Monday, February 24, 2014

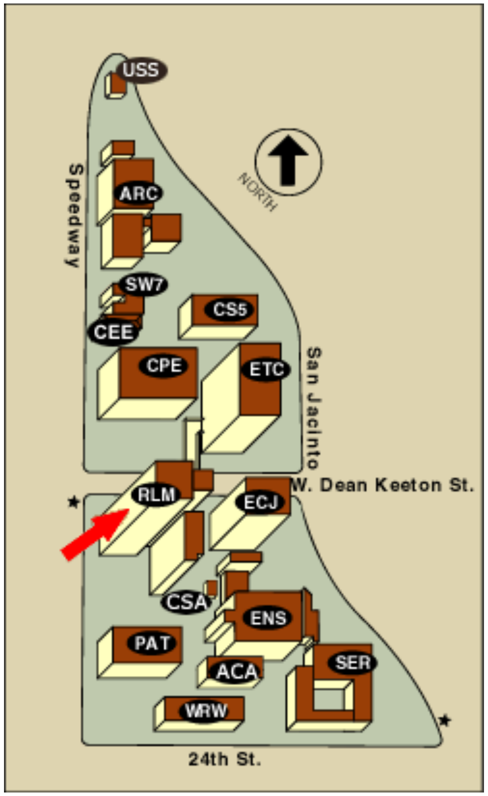
Exam 2, Skywatch 2, a week from Today, 3/3.
Review sheet posted this afternoon

Review session Thursday, 5 – 6 PM, RLM 7.104

Reading for Exam 2: Sections 6.1, 6.4, 6.5, 6.6, Betelgeuse interlude.

Background: Sections 1.2.1, 2.1, 2.2, 2.4, 2.5,

Astronomy in the news:



Ex-astronaut Ed Lu is heading a mission to launch a private spacecraft to monitor asteroids that might hit the Earth.

Update on new “nearby” supernova SN 2014J in M82

Data rolling in. Stay tuned.

Sky Watch Targets

Binary Stars

Sirius, if you have not already done it.

Algol, Beta Persei in Perseus

Antares, Alpha Scorpii in Scorpius

Beta Lyrae in Lyra

Rigel, Beta Orionis in Orion (triple star system)

Spica in Virgo

Back to physics of Type Ia Supernovae - exploding white dwarfs

Chapter 6, Section 6 in Cosmic Catastrophes

Background in Chapters 3, 4, 5.

Sky Watch

Explosions on the surface of white dwarfs, related to Type Ia, but not full-fledged supernovae

Classical Novae:

CP Pup, toward constellation Puppis in 1942

Pup 91, another toward Puppis in 1991 (not same place in our Galaxy, just accidently off in the same approximate direction)

QU Vul, toward constellation Vulpecula, white dwarf composed of Oxygen, Neon, and Magnesium rather than Carbon and Oxygen.

GK Per toward constellation Perseus - has had both a classical nova eruption in 1901 and dwarf nova eruptions.

Sky Watch

More explosions on the surface of white dwarfs

Recurrent Novae:

U Sco in the constellation Scorpius is a Recurrent Nova,
It may be a candidate to explode as a supernova!

Might see Scorpius. Also has neutron stars and black holes.

T Pyx in constellation Pyxis.

RS Oph in Ophiuchus

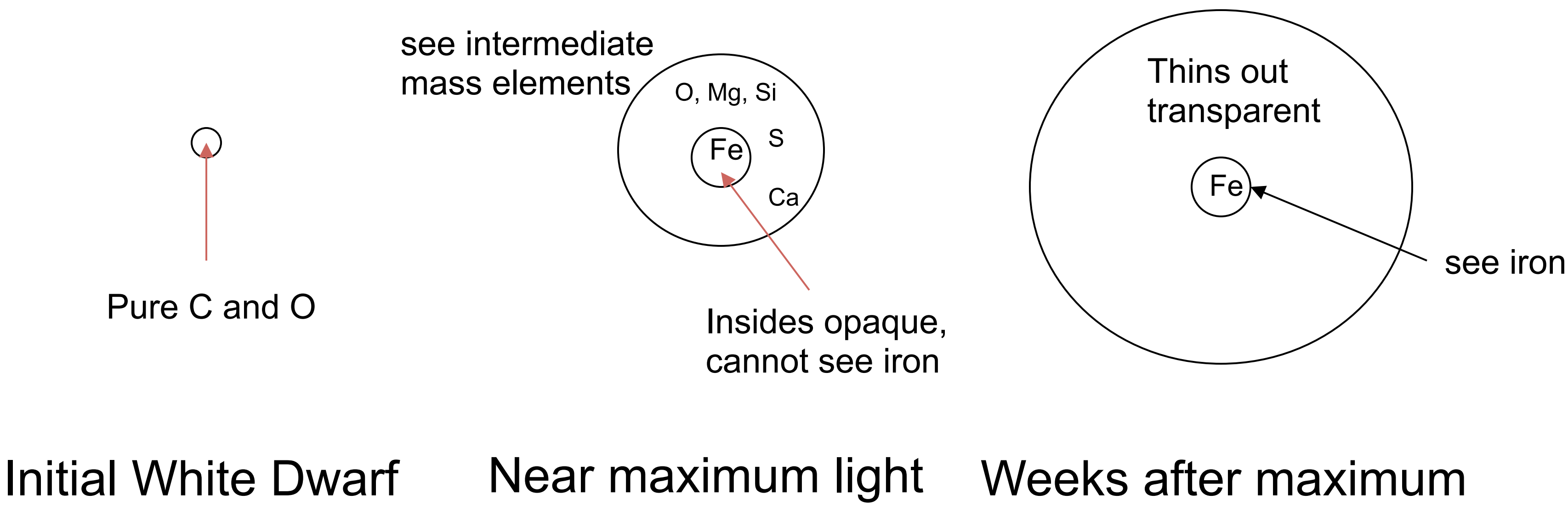
Goal

To understand the process of thermonuclear explosion in a white dwarf to make a Type Ia supernova.

Type II (Ib, Ic): energy from falling, gravity. Type Ia: energy from thermonuclear explosion.

For core collapse, iron is produced BEFORE the explosion in the progenitor star and triggers collapse. For thermonuclear explosion of carbon and oxygen, iron us produce DURING the explosion.

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



Models based on Chandrasekhar-mass 1.4 solar 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 (important detail later), only partial burning of C and O leaving O, Mg, Si, S, Ca in outer layers.

Discussion point:

What is the difference between a fire and a bomb?

Two stages to explosion:

Deflagration - slower than speed of sound, like a flame

Detonation – involves a supersonic shockwave, faster than the speed of sound. Shock wave ignites the fuel, burning drives the shock. A detonation is self-propagating. Result is like a stick of dynamite or a bomb

Force, acceleration are related to the change in pressure.

A shock wave involves a sharp, steep growth in pressure from in front to behind the shock front. Severe force and acceleration.

A detonation is faster and more violent than a deflagration since it involves a shock wave.

Deflagration versus Detonation

Important Principles

Pressure waves that cause a star to expand and explode travel at about the speed of sound.

An exploding star expands at about the speed of sound in the ejected matter.

A subsonic deflagration (a “flame”) cannot catch up with the pressure waves it creates, nor with the outer expanding matter.

A supersonic detonation (a “bomb”) will propagate faster than pressure waves or exploding, expanding matter, and thus can catch up with and burn outer material.

Thermonuclear burning of carbon and oxygen at high density characteristic of the white dwarf will producd iron.

Detonations do not give the white dwarf time to react.

⇒ For ***detonation alone***, the white dwarf would have no time to expand. It would burn entirely at the original high density and be turned essentially entirely to iron, but observe intermediate mass elements on the outside, so ***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 would be expelled.

Predict feeble explosion and careful observation shows little or no carbon, so ***Wrong!***

Deflagration followed by Detonation

The ***deflagration*** starts the explosion:

Produces iron on the inside

Shoves much of the unburned carbon and oxygen to lower densities.

The ***detonation*** catches up with the expanding outer parts

Burns carbon and oxygen to oxygen, magnesium, silicon, calcium

Deflagration followed by detonation:

Gives the right energy

Gives the right elements on the inside and outside

Predicts very little unburned carbon and oxygen.

Matches wide variety of observations!

All data, UV, optical, IR, X-ray are consistent with this picture

Physics problem - why does the subsonic deflagration change to a supersonic detonation?

Important unsolved problem of terrestrial physics as well as supernovae.

Pipeline, mine explosions – the recent disasters in San Bruno, California, 2010, Upper Big Branch mine in West Virginia, 2010, West, Texas fertilizer explosion 2013, may have involved a detonation, more violent, dangerous than a "flame."

Buncefield, England, 2005, leaking fuel tanks, vapor cloud, turbulent deflagration converted to hugely destructive detonation after encountering a stand of trees that enhanced the turbulence.

Very recent, highly detailed supercomputer simulations suggest that turbulence packs the subsonic flame until no matter which way it goes, it runs into another flame.

Rapid burning of turbulent, packed region triggers detonation.

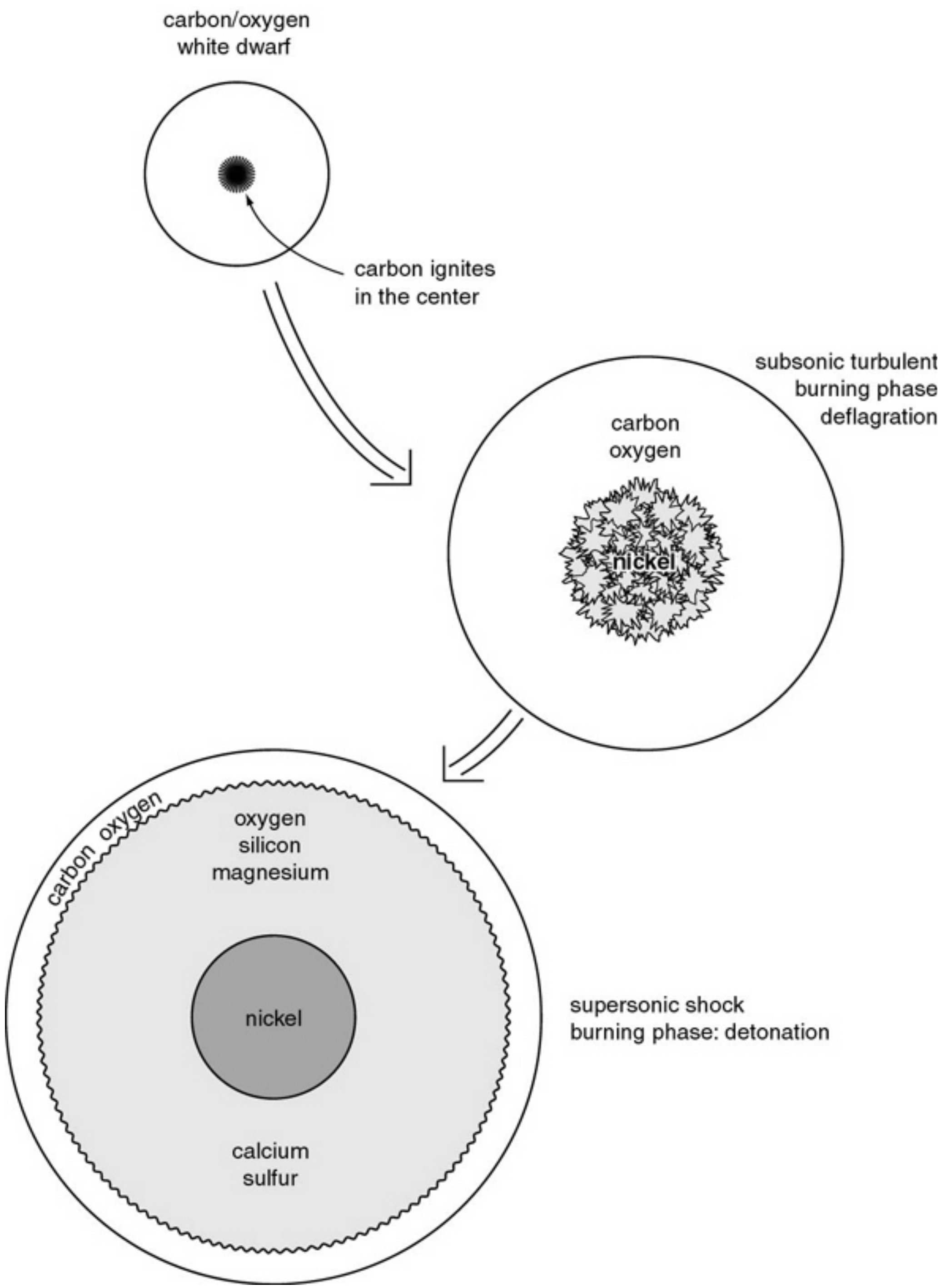


Figure 6.4

Presence of nickel, conversion of nickel to iron explained later

One Minute Exam

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

➡ The exploded material is made of equal parts silicon and iron

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

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

⬇ The supernovae was powered by the collapse of an iron core

One Minute Exam

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

➡ All the ejected matter would be iron.

⬅ A neutron star would be left behind.

⬆ The ejected matter would contain lots of carbon

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

End of Material for Exam 2