February 28, 2011

Second exam Friday. Review sheet posted. Review 5 PM Thursday, room TBD.

Second Sky Watch due.

Reading: Sections 6.4 - 6.7, Betelgeuse, Section 1.2, Chapter 2, Sections 3.1 - 3.5, 3.10, 4.1 - 4.5.

Astronomy in the news? Space Shuttle launch from above, courtesy Joseph Triola.

Pic of the day: Full Snow Moon over Edmonton, Canada.



Goal – to understand how white dwarfs in binary star systems can, and cannot, grow to the Chandrasekar mass and explode. Classical Novae: infrequent, powerful explosions on surface of white dwarf. Problem with losing mass from white dwarf during surface explosions.

Recurrent Novae like USco: more frequent, less disruptive explosions on the surface of a white dwarf. Do seem to have large mass white dwarfs, encouraging, but maybe not enough of them to account for the rate of explosions of Type Ia supernovae. 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 Larger WDs spiral closer by gravitational radiation? ^{radius}

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



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.

Goal - to understand what makes supernovae shine.

Light Curves

Why is the light curve different for Type II?

Why is the light curve similar for Type Ia, Ib. Ic?

Why are Type Ia brighter than Type Ib, Ic?



Light Curves

Ejected matter must expand and dilute before m_{m}^{u} photons can stream out and supernova becomes bright: *must expand to radius* ~ 100 × Earth or bit



Maximum light output ~ 2 weeks after explosion

Type II in red giants have head start, radius already about the size of Earth's orbit; light on plateau comes from *heat of original explosion*

Ejected matter cools as it expands: for white dwarf (Type Ia) or bare core (Type Ib, Ic) tiny radius about the size of Earth, must expand huge factor > 1,000,000 before sufficiently transparent to radiate. *All heat of explosion is dissipated in the expansion By time they are transparent enough to radiate, there is no original heat left to radiate*

Need another source of energy for Type I a, b, c to shine at all!