February 24, 2010

Second exam, Friday. **33 Questions.** Review Sheet Posted. Review Session Tomorrow, Room WEL 2.312. (NOT RLM 15.216B) 5:00 - 6:00 PM.

Reading, Sections 6.4, 6.5, 6.6, 6.7 (background: Sections 1.2, 2.1, 2.4, 2.5, 3.3, 3.4, 3.5, 3.10, 4.1, 4.2, 4.3, 4.4, 5.2, 5.4

Astronomy in the News? 23rd Anniversary of SN 1987A today. Nova Scorpii 2010 just went off.

Pic of the Day - Checking out the observing cupola on new Tranquility module.

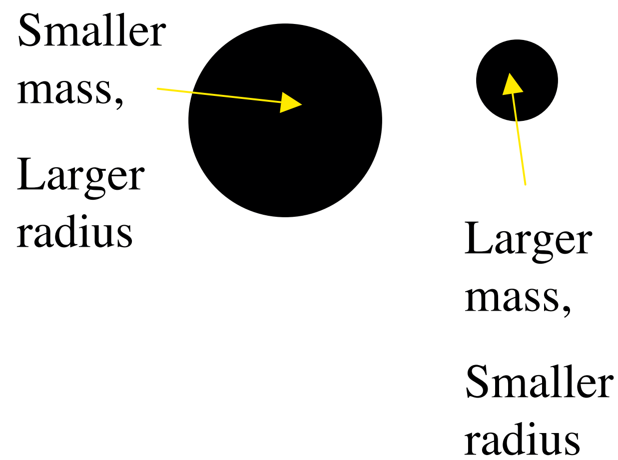
Goal - understand how white dwarfs in binary star systems can, and cannot grow to the Chandrasekar mass and explode.

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

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

New research reported in Nature last week claims there are no -X-rays from elliptical galaxies that would represent white dwarfs preparing to explode as Type Ia supernovae.

Accreting mass through an accretion disk in a binary system to make a Type Ia supernovae should make some X-rays.

Before two white dwarfs merge there should be no X-rays,

Therefore, Type Ia supernovae in elliptical galaxies come from binary white dwarf mergers!?

Maybe….

Determining how nature produces Chandrasekhar mass carbon/oxygen white dwarfs that explode as Type Ia supernovae remains a major challenge.

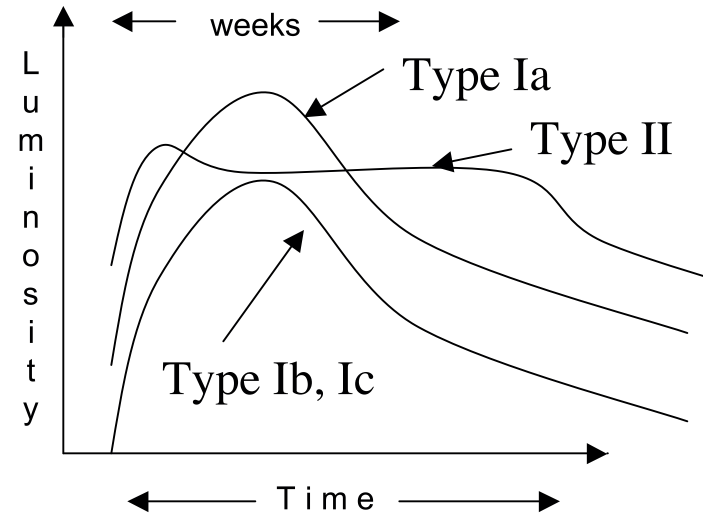
Goal - to understand what makes supernovae shine.

Light Curves

Why is the light curve different for Type II?

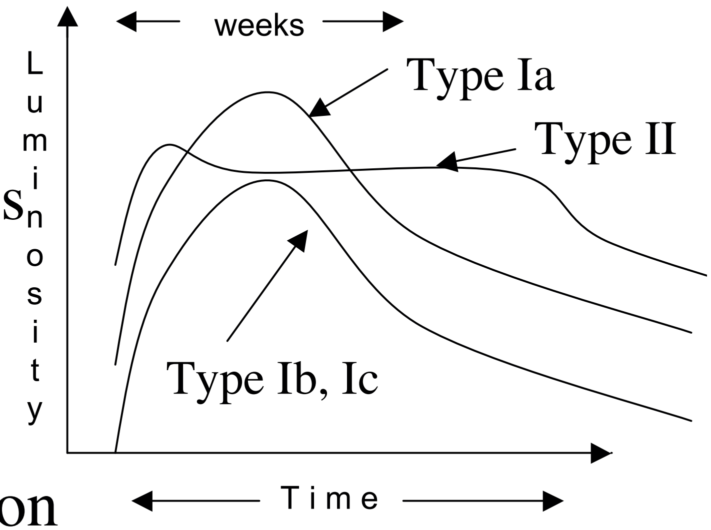
Why is the light curve similar for Type Ia, Ib. Ic?

Why are Type Ia brighter than Type Ib, Ic?



Light Curves

Ejected matter must expand and dilute before photons can stream out and supernova becomes bright: ***must expand to radius ~ 100 × Earth orbit***



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!

Type Ia start with C, O: number of protons equal to number of neutrons (built from helium building blocks)

Iron has 26p 30n ***not equal***

C, O burn too fast (~1 sec) for weak nuclear force to convert p to n (§1.2.1)

Similar argument for Type Ib, Ic, core collapse. Shock wave hits silicon layer with #p = #n, burns too quickly for weak nuclear force to convert p to n.

Fast explosion of C/O in Type Ia, shock hitting layer of Si in Type Ib, Ic make element closest to iron (same total p + n) with #p = #n

Nickel-56: 28p 28n total 56 -- Iron-56: 26p 30n total 56

Ni-56 is unstable to radioactive decay

Nature wants to produce iron at bottom of nuclear "valley"
decay caused by (slow) weak force p $\rightarrow$ n

Nickel -56	γ-rays heat $\rightarrow$	Cobalt-56	γ-rays heat $\rightarrow$	Iron-56
28p	"half-life"	27p	"half-life"	26p
28n	6.1 days	29n	77 d	30n

Secondary heat from γ-rays makes Type I a, b, c shine

Type Ia are brighter than Type Ib and Ic because they produce more nickel-56 in the original explosion.

The thermonuclear burning of C and O in a white dwarf makes about 0.5 - 0.7 solar masses of nickel-56.

A core collapse explosion that blasts the silicon layer makes about 0.1 solar masses of nickel-56.

Type II also produce about 0.1 solar mass of nickel-56, but the explosion energy radiated from the red giant envelope in the plateau tends to be brighter. After the envelope has expanded and dissipated, the remaining radioactive decay is seen.

One Minute Exam

Type Ic supernovae are usually dimmer than Type Ia supernovae because:

➡ Type Ic form neutron stars

⬅ Type Ic have no hydrogen or helium

⬆ Type Ic have binary companions

⬇ Type Ic produce less nickle-56

End of Material for Exam 2

Kepler

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

Tycho