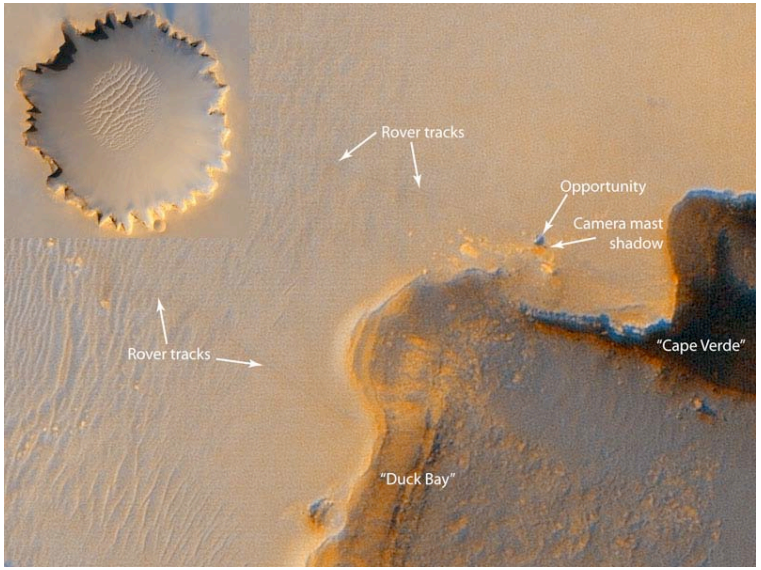
10/9/06

Exam 2, Chapters 6, 7, Friday, October 20

Chapters 6, 7 posted - revised, updated for second edition

News? North Korea detonates a nuclear bomb.

Pic of the day - Opportunity on Mars



Back to physics of Type Ia Supernovae - exploding white dwarfs

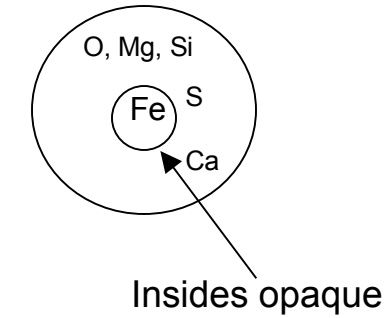
Chapter 6, Section 5 in Cosmic Catastrophes

Section 6 in Second Edition

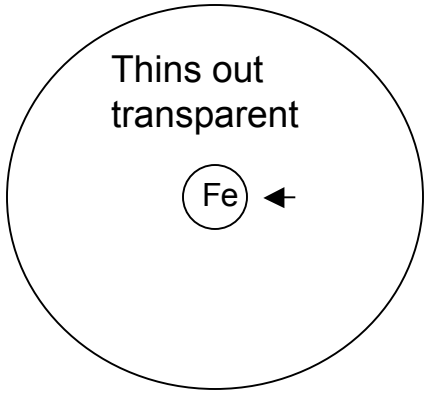
Type II (Ib, Ic) energy from falling, gravity, Type Ia energy from thermonuclear explosion. About the same energy, that required to explode a core with the mass of the Sun, radius of the Earth.

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 -- 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

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?

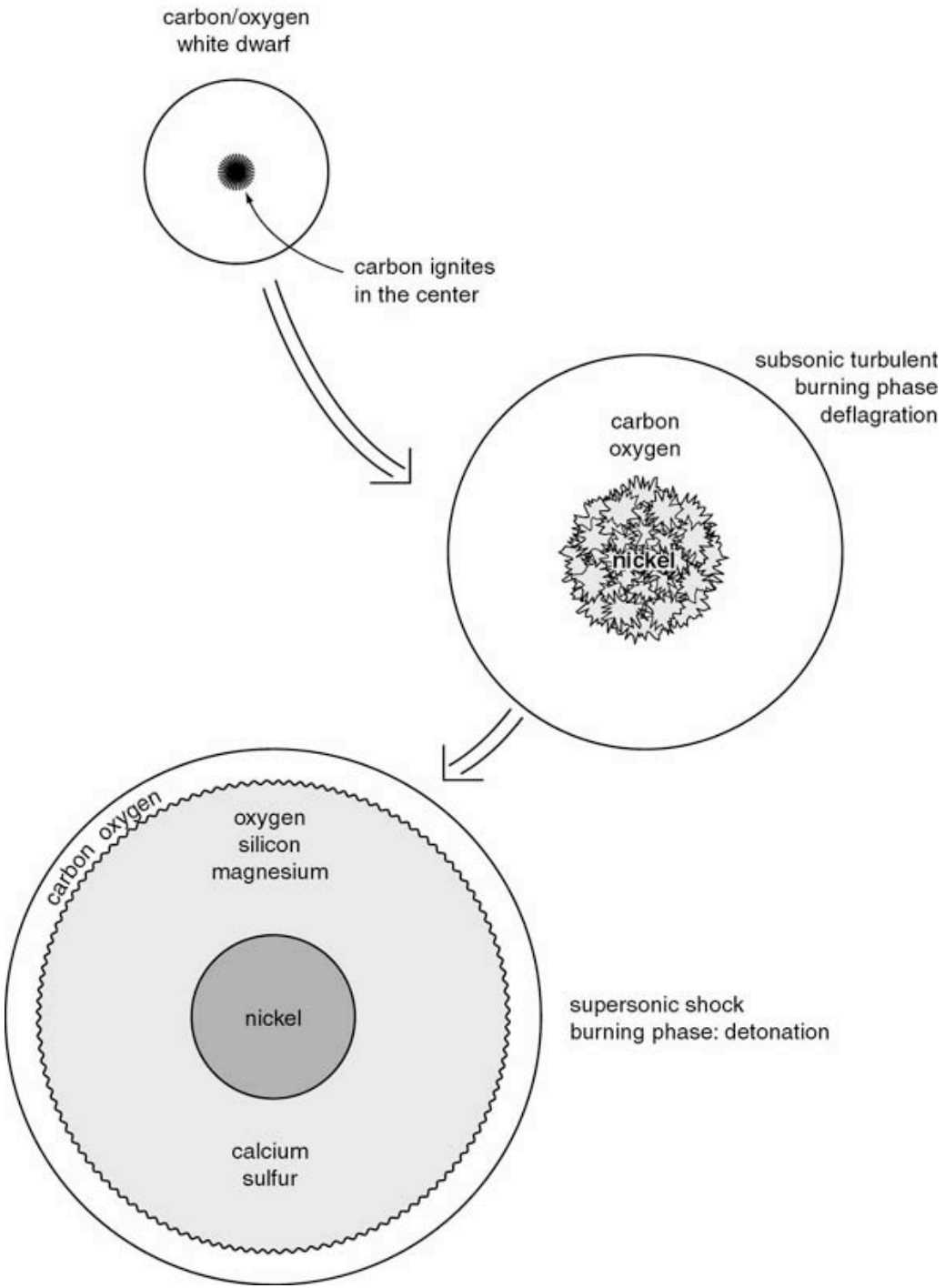

carbon/oxygen
white dwarf
carbon ignites
in the center
subsonic turbulent
burning phase
deflagration
carbon
oxygen
nickel
carbon oxygen
oxygen
silicon
magnesium
nickel
calcium
sulfur
supersonic shock
burning phase: detonation

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

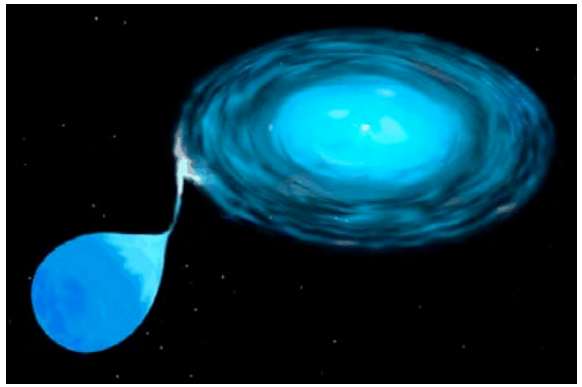
How does nature grow a white dwarf to 1.4 $M_{\odot}$?

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?*

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?