Evolution of a $7M_{\odot}$ Star

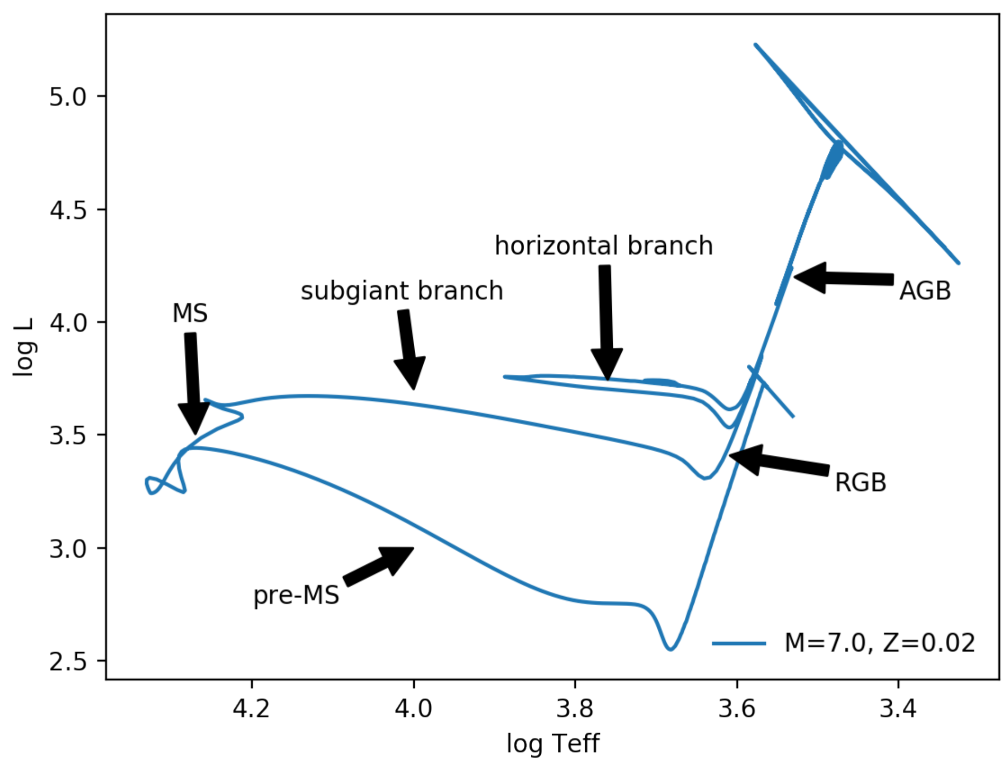

Figure 1: HRD for $7M_{\odot}$ star, tracing its evolution in luminosity and temperature. Will be used as reference for the rest of the plots.

Evolutionary Stages

Main Sequence H burning in core. (nuclear timescale; longest phase)

Subgiant Branch H is exhausted in the core, but continues to burn in a shell. Core contracts, envelope expands, and the star cools to the bottom of the RGB on a thermal timescale.

Red Giant Branch Still no core fusion, just H burning in shell. He builds up in the core but does not ignite. Star becomes larger and more luminous.

Horizontal Branch He ignites in core, star heats dramatically. (nuclear timescale; 2nd longest phase)

Asymptotic Giant Branch He is exhausted in core, but continues to burn in shell, and H burns in shell outside of that. Star cools and grows again. Thermal pulses occur when He shell approaches H shell and they interact.

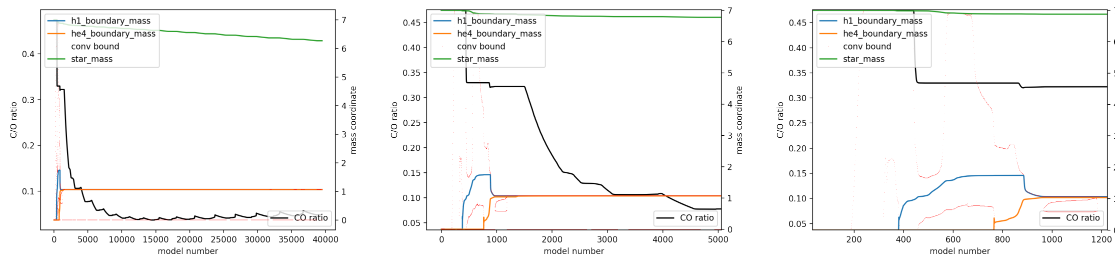

Figure 2: CO ratio and stellar mass over time, with the exciting early stuff enlarged in the centre and right-hand panels.

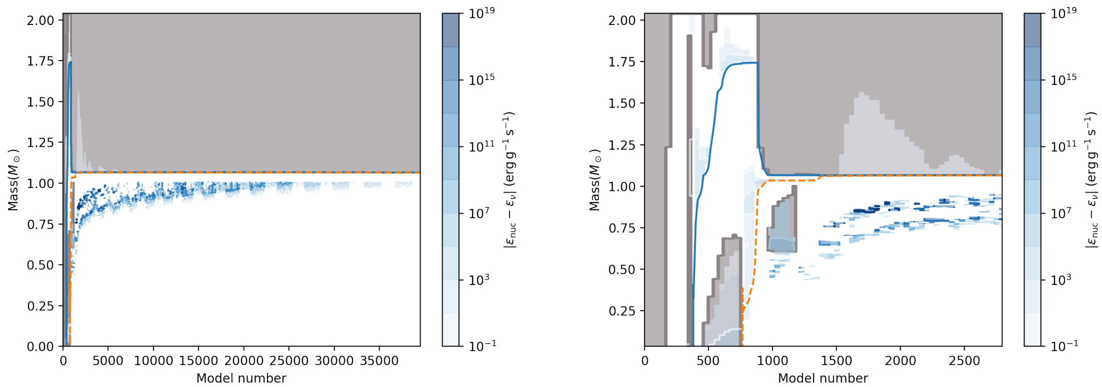

Figure 3: Kippenhahn diagram, with the early exciting stuff enlarged in the right-hand panel.

Specific Points in the Evolution of a $7M_\odot$ Star

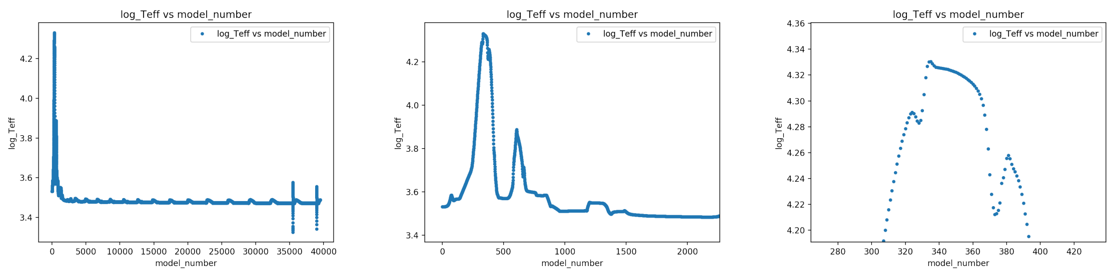

Figure 4: T_{eff} plotted against model number. Comparison with the HRD lets us determine the model number of various evolutionary points of interest. *Left:* entire evolutionary T progression. *Centre:* Enlargement of early temperature fluctuations, including main sequence ($\approx$ model 365) and horizontal branch ($\approx$ model 625). *Right:* Detail of the main sequence. An equivalent plot of luminosity against model number was used to locate the red giant branch, which will be represented by model 490.

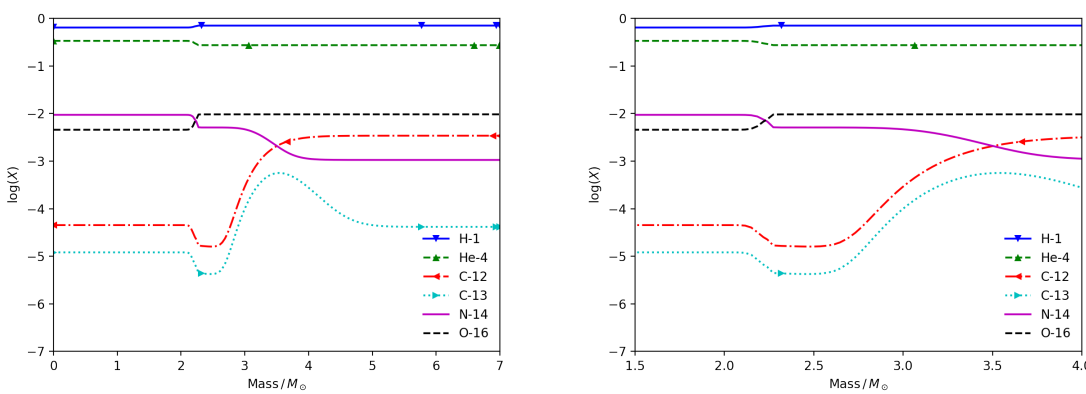

Figure 5: Main sequence (H-burning core) chemical abundance profiles, plotted for model 365. H-burning can be seen at M$\sim 2.25 M_\odot$, where H decreases and He increases towards the centre. Closer to the centre, abundance profiles are flat due to convective mixing. This star is massive enough that H burns via the CNO cycle. Because N-14 has the lowest cross-section for proton capture, H-burning increases its abundance.

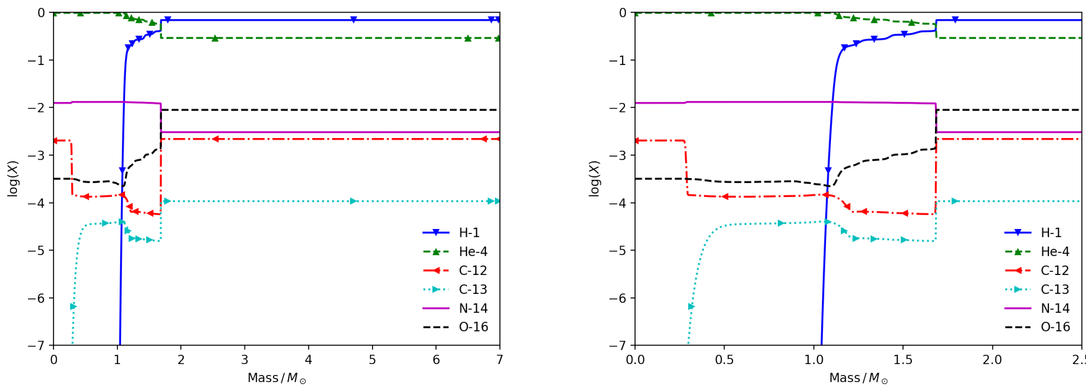

Figure 6: Red giant branch (H-burning shell) chemical abundance profiles, plotted for model 490. H-burning shell is visible from $\sim 1.1 - 1.6 M_\odot$, over which the H decreases and He increases. Interior to that is the H-free core, where He is building up.

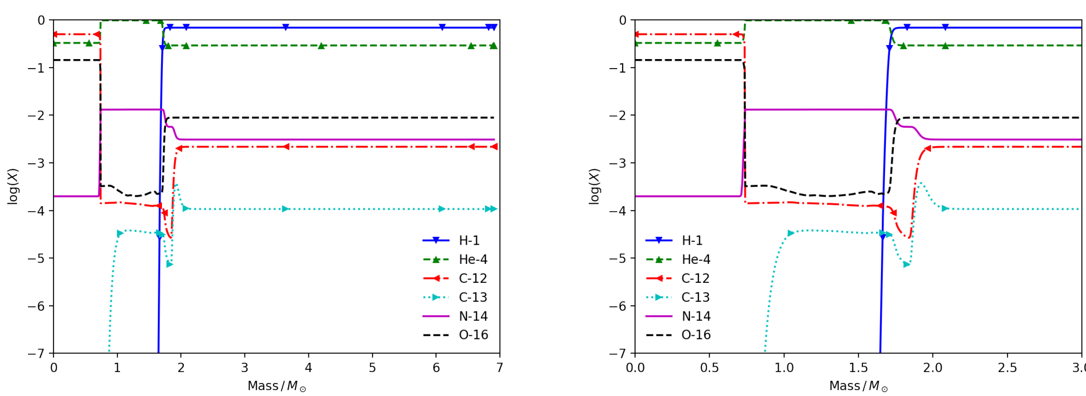

Figure 7: Horizontal branch (He-burning core) chemical abundance profiles, plotted for model 625. He-burning can be seen at $\sim 0.75 M_\odot$, and the H-burning shell at $\sim 1.7 M_\odot$. Due to 14N providing a bottleneck in the CNO cycle, the region between H and He burning has depleted 12C, 13C, and O16, and enriched 4He and 14N. He burning then produces 12C through the triple-alpha process. A CO core begins to form

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