3/21/05

Second Exam - returned

News? Yesterday first day of Spring!

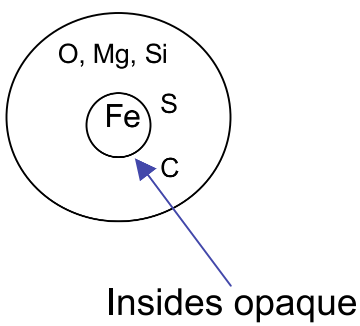
Pic of the day

Horsehead Nebula

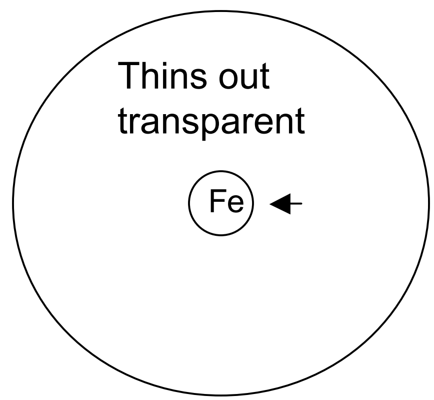
Type Ia - many, if not all, old ⇒ only credible idea is to rejuvenate a white dwarf.

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 see O, Mg, Si, S, Ca early on, Iron later => iron inside



near maximum light



Weeks after maximum

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 $\Rightarrow$ runaway $\Rightarrow$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.

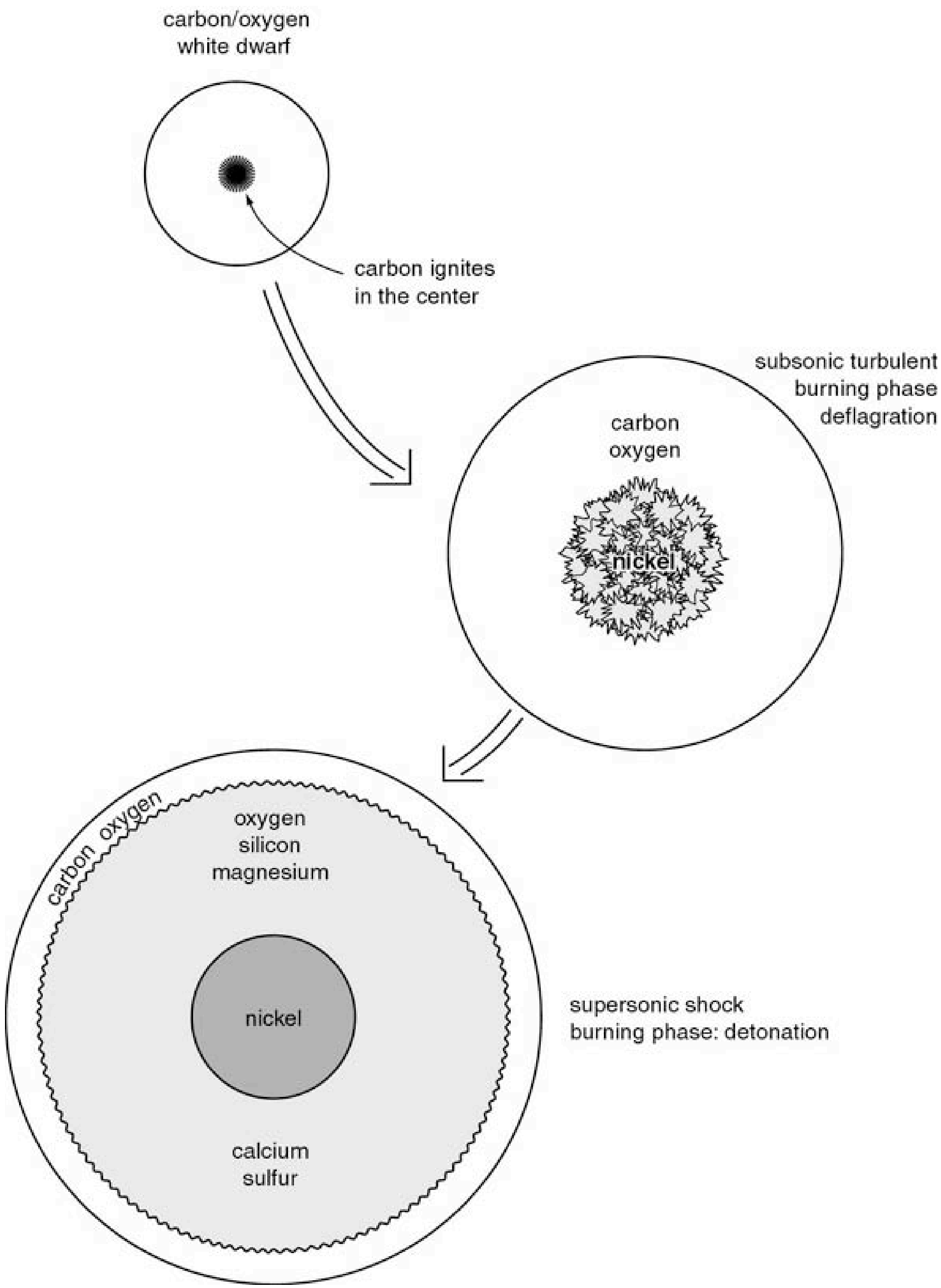
Two stages to explosion:

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


carbon/oxygen
white dwarf
carbon ignites
in the center
subsonic turbulent
burning phase
deflagration
carbon
oxygen
nickel
carbon oxygen
oxygen
silicon
magnesium
nickel
calcium
sulfur
supersonic shock
burning phase: detonation

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

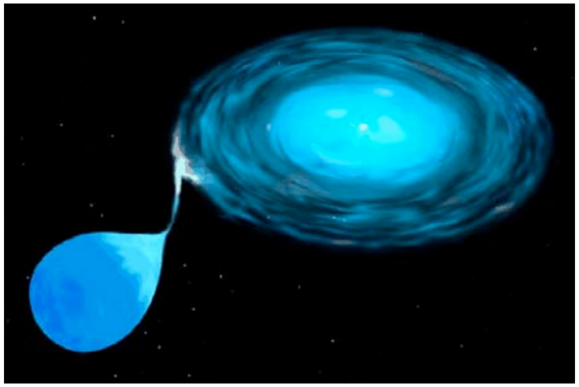
How does nature grow a white dwarf to 1.4 $M_\odot$?

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 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?

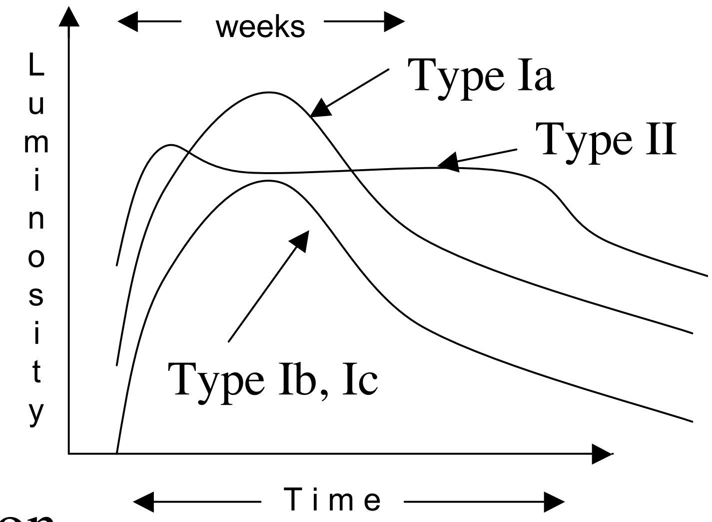
Super Soft X-ray Sources - red giant transferring to white dwarf fast enough to keep H hot, thermal pressure, regulated burning, H → He → C/0 on outside, add carbon and oxygen to the white dwarf, the white dwarf will grow.

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 *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 dissipated in 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 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 weak force p $\rightarrow$ n

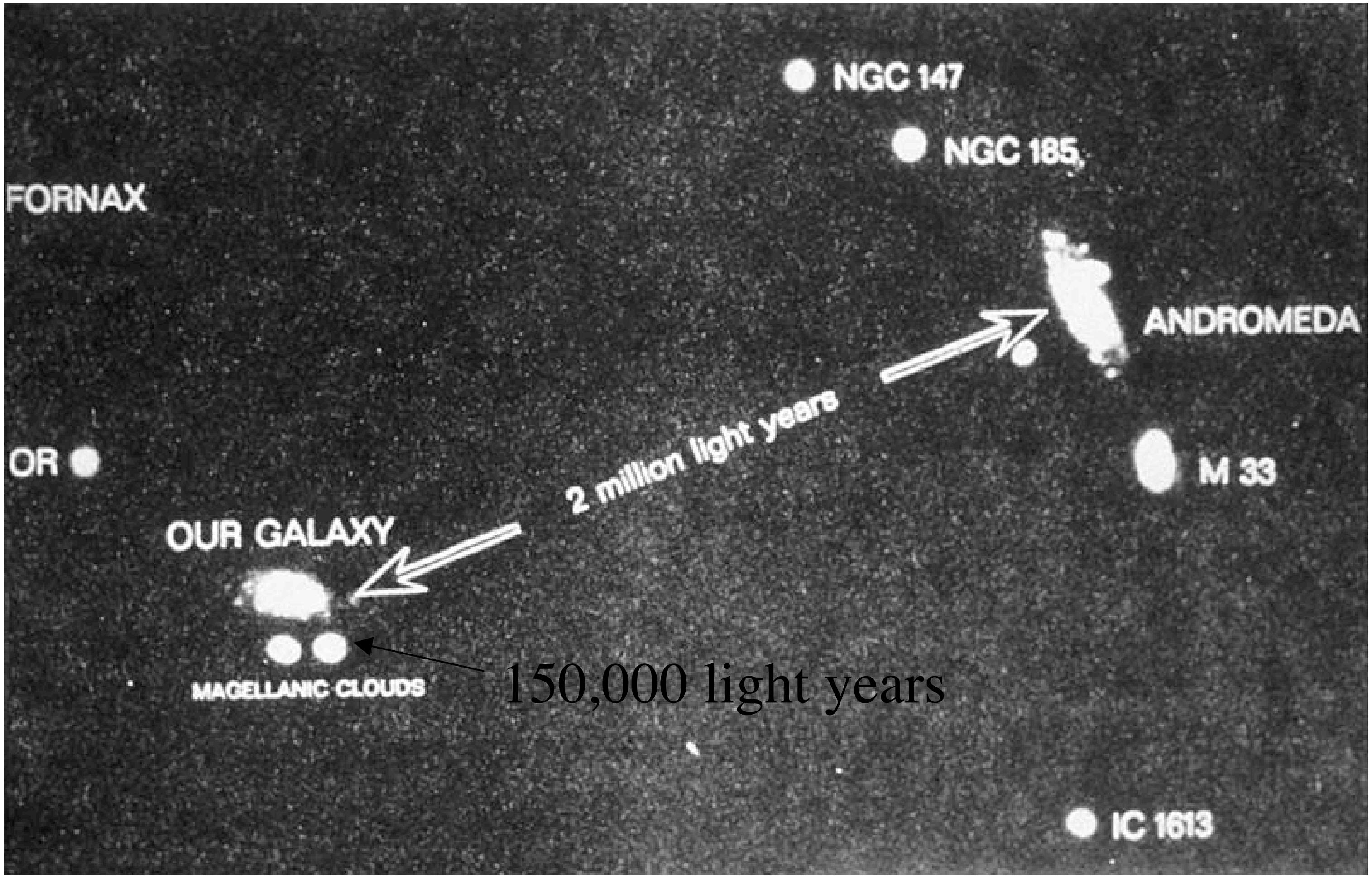
Nickel -56	γ-rays heat →	Cobalt-56	γ-rays heat →	Iron-56
28p	"half-life"	27p	"half-life"	26p
28n	6.1 days	29n	77 d	30n

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

Kepler

Tycho

Local group


NGC 147
NGC 185
FORNAX
ANDROMEDA
2 million light years
OR
M 33
OUR GALAXY
MAGELLANIC CLOUDS
150,000 light years
IC 1613