Monday, March 17, 2014

Reading for Exam 3: End of Section 6.6 (Type Ia binary evolution), 6.7 (radioactive decay), Chapter 7 (SN 1987A), Chapter 8 (Neutron Stars) - Sections 8.1, 8.2, 8.5, 8.6, 8.10

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

Astronomy in the news:

Friday was pi-day 3/14, also Einstein's birthday.

New Cosmos Series – cosmic calendar, evolution so far.

News conference at Harvard this morning, right now, may announce detection of polarization of cosmic microwave background radiation, a strong indirect measurement of gravitational waves generated in the Big Bang; a potential Nobel Prize.

Update on new “nearby” supernova SN 2014J in M82

Nothing to report

Goal

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

Goal

To understand how accretion disks shine and cause matter to accrete onto the central star.

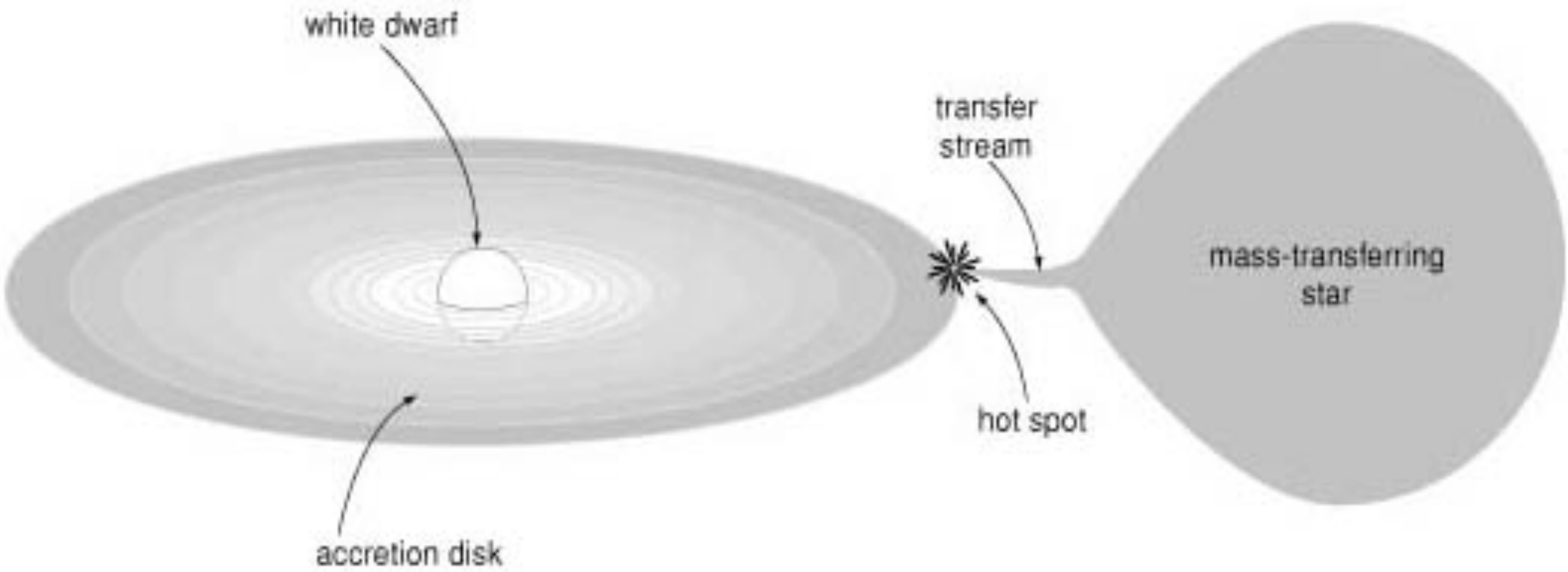
Goal

To understand how nature may grow white dwarfs to the Chandrasekhar mass.

Cataclysmic Variables

Second stage of mass transfer (Section 5.2)
General Category "Novae"
"New" stars flare up, see where none had been seen before.

All CVs share same general features: ***transferring star***, ***transfer stream***, ***hot spot***, ***accretion disk***, and ***white dwarf***.



§ 5.4 Final Evolution of Cataclysmic Variables

Some CVs have managed to reach large white dwarf masses
$M_{wd} \sim M_{ch}$ Chandrasekhar mass, 1.4 solar masses, like U Sco, RS Oph

If get close enough to M_{ch}, attain high density,
ignite carbon in center
Quantum Deregulated → violent explosion
Type Ia Supernova?!

What CVs have white dwarfs that reach M_{ch}?

Classical Novae:

Infrequent outbursts, powerful explosions on the surface of a white dwarf.

Not a supernova, the white dwarf survives.
Explosion of surface H shell also rips off a bit of the white dwarf mass - we see excess carbon & oxygen in ejected matter
white dwarf shrinks in mass rather than growing to the Chandrasekhar Limit.

Binary systems that have classical nova explosions seem unable to proceed to Type Ia supernova explosions.

Likely outcome in this case - 2nd star finally burns out H, tries to form red giant, mass transfer, mass loss from binary **=>** ***Two WDs!***

If the first white dwarf formed does not explode, the other star will make a white dwarf, so will have two white dwarfs orbiting one another (details to follow).

Recurrent Novae like U Sco, RS Oph:

More frequent outbursts, less disruptive explosions than classical novae on the surface of a white dwarf.

Recurrent nova systems do seem to have large mass white dwarfs that are gaining mass.

Encouraging, but maybe not enough of them to account for the rate of explosions of Type Ia supernovae.

Exactly what kind of binary system gives rise to Type Ia supernovae is not yet known.

One Minute Exam

We expect classical nova systems to end up making two white dwarfs orbiting one another because:

➡ The first white dwarf loses mass and hence cannot grow and explode

⬅ The first white dwarf will accrete mass until it reaches the Chandrasekhar limit

⬆ The main sequence star transferring mass must eventually make a white dwarf

⬇ The second white dwarf has the Chandrasekhar mass

Classical Novae:

Binary systems that have nova explosions seem unable to proceed to Type Ia supernova explosions.

Eventually, the other star will make a white dwarf, so will have two white dwarfs orbiting one another.

We observe binary systems with two white dwarfs, so we know nature makes them somehow.

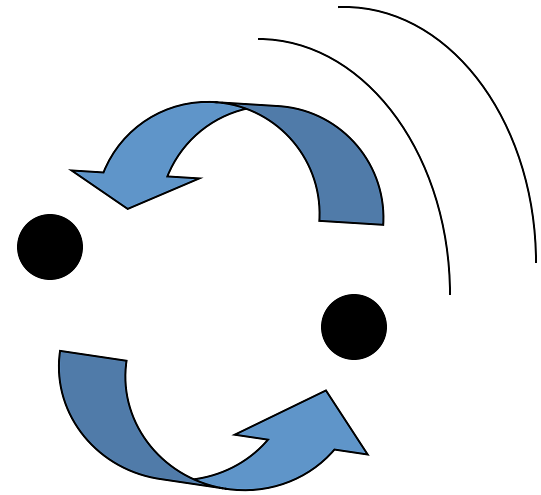
Goal – to understand what happens to two white dwarfs in a binary system.

We do observe 2 white dwarfs in orbit in some cases - is that the end?

No: ***gravitational radiation*** (§ 3.10)

ripples in curved space-time

like paddle on surface of pond



remove energy from orbit - acts as drag

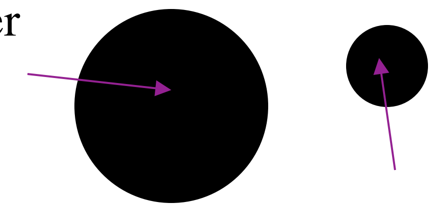
If you try to slow down an orbiting object what happens?

Falls inward, speeds up,
Get more gravitational radiation, more inspiral

Given enough time (billions of years) 2 white dwarfs must spiral together!

What happens when two white dwarfs spiral together?

New physical fact:
Larger mass WD has smaller radius



Which WD has the smaller Roche lobe?

What happens to the Roche lobes as the WDs spiral closer by gravitational radiation?

Which fills its Roche Lobe first?

When that WD fills its Roche lobe, what happens to its radius?

When that WD fills its Roche lobe, what happens to its Roche lobe?

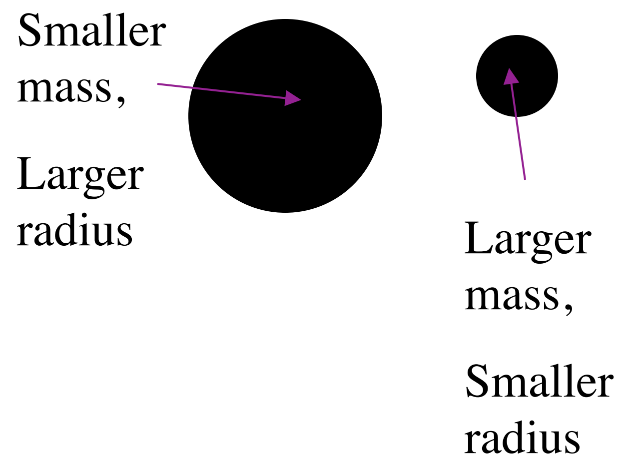
What happens to the white dwarf?

What happens when two white dwarfs spiral together?

Which WD has the smaller Roche lobe?

The smaller mass

What happens to the Roche lobes as the WDs spiral closer by gravitational radiation?



They both get smaller

Which fills its Roche Lobe first?

Must be the smaller mass

As small mass WD loses mass, its ***radius gets larger***,
but its ***Roche Lobe gets smaller***! Runaway mass transfer.

Small mass WD transfers essentially all its mass to larger mass WD

Could end up with one larger mass WD

If larger mass hits $M_{ch} \rightarrow$ could get explosion => Supernova