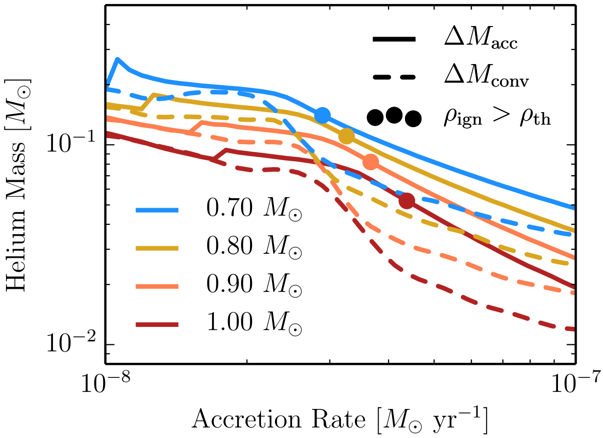
White Dwarfs Accreting from Helium Donors

$^{14}\mathrm{C} + \alpha \rightarrow {}^{18}\mathrm{O}$ turned off.



White Dwarfs Accreting from Helium Donors

New $^{14}\mathrm{C} + \alpha \rightarrow {}^{18}\mathrm{O}$ rate.



White Dwarfs Accreting from Helium Donors