2/20/08

Astronomy in the news? Full lunar eclipse tonight - but clouds?

Special lecture, “The Possibility of Life Elsewhere in the Universe”
TONIGHT, Feb 20, 7:30 PM Welch 2.224

2 points extra credit on exam 2 for attendance, Pick up chit from Sean Couch after the lecture, turn it in Friday.

Pic of the Day - long exposure
of lunar eclipse

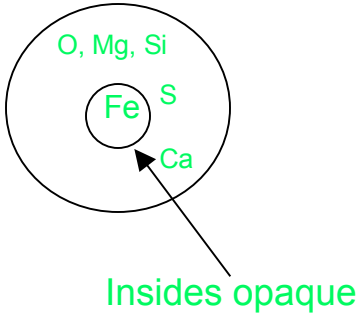
Back to physics of Type Ia Supernovae - exploding white dwarfs

Chapter 6, Section 6 in Cosmic Catastrophes

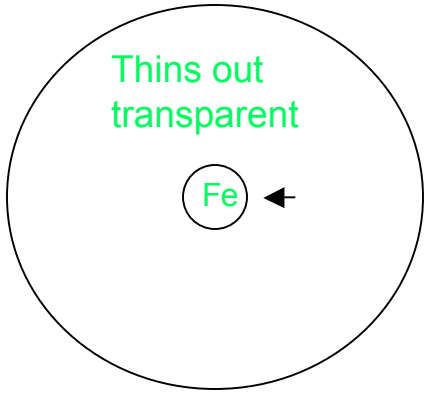
Type II (Ib, Ic) energy from falling, gravity, Type Ia energy from thermonuclear explosion. About the same energy, that required to explode a core with the mass of the Sun, radius of the Earth.

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



Near maximum light



Weeks after maximum

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

Large quantum pressure deep inside the white dwarf -- 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, X-ray are consistent with this picture

Detonations do not give the star time to react.

⇒For ***detonation alone***, the white dwarf would be turned essentially entirely to iron, *Wrong!*

Deflagrations give the outer parts of the white dwarf time to expand, quench burning.

⇒For ***deflagration alone***, the outer parts are never burned, explosion would be relatively weak, substantial unburned carbon and oxygen must be expelled.

Careful observation in the ***infrared*** show no carbon, so ***Wrong!***

⇒For deflagration followed by detonation, the detonation catches up with the expanding outer parts, burns everything, gives the right energy, predicts essentially no unburned carbon and oxygen.
Matches wide variety of observations!

Physics problem - why does the deflagration change to detonation?

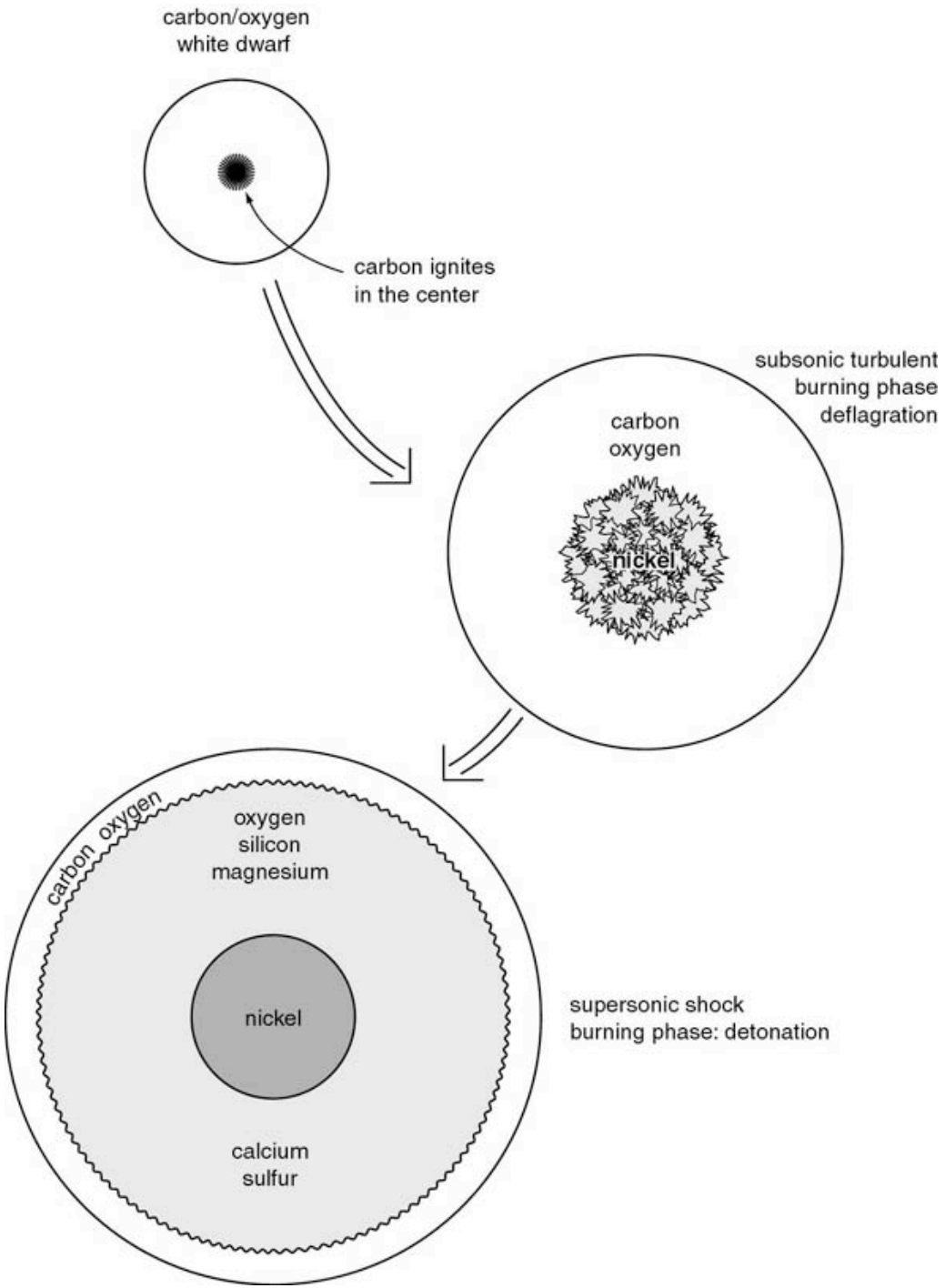

carbon/oxygen
white dwarf
carbon ignites
in the center
subsonic turbulent
burning phase
deflagration
carbon
oxygen
nickel
carbon oxygen
oxygen
silicon
magnesium
nickel
calcium
sulfur
supersonic shock
burning phase: detonation

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 parts 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

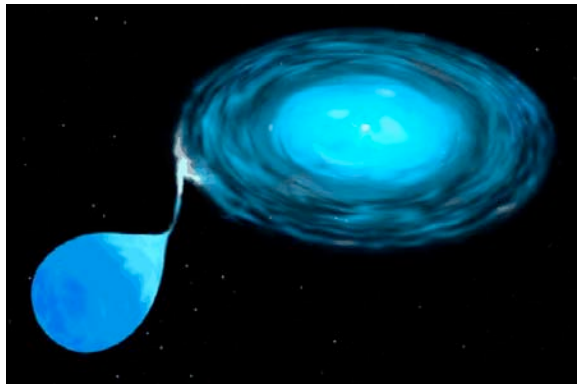
How does nature grow a white dwarf to 1.4 $M_{\odot}$?

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?*

One Minute Exam

Why does a subsonic deflagration “flame” alone fail to account for the observations of a Type Ia supernova?

A) All the ejected matter would be iron.

B) A neutron star would be left behind.

C) The ejected matter would contain lots of carbon

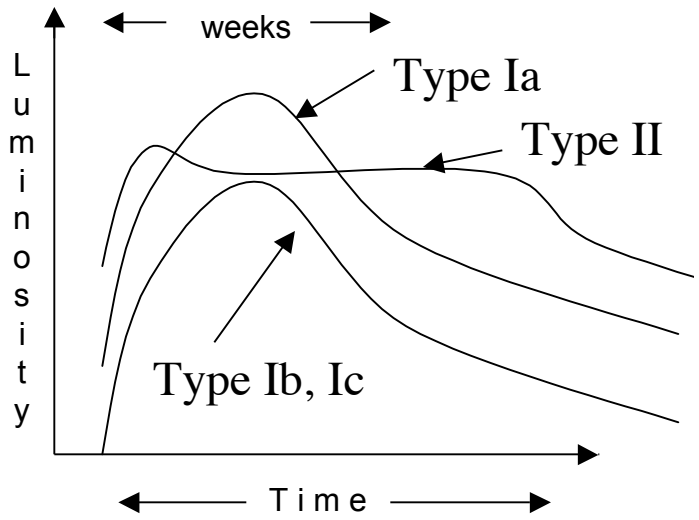
D) The ejected matter would have silicon on the outside and iron on the inside

Light Curves

Why is the light curve different for Type II?

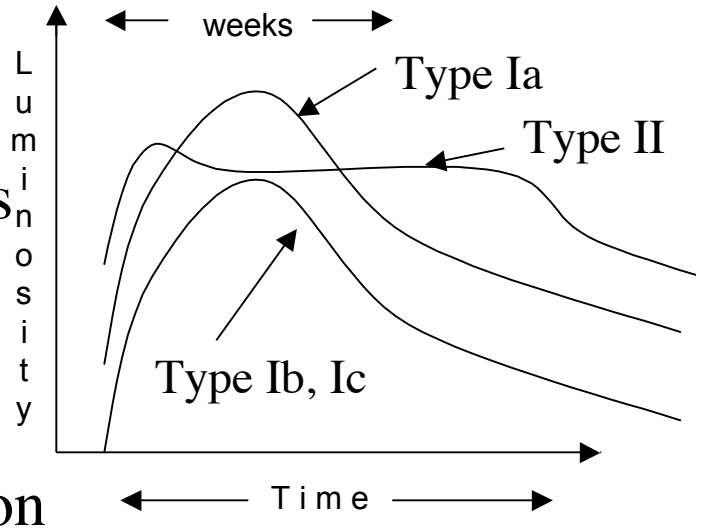
Why is the light curve similar for Type Ia, Ib. Ic?

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!