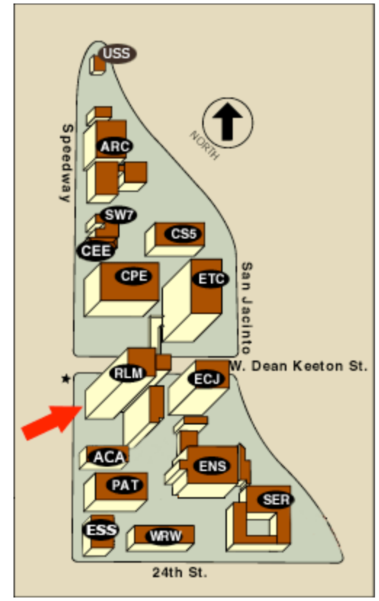
Wednesday, February 24, 2016

Exam 2, Skywatch 2, Friday, 2/26. Review sheet posted.

Review session, Thursday, 4:30 – 5:30 PM RLM 15.216B
(Backup RLM 5.124)



Office Hours today at 5

Reading for Exam 2: Sections 6.1, 6.4, 6.5, 6.6

Betelgeuse interlude

Background: Sections 1.2.1, 2.1, 2.2, 2.4, 2.5

Weather may be poor this week: Sky Watch Out!

Astronomy in the news?

How do white dwarfs get to an explosive condition?

Reading for Exam 3:

Chapter 6, end of Section 6 (binary evolution), Section 6.7 (radioactive decay), Background in Chapters 3, 4, 5.

Background: Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.8, 3.10, 4.1, 4.2, 4.3, 4.4, 5.2, 5.4 (binary stars and accretion disks).

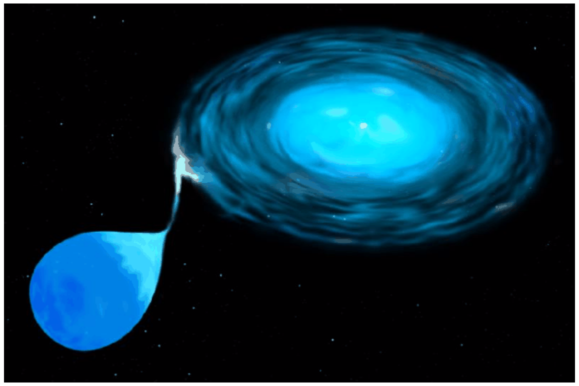
Most popular model: Type Ia are Chandrasekhar mass, 1.4 $M_\odot$, carbon/oxygen white dwarfs; many, if not all, are old.

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

No direct evidence in Type Ia explosions 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:

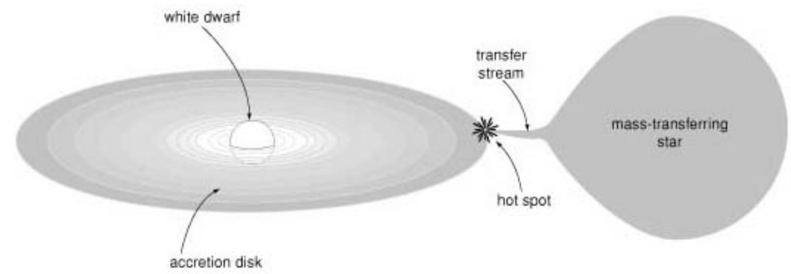


What's going on?

Goal

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

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

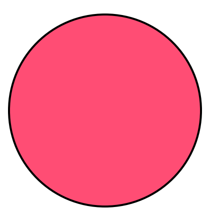
Newton: P^2 proportional to $\dfrac{a^3}{M_1 + M_2}$

Measure period and separation, deduce total mass of 2 stars: method to "weigh" the system, get total, subtract "normal" star, get weight of white dwarf, neutron star, or black hole.

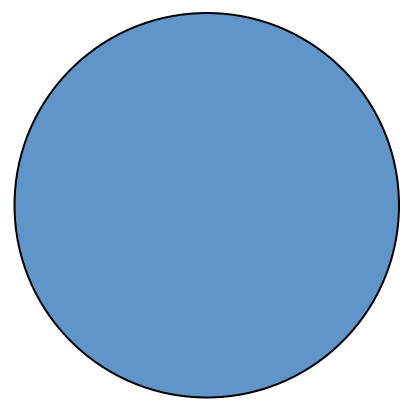
Fundamental property of stellar evolution:

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.

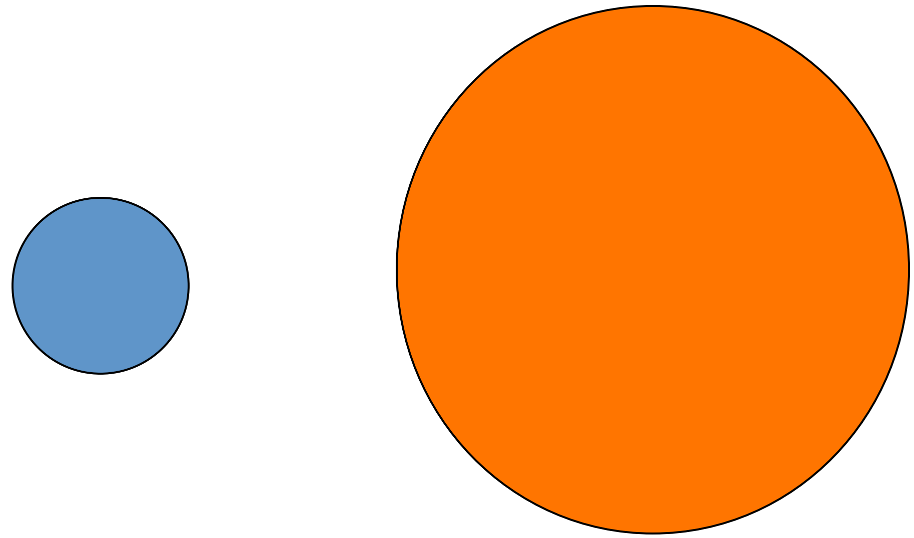


small mass, long life



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 the most massive?

Use Kepler's law to measure total mass, then other astronomy (luminosity and temperature of the 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

Discussion Point:

Explain to your neighbor why this is a dilemma.

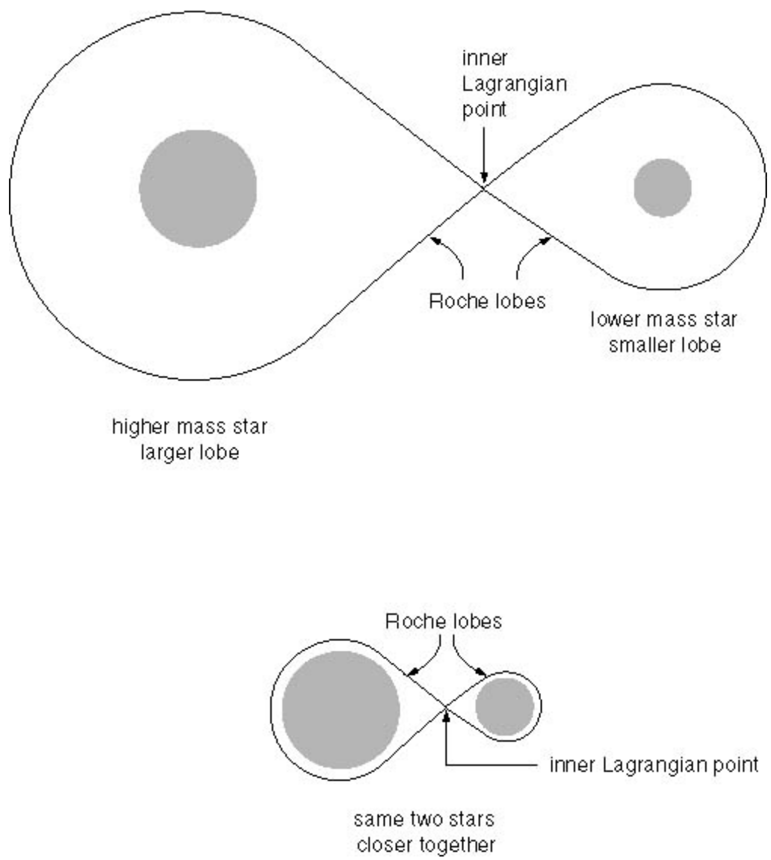
Do you remember how Kepler’s 3rd law can be used to measure the total mass of the binary system?

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.

3.1



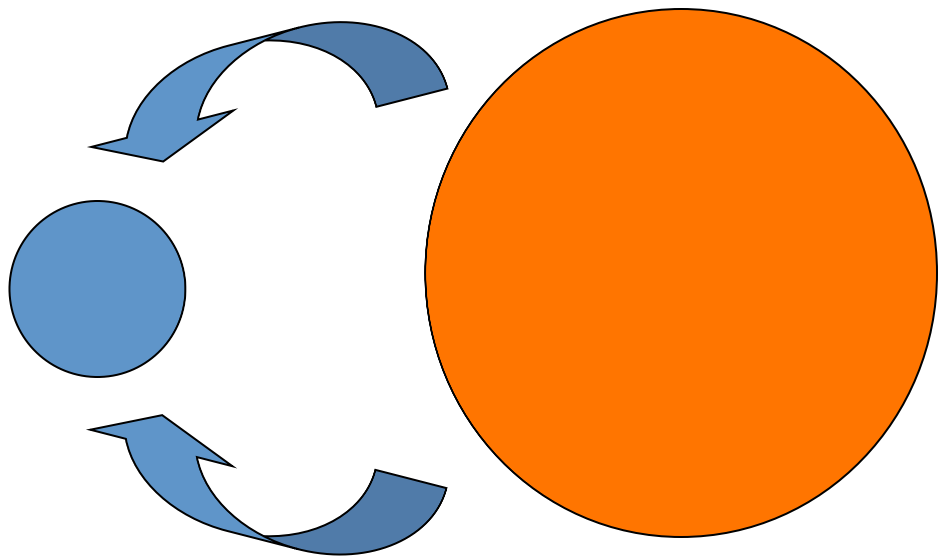
Caution: the most massive star may not have the largest radius!

Solution to Algol Paradox

Mass Transfer

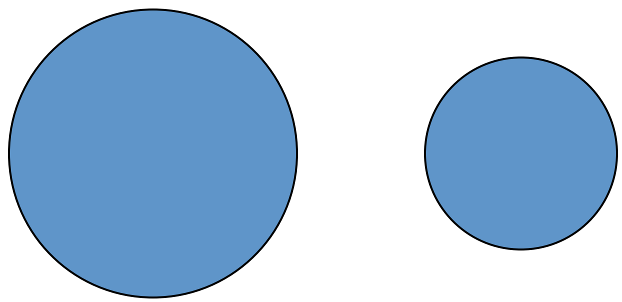
The red giant swells up, fills then overfills its Roche lobe and transfers mass to the companion.

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



One Minute Exam

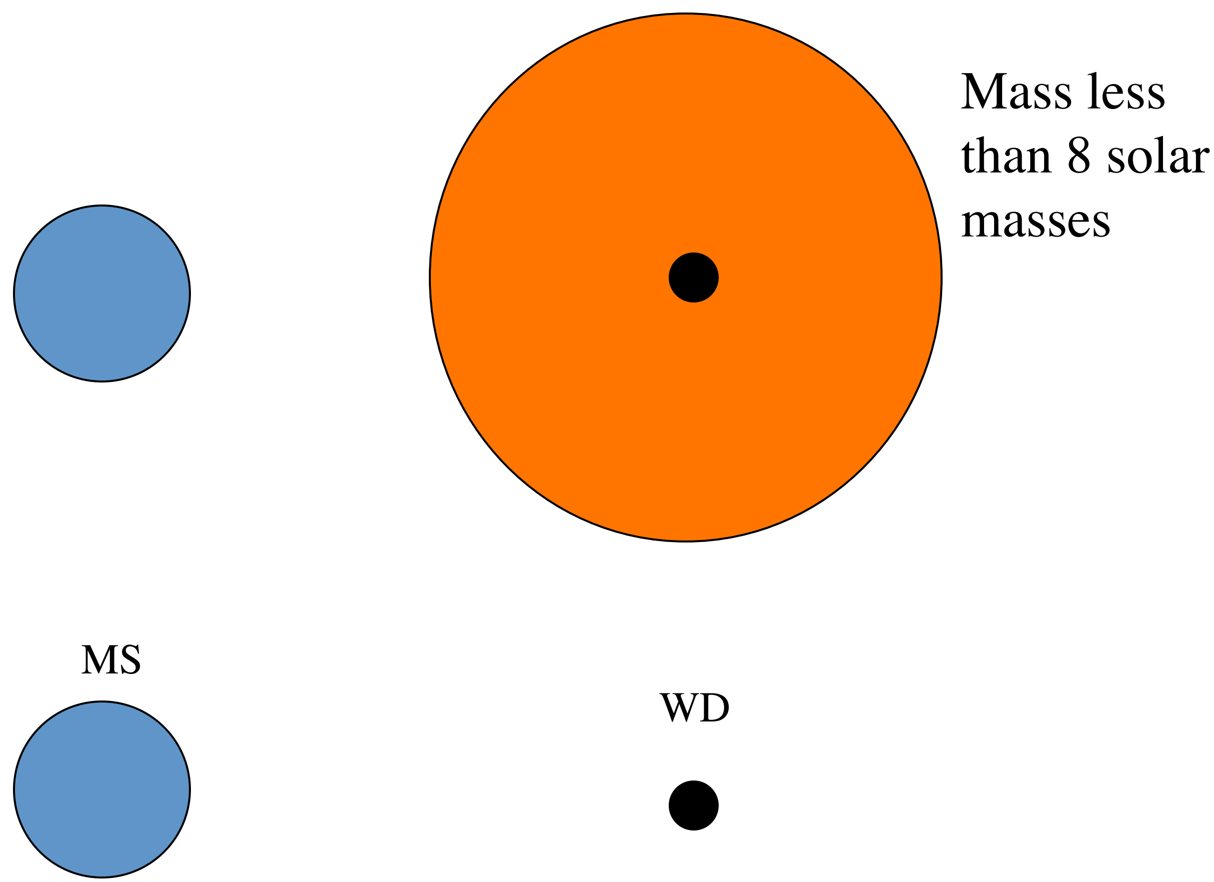
Two stars orbit one another in a binary system



Which star has the largest Roche lobe?

- the one on the left
- the one on the right
- insufficient information to answer the question

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 (if the red giant were more massive, the helium core would evolve to be a Type Ib/c).



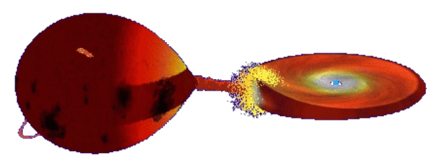
First star evolves, sheds its envelope, leaves behind a white dwarf.

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.***

$\Rightarrow$ 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.