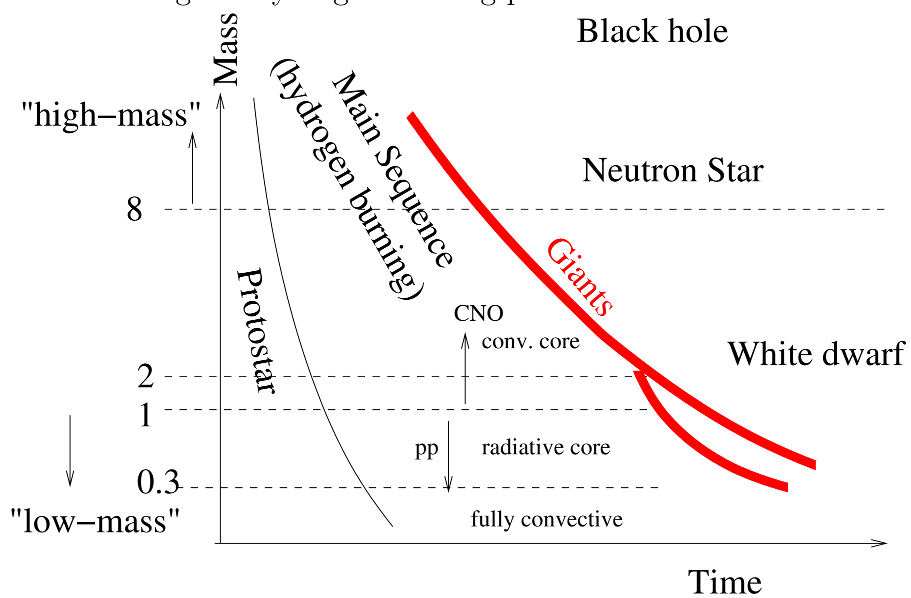
20 Astro notes 2018/10/10 - Wed - Stars

handed back and discussed exam

20.1 Stellar evolution and the main sequence

Evolution during the hydrogen burning phase.



Main parameters: birth mass, time. Other paramers (not shown) composition, rotation, maybe magnetic field.

Want to understand how the star's structure changes as it evolves. The main reason that this can be done is that there is a hierachy of timescales.

$$t_{\rm nuc} \gg t_{\rm grav-therm} \gg t_{\rm dyn}$$

The time on the main sequence is
(student)

$$t_{MS} = \frac{E_{nuc}}{L} \sim \frac{\Delta E_{nuc,H} M/m_p}{L} \propto \frac{M}{M^3} \propto M^{-2}$$

Thus higher mass stars live much shorter time.

Also since the evolution time in H and He burning phases is much longer than the Kelvin-Helmlotz time, the star evolves from one semi-static solution to another where each solution is in balance, hydrostatic, or even mostly thermal balance.

Evolution during this time is one of changing the interior composition (H$\rightarrow$He) from one thermal equilibrium state to another.

20.2 Thresholds in initial mass

There are several thresholds between high- and low-mass stars that depend on the stage of life. Four are shown in the diagram:

1. Remnant type, Neutron star or White dwarf, $\sim 9M_{\odot}$.

The most obvious threshold is based on end of life, in that stars about about 8 to 10 $M_{\odot}$ will have their cores collapse and explode as a supernovae, but less massive stars will just stop fusion and settle into being a white dwarf star.

2. Fusion process, $\sim 1M_{\odot}$

Also called the upper vs. lower main sequence. This has to do with the how fusion takes place, CNO catalytic fusion for higher masses, p+p for lower masses. This results in the presence or absence of a convective core.

3. Immediate or delayed transition to core helium fusion, $\sim 2.5M_{\odot}$

i.e. is shell (off-center) H burning required between the end of core H burning and core He burning? Schönberg-Chandrasekhar limit. Below this limit there is a distinct RGB (red giant branch, shell H burning) and AGB (Asymptotic giant branch, shell He,H burning) separated by the HB (horizontal branch, core He burning). Above, there is not really a separate RGB.

4. Fully convective vs. radiative core, $\sim 0.3M_{\odot}$

Below this threshold star is always fully mixed (i.e. surface and interior abundances evolve together) unlike at higher masses