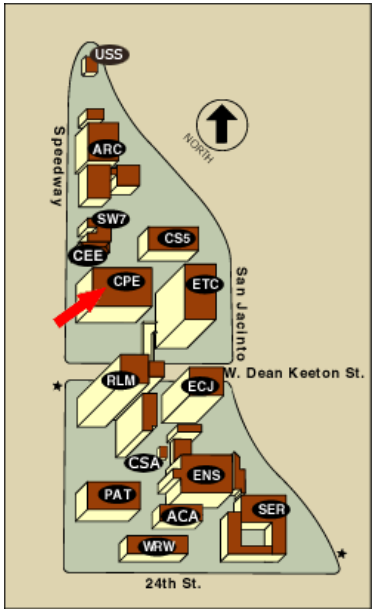
Wednesday, February 22, 2012

Exam 2 on Friday. Review sheet posted.

Review session, Thursday, 5 – 6 pm, CPE 2.214

Second Sky Watch due Friday.

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?

News:

Tomorrow, February 23, is the 25th anniversary of the discovery of Supernova 1987A, to be covered in Chapter 7.

Goal – to understand how white dwarfs in binary star systems can, and cannot, grow to the Chandrasekar mass and explode.

Classical Novae:

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

Not a supernova, the white dwarf survives.

Problem with losing mass from white dwarf during surface explosions. White dwarf shrinks in mass rather than growing to the Chandrasekhar limit.

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 (details to follow, and to be on third exam).

Recurrent Novae like USco:

More frequent outbursts, less disruptive explosions 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.

Sky Watch

Classical Novae:

CP Pup, toward constellation Puppis in 1942

Pup 91, another toward Puppis in 1991 (not same place in our Galaxy, just accidently off in the same approximate direction)

QU Vul, toward constellation Vulpecula, white dwarf composed of Oxygen, Neon, and Magnesium rather than Carbon and Oxygen.

GK Per toward constellation Perseus - has had both a classical nova eruption in 1901 and dwarf nova eruptions.

Sky Watch

Recurrent Novae:

U Sco in the constellation Scorpius is a Recurrent Nova,
It may be a candidate to explode as a supernova!

Might see Scorpius. Also has neutron stars and black holes.

T Pyx in constellation Pyxis.

RS Oph in constellation Ophiucus

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

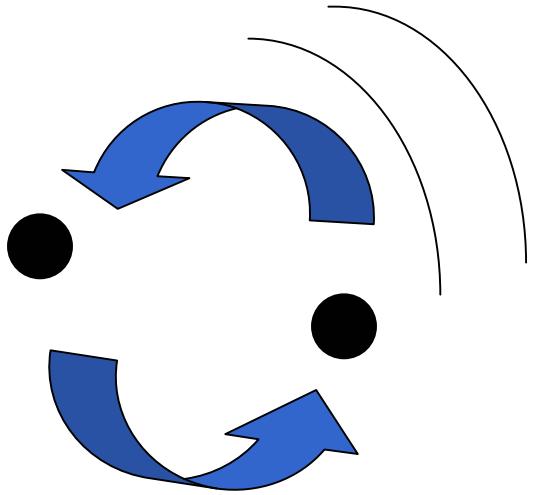
The second white dwarf has the Chandrasekhar mass

End of Material for Exam 2

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?

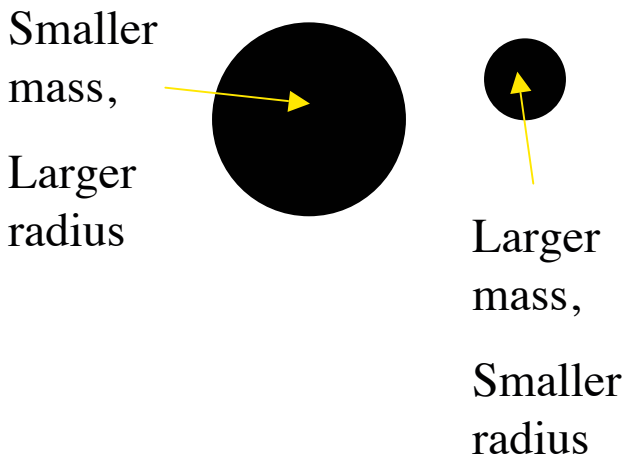
What happens to the Roche lobes as the WDs spiral closer by gravitational radiation?

Which fills its Roche Lobe first?

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

When the first 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?

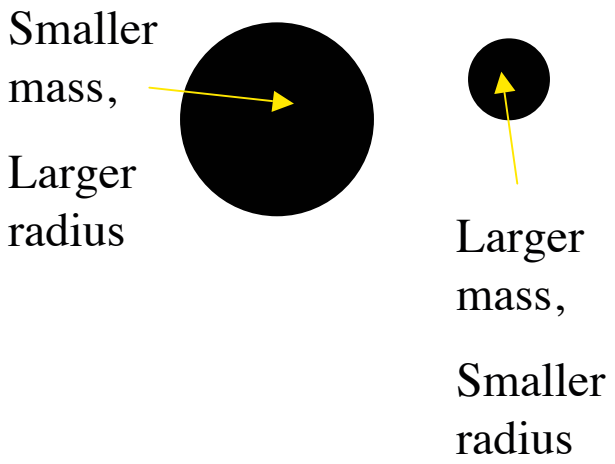
The smaller mass

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} → could get explosion => Supernova

Bottom line:

There are two plausible ways in which a binary star system can lead to a Type Ia supernova:

1)The first white dwarf to form, from the originally most massive star, grows to very near the Chandrasekhar mass, ignites carbon and explodes while the other star is still transferring mass. My preferred explanation, but not firmly proven.

2)Two white dwarfs form, spiral together, the least massive one is torn apart when it fills its Roche lobe and the most massive one grows to near the Chandrasekhar mass, ignites carbon and explodes.

Astronomers are trying to determine which (if either) works.

One Minute Exam

In a binary white dwarf system, the smaller mass white dwarf is destroyed because:

It has the larger Roche lobe

Gravitational radiation pulls it apart

As it loses mass, more mass loss is induced

Carbon ignites it its center