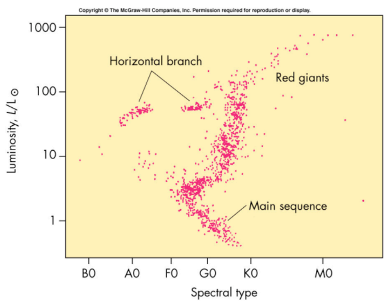
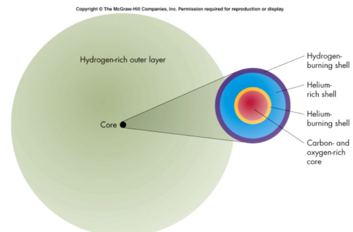
More stellar evolution…bloated stars and compact cores



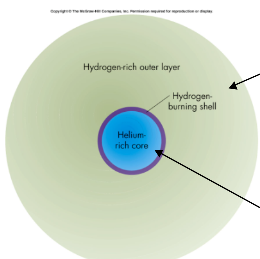
What's the point of this?

In an evolved star, the appearance of the surface is not a good indicator of its deep interior



What the core is doing is not obvious from the surface of the star

What will be the structure of the Sun 5 billion years from now?



Outer layers of star swell up and cool --> red giant (not obvious)

Old core (now helium) continues to contract (it's not in hydrostatic equilibrium)

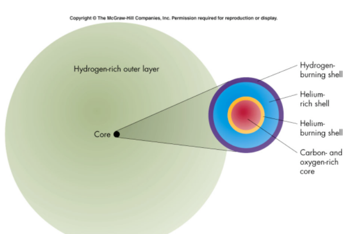
demo

Eventually, temperatures in compact core reach high enough temperatures for helium fusion reactions, the "triple alpha process"

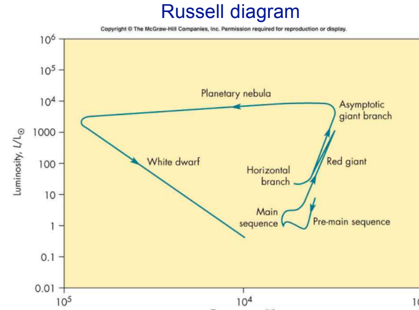
Triple alpha process can proceed when the temperature reaches 100 million K.

The helium core is converted into carbon and oxygen. The chemical composition of the core becomes highly varied

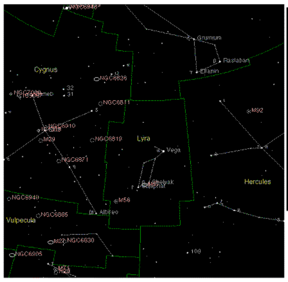
Later in the future life of the Sun

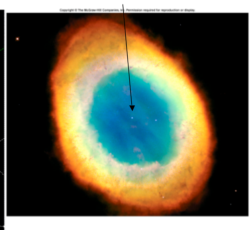


What we see is the outside (photosphere) of the star. While this is going on in the core, the post-main sequence star moves around on the Hertzsprung-Russell diagram



Old evolved stars throw off their outer layers, producing objects called planetary nebulas, revealing the weird cores



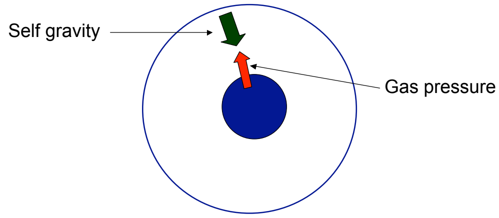


Another planetary nebula: M27 (we saw it during the field trip)

As cores contract, the density goes to “astronomical” levels, matter acts in funny ways

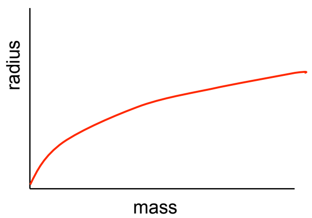
- Gas in this room, the “perfect gas law” PV=nRT. Pressure depends on both density and temperature
- Extremely dense, “degenerate” gas PV=Kn. Pressure depends only on density
- Demo

The contracted core reaches a new balance between gravity and degenerate gas pressure



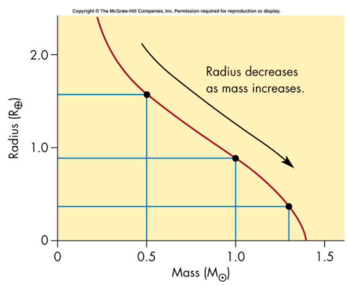
What are the physical properties of these objects?

Solutions to the equations give radius of degenerate core as a function of its mass



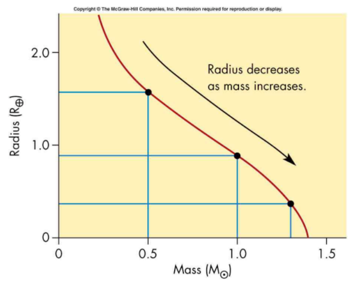
What one might expect for how R depends on M

What the solution really is for such an object



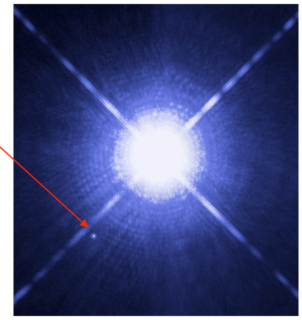
Note the scales: solar masses but **Earth** radii!

Do such objects really exist in nature? Is this story confirmed by objects in the sky?



They do exist! The white dwarf stars

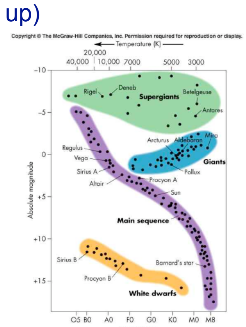
- Sirius is a binary star. Its companion is a white dwarf
- Appendix 12 (nearest stars) lists 2 of them, so they must be very common



View from a spaceship in the Sirius system

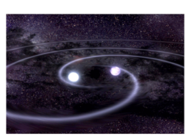
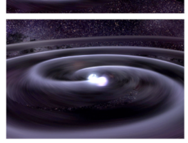
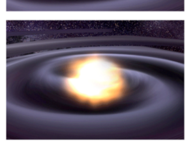
We know the white dwarfs must have the properties as described (we're not making this up)

- We know the mass of Sirius B (1.02 versus 2.40 solar masses for Sirius A)
- Even though it is hotter than Sirius A, it is much fainter (look at difference in absolute magnitudes
- The only way to do this is with small WD radius



There are many known examples of white dwarfs; they are a common phenomenon in the galaxy

http://www.astronomy.villanova.edu/WDCatalog/index.html

White dwarfs are the first class of **stellar remnants**, the end products of stellar evolution