2/27/06

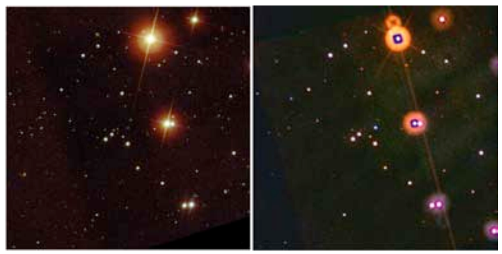
Exam 2, Chapter 6, this Friday March 3, review sheet posted today review Thursday, 5 PM RLM 4.102

100 Books - Shipped tomorrow??

Chapter 6 posted - revised, updated for second edition

News?

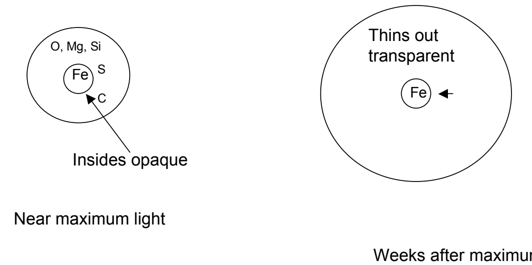
Pic of the day - GRB060218/SN2006aj



Type II (Ib, Ic) energy from falling, gravity, Type Ia energy from thermonuclear explosion. About the same energy, that required to explode a core with the mass of the Sun, radius of the Earth.

Type Ia - many, if not all, are old ⇒ only credible idea is to grow a white dwarf by mass transfer in a binary system.

Type Ia - see O, Mg, Si, S, Ca early on, iron later => iron inside



Models based on Chandrasekhar-mass C/O white dwarfs give observed composition structure!

Large quantum pressure -- high density and temperature overcome charge repulsion - very unregulated - ignite Carbon ⇒ runaway ⇒total explosion, no neutron star or black hole.

Models give thorough burning to iron on inside, only partial burning of C and O leaving O, Mg, Si, S, Ca in outer layers.

Two stages to explosion:

Deflagration - slower than speed of sound, like a flame

Detonation - supersonic shockwave, faster than the speed of sound - like a stick of dynamite

All data, UV, optical, IR are consistent with this picture

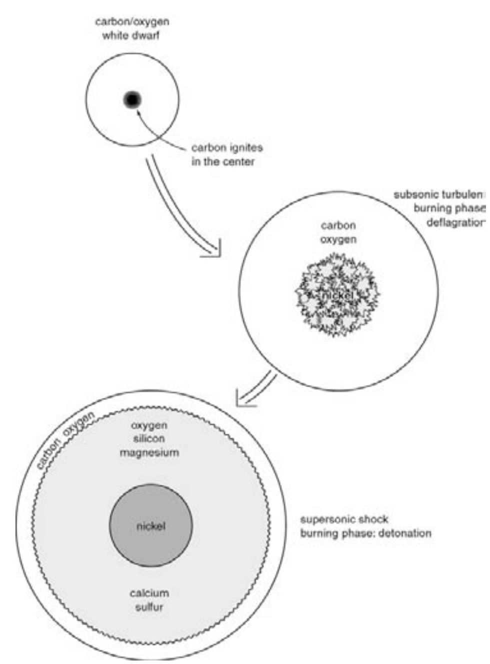


Figure 6.4

One Minute Exam

Astronomers detect Silicon when a Type Ia supernova is brightest and iron after it has faded. This means:

A) The exploded material is made of equal part silicon and iron

B) The white dwarf that exploded could not be made of carbon and oxygen

C) The iron is in the inner portions of the ejected matter, the silicon in the outer portions

D) The supernovae was powered by the collapse of an iron core

Type Ia ***are*** Chandrasekhar mass carbon/oxygen white dwarfs

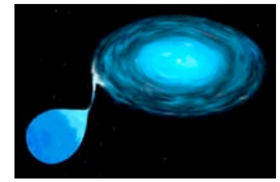
How does nature grow a white dwarf to 1.4 $M_\odot$?

Classical Novae: Problem with losing mass from white dwarf

Recurrent Novae: do seem to have large mass white dwarfs, encouraging.

Probably a binary, everyone assumes so.

No direct evidence, some recent indirect hints.



Hint from polarization - not quite round -- *why?*

Need ~ 1 SN Ia per 300 years in Galaxy like Milky Way

Recurrent Novae → how to get to 1.3 solar masses, as seen currently in U Sco?

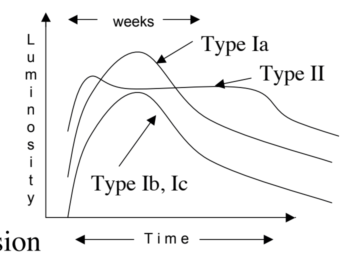
Are there enough recurrent novae to give one explosion per 300 years?

Super Soft X-ray Sources - red giant transferring to white dwarf fast enough to keep H hot, thermal pressure, regulated burning, H → He → C/0 on outside, add carbon and oxygen to the white dwarf, the white dwarf will grow.
Enough? Recent computer studies → yes?

Binary white dwarfs, gravitational radiation, spiral together
Enough? Make some, not all, Type Ia?

Light Curves

Ejected matter must expand and dilute before photons can stream out, 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 ~ Earth's orbit light on plateau comes from *heat of explosion*

Ejected matter cools as it expands: for white dwarf (Type Ia) or bare core (Type Ib, Ic) tiny radius ~ 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

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 <u>total 56</u> -- Iron-56: 26p 30n <u>total 56</u>

Ni-56 is unstable to radioactive decay

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

Nickel -56	γ-rays heat →	Cobalt-56	γ-rays heat →	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 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.

End of Material for Test 2