

Monday, September 30, 2013

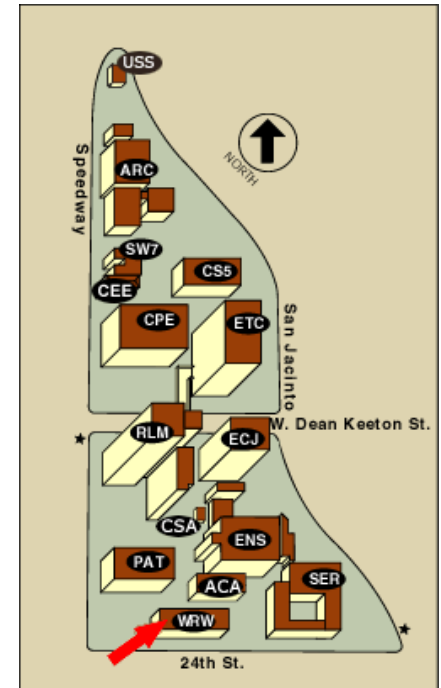
Exam 2 Friday. Review sheet posted.

Review session Thursday, 5 – 6 PM, WRW 102

Reading: Sections 6.1 (Type Ib/c), 6.4, 6.5 (but not detail on polarization), 6.6, Betelgeuse, Section 1.2.1 (neutrinos), Sections 2.1, 2.2, 2.4, 2.5, Sections 3.1 – 3.5, 3.8, 4.1 – 4.4, 5.2, 5.4. [Evolution of 2 white dwarfs, end of Section 5.4 and Section 6.7 will be on Exam 3]

Astronomy in the news?

If government shuts down tonight at midnight, 97% of NASA's employees will be furloughed with no salary. The 3% includes the continued operation of the International Space Station



Goal

To understand how stars, and Type Ia supernovae, evolve in binary systems.

Normal Type Ia *are* Chandrasekhar mass, $1.4 M_{\odot}$, carbon/oxygen white dwarfs; many, if not all, are old.

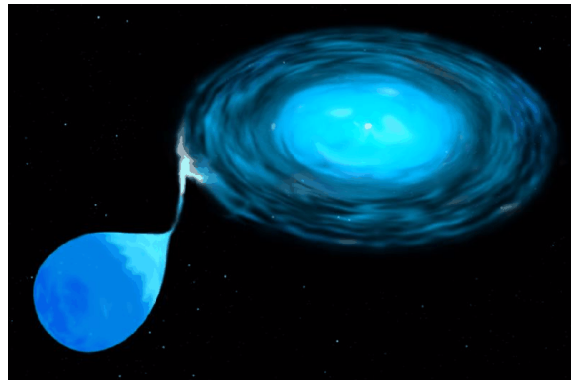
Only credible idea is to grow a white dwarf by mass transfer in a binary system.

No direct evidence for binary systems, some recent indirect hints.

How does nature grow a white dwarf to $1.4 M_{\odot}$?

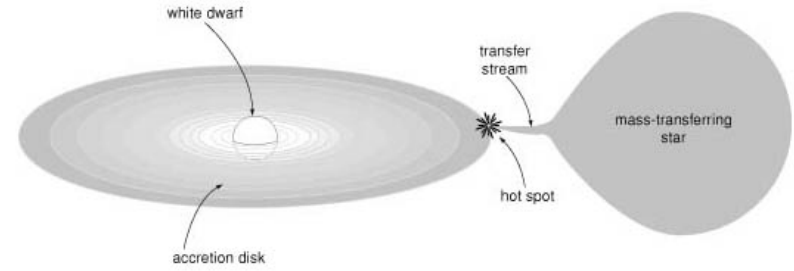
The progenitors of Type Ia supernovae may look like this:

What's going on?



White dwarfs in Binary Systems

Binary Evolution: **Chapter 3**



Kepler's 3rd Law P^2 (squared) proportional to a^3 (cubed)

Period size of orbit
Time to orbit

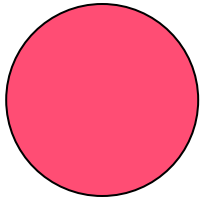
Newton: P^2 proportional to
$$\frac{a^3}{M_1 + M_2}$$

total mass of 2 stars: method to “weigh”
the system, get total, subtract “normal”
star, get weight of WD, NS, BH

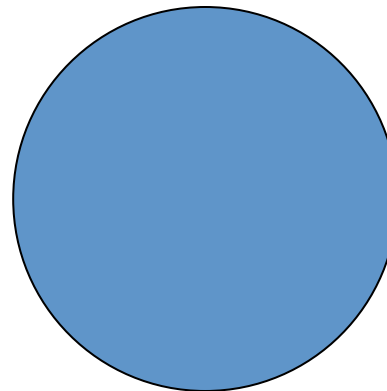
Fundamental property of stellar evolution:

A more massive star has more fuel, but is also *hotter to give the pressure to support the higher mass against gravity*, brighter, burns that fuel faster.

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

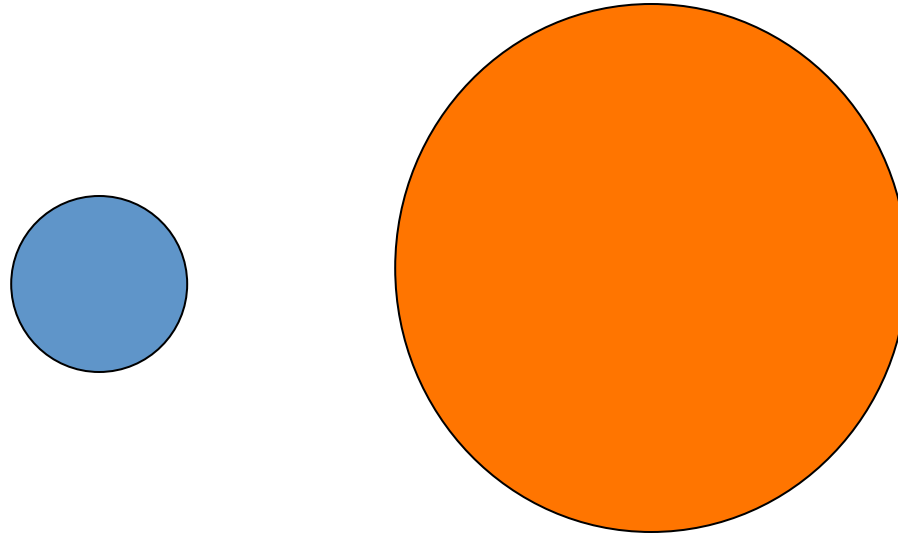


small mass, long life



high mass, short life

Algol paradox: Algol is a binary (actually triple) star system with a Red Giant orbiting a blue-white Main Sequence companion. The two stars were born at the same time.



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 $\sim 0.5 M_{\odot}$ - but more evolved

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

Discussion Point:

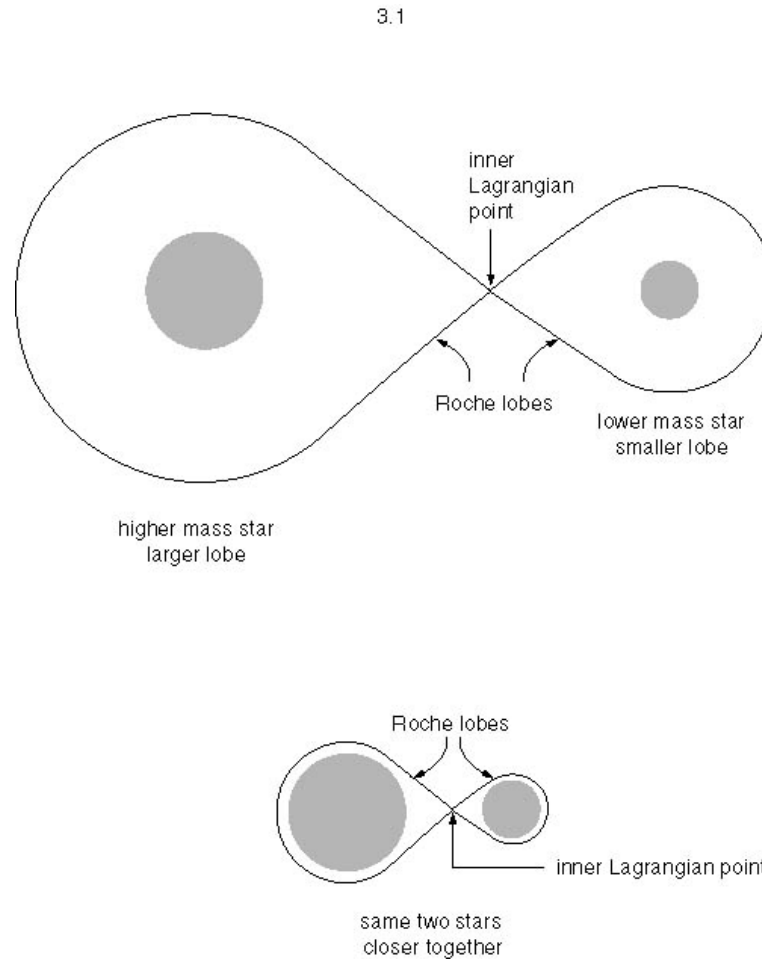
Explain to your neighbor why this is a dilemma.

Do you remember how Kepler's 3rd law can be used to measure the total mass of the binary system?

Binary Stars - Chapter 3

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.



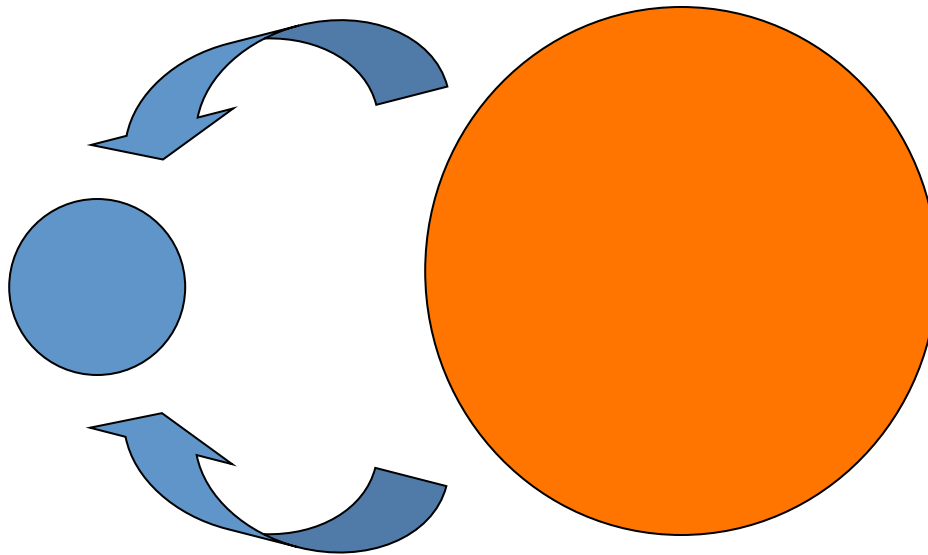
Caution:
the most
massive
star may
not have
the largest
radius!

Solution to Algol Paradox

Mass Transfer

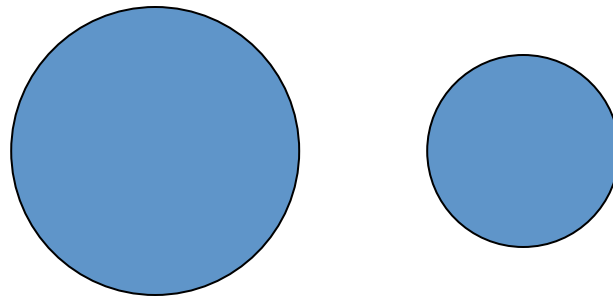
The red giant swells up, fills then overfills its Roche lobe and transfers mass to the companion.

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



One Minute Exam

Two stars orbit one another in a binary system



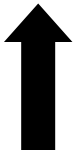
Which star has the largest Roche lobe?



the one on the left



the one on the right

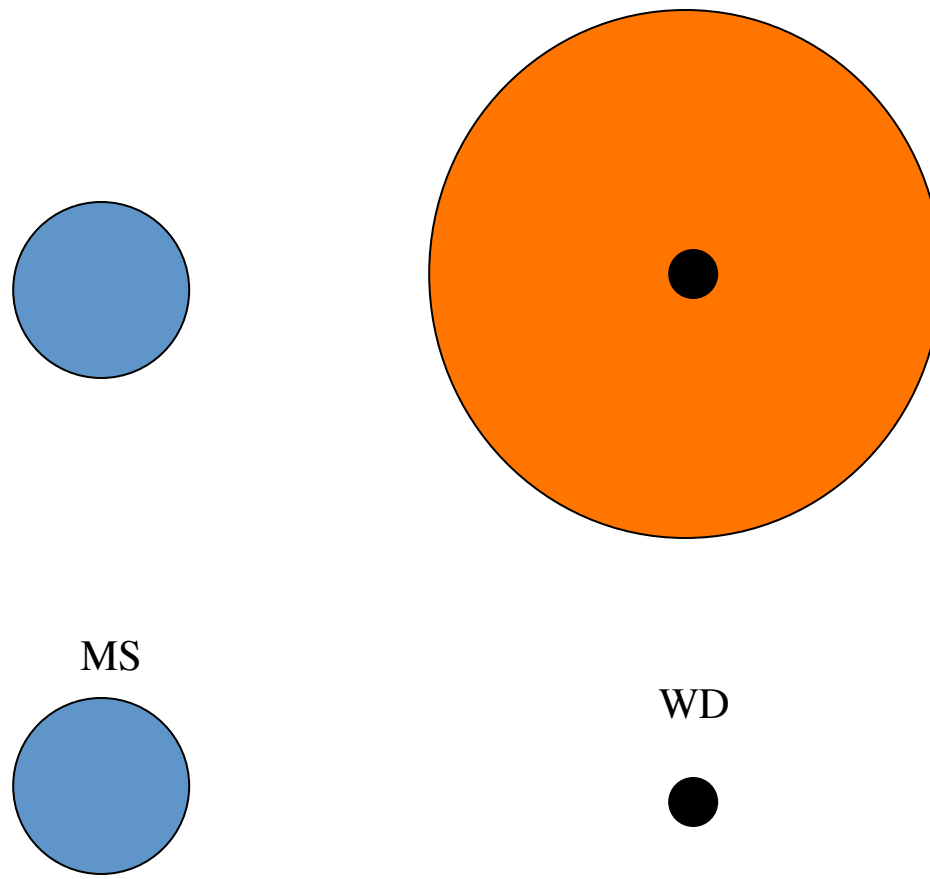


insufficient information to answer the question



Which star is the most massive?

In common circumstances for binary star systems, 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



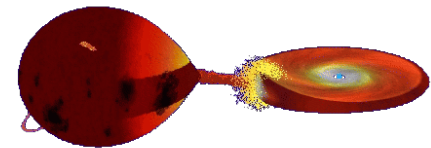
First star evolves, sheds its envelope, leaves behind a white dwarf.

Then the second star that was *originally* the less massive evolves, fills its Roche Lobe and sheds mass onto the white dwarf.

The white dwarf is a tiny moving target, the transfer stream misses the white dwarf, circles around it, collides with itself, forms a ring, and then settles inward to make a flat disk.

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

⇒ the result is an *Accretion Disk* (Chapter 4).



An accretion disk requires a transferring star for supply and a central star to give gravity, but it is essentially a separate entity with a structure and life of its own.

One Minute Exam:

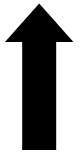
Two stars are born orbiting one another in a binary system.
Which star will transfer matter first?



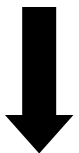
The most massive star



The least massive star



The one with the smaller Roche lobe



The one with the smaller radius

Goal – to understand how accretion disks work, what sort of radiation they emit.

Basic Disk Dynamics - Figure 4.1

