Reading: Chapters 1 - 5

Lectures posted (pdf files) on the web site

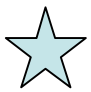
Anyone try to find Betelgeuse? What direction?

Astronomy in the news?

Pic of day - Delta IV

Quantum Pressure -- just depends on squeezing particles,
electrons for white dwarf, to very high density
-- depends on density only
-- *does not* depend on temperature

Important Implication:

Normal  Radiate energy, pressure tries to drop, star gets **hotter** (and higher pressure)

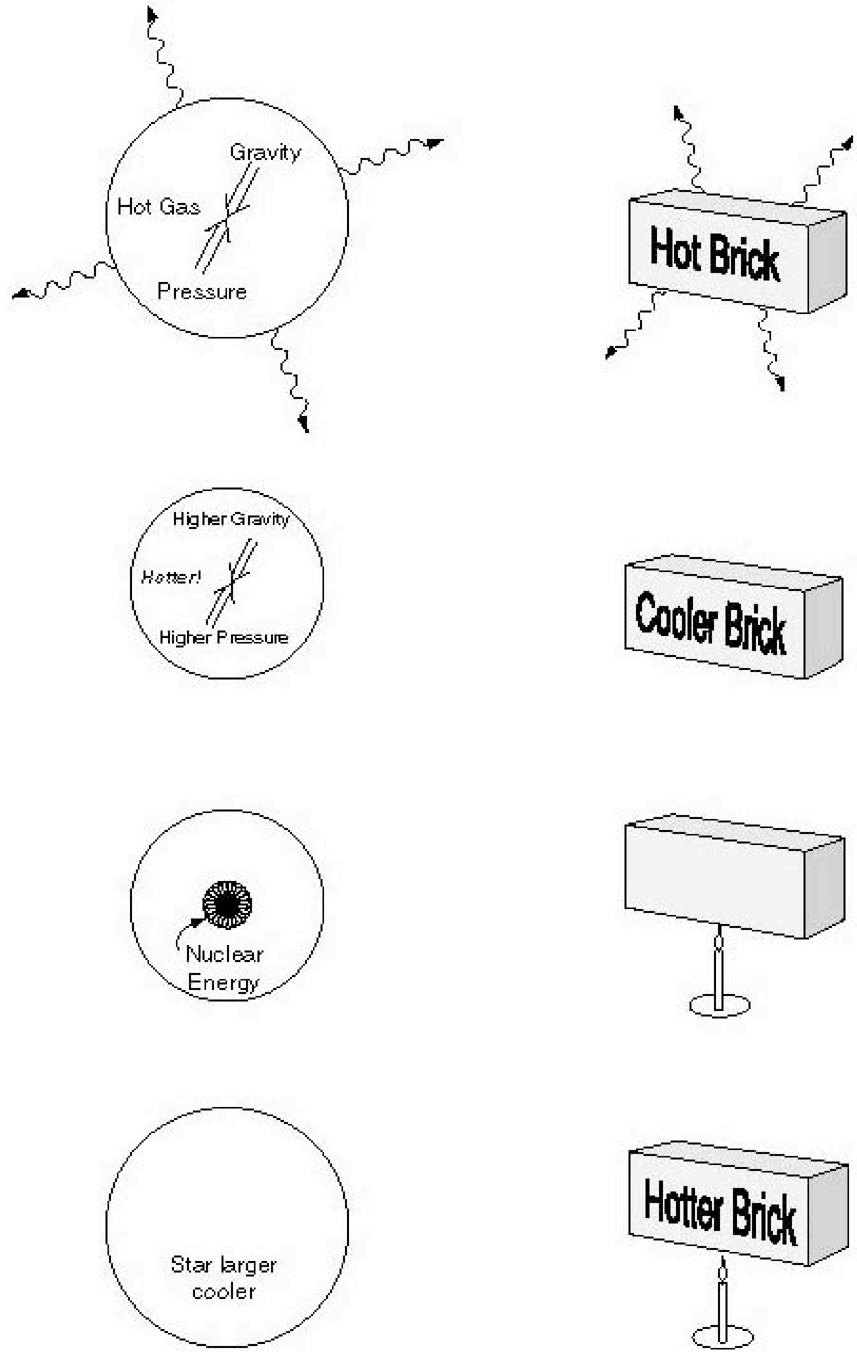
White Dwarf Radiate energy, *temperature does not matter*, pressure remains constant, star gets **cooler**

Opposite behavior

Normal Star - *Regulated* put in energy, star expands, cools

White Dwarf - *Unregulated* put in energy, hotter, more nuclear burning -- explosion!

Figure 1.3



Gravity
Hot Gas
Pressure
Hot Brick
Higher Gravity
Hotter!
Higher Pressure
Cooler Brick
Nuclear
Energy
Star larger
cooler
Hotter Brick

Behavior of white dwarf, Quantum Pressure, worked out by S. Chandrasekhar in the 1930's

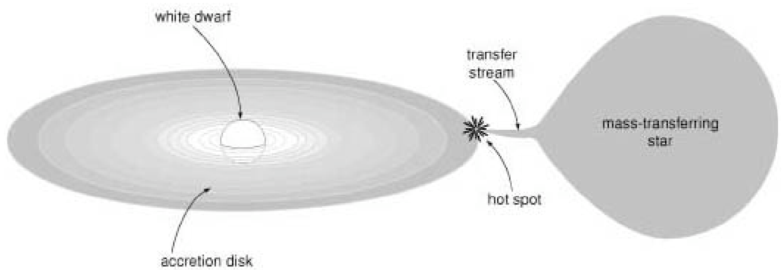
Limit to mass the Quantum Pressure of electrons can support

Chandrasekhar limit ~ 1.4 $M_\odot$

→ density ~ billion grams/cc ~ 1000 tons/cubic centimeter

Maximum mass of white dwarf.

White dwarfs in Binary Systems



Binary Evolution: **Chapter 3**

Kepler's 3rd Law $P^{2\text{(squared)}}$ proportional to $a^{3\text{ (cubed)}}$

Period
Time to orbit

size of orbit

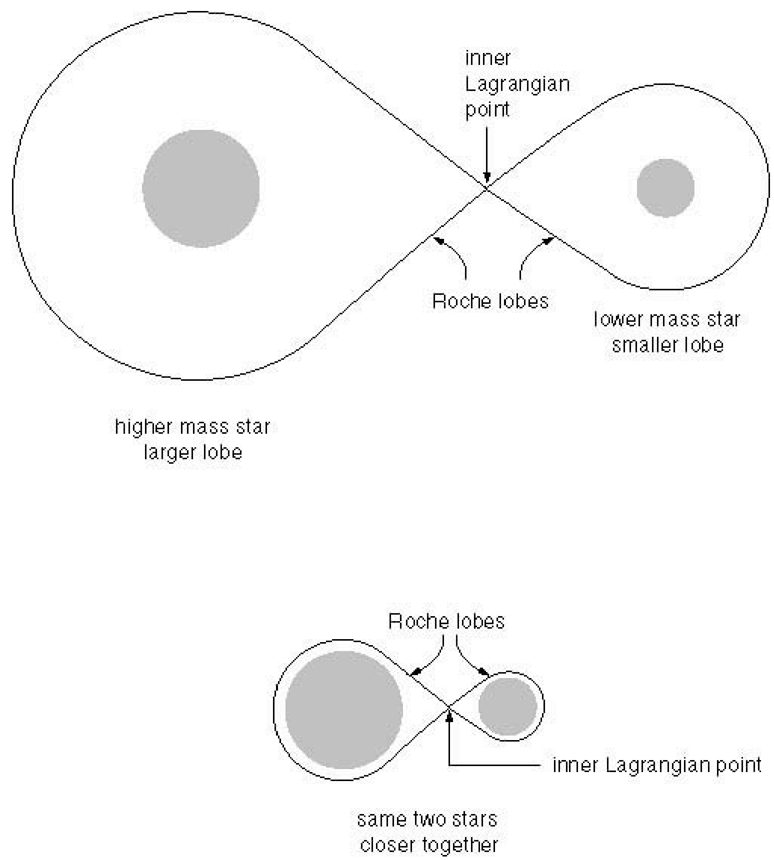
Newton: P^2 proportional to $\dfrac{a^3}{M_1 + M_2}$

total mass of 2 stars: way to "weigh" the system, get total, subtract "normal" star weight WD, NS, BH

Roche Lobes Fig 3.1

Roche lobe is the gravitational domain of each star. Depends on size of orbit, but more massive star always has the largest Roche lobe.

3.1

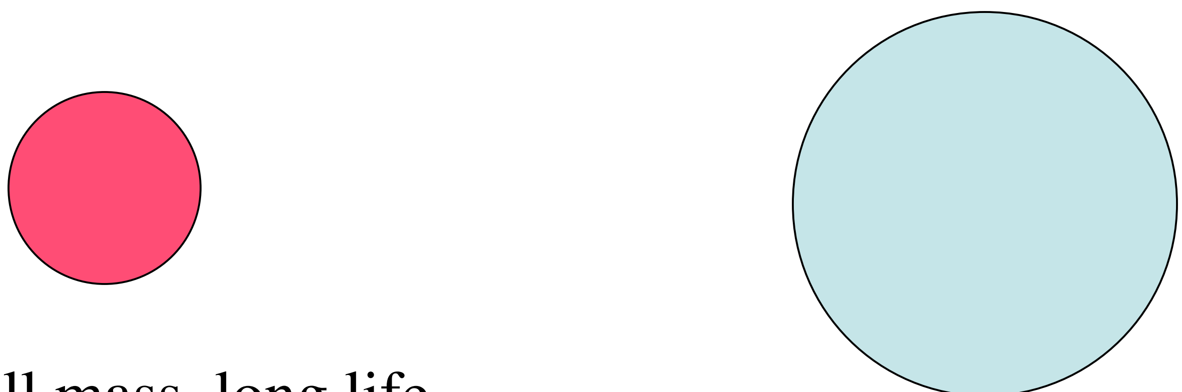


Caution: the most massive star may not have the largest radius!

Fundamental property of stellar evolution:

A more massive star has more fuel, but is also brighter, burns that fuel faster.

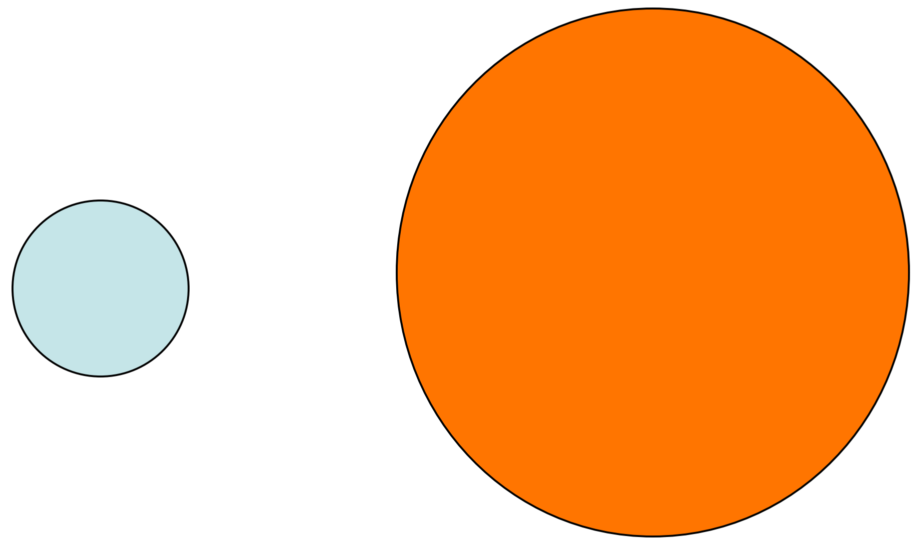
=> ***stars with higher mass on the main sequence evolve more quickly than stars with lower mass.***



small mass, long life

high mass, short life

Algol paradox: Algol is a binary star system with a Red Giant orbiting a blue-white Main Sequence companion.



Which is most massive?

Use Kepler's law to measure total mass, then other astronomy (luminosity of main sequence star tells the mass) to determine the individual masses.

Answer: the unevolved main sequence star!

Red Giant ~ 0.5 $M_{\odot}$ - but more evolved

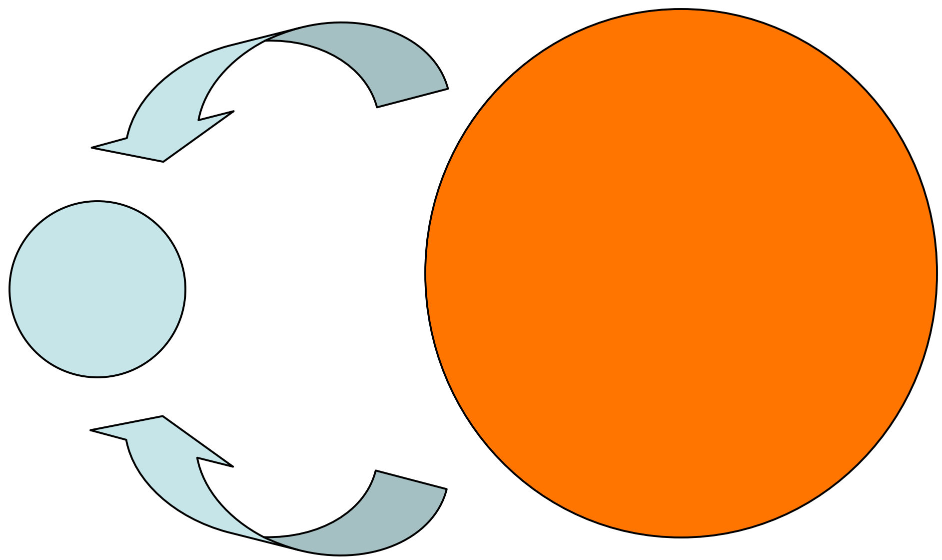
Blue-white Main Sequence star ~ 2-3 $M_{\odot}$ - but less evolved

Solution

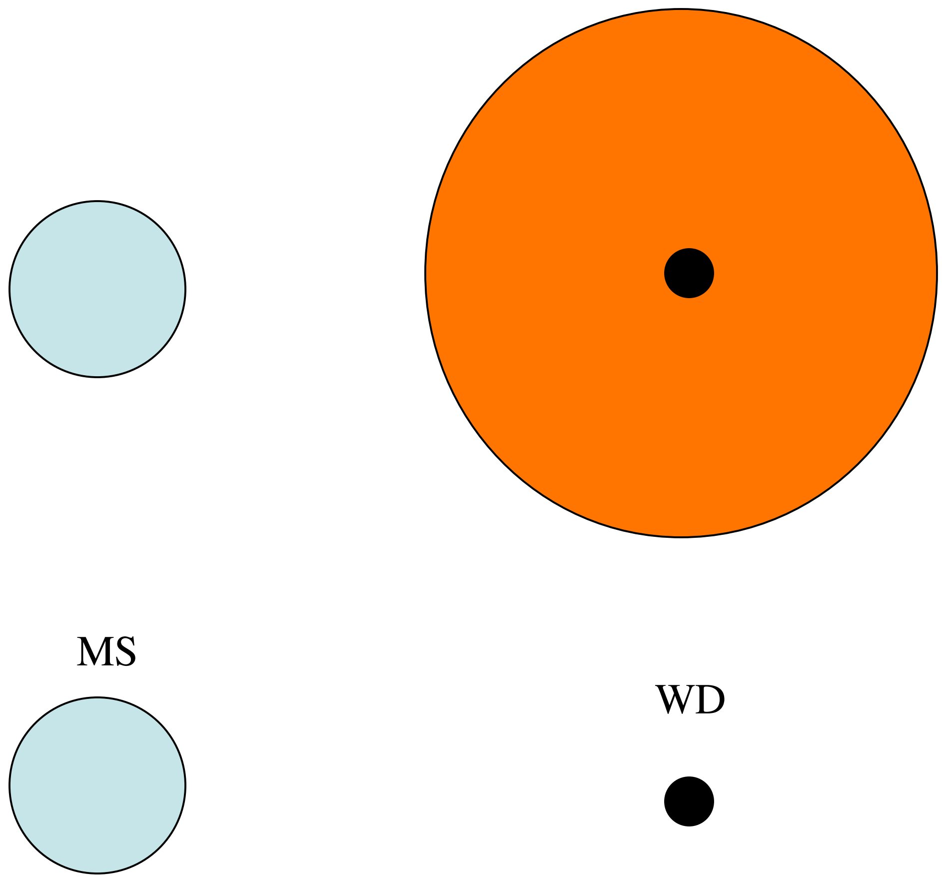
Mass Transfer

The red giant swells up, fills then overfills its Roche lobe and transfers mass to the companion.

The star that will become the red giant starts as the more massive star, but ends up the less massive.



In common circumstances, all the hydrogen envelope is transferred to the companion (or ejected into space), leaving the core of the red giant as a white dwarf orbiting the remaining main sequence star



Then the main sequence star evolves, the second star that was *originally* the less massive.

Mass flows onto the white dwarf.

The white dwarf is a moving target, the transfer stream collides, forms a ring, settles inward to make a flat disk.

Matter gradually spirals inward, a process called ***accretion.***

⇒ forms an ***Accretion Disk*** (Chapter 4).