February 23, 2011

Reading: Sections 6.6, 6.7, Betelgeuse, Sections 3.1 – 3.5, 3.10, 4.1 – 4.5.

Astronomy in the news? Space Shuttle Discovery due to launch to International Space Station tomorrow.

Happy Birthday SN 1987A! First Light, February 23, 1987.

A large fraction of visible stars are called by Arabic names. The current number of scientific papers per unit of population in the Arab world is about 2 percent of that of an industrialized country. The current turmoil should lead to a return of the Arab world to scientific productivity, in a generation.

Pic of the day: view from the center of the solar system outward by MESSENGER spacecraft.





SN 1987A first naked eye supernova since Kepler's in 1604 Happy Birthday!



### Tycho

Goal

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



## 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, Beta Perseus, second brightest star in the constellation Perseus Ancient Arabs called the star **Al-Ghul**, the Ghoul

The Hebrews knew Algol as **Rosh Ha'Satan**, Satan's Head, or perhaps **Rosh Ha'Shed**, head of the devil or of a genie.

The Chinese called it **Tseih She**, the Piled-up Corpses

In Greek mythology, Algol is the head of the Gorgon Medusa that Perseus carries under his left arm.

Algol

Find Algol for your Sky Watch Project.



*Algol paradox*: Algol is a binary (actually triple) 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 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

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!

same two stars closer together

# 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*.

 $\Rightarrow$  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.

One Minute Exam:

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





The one with the smaller Roche lobe



The one with the smaller radius