

Monday, February 20, 2017

Second exam, Skywatch, Friday, February 24.

Review Sheet Posted. Exam review Thursday, 5 – 6 PM, WEL 2.308.

Office Hours today at 5

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

Weather may be poor this week: Sky Watch Out!

Astronomy in the news?

Private enterprise in space. Yesterday, SpaceX (Elon Musk) launched a Dragon capsule with supplies for the International Space Station from the Kennedy Space Center in Florida and landed the booster to be re-used.

A question of courtesy to your classmates

Students closing books and laptops and leaving class early are disrupting other students.

I will always try to stop the class on time at 2:50 PM.

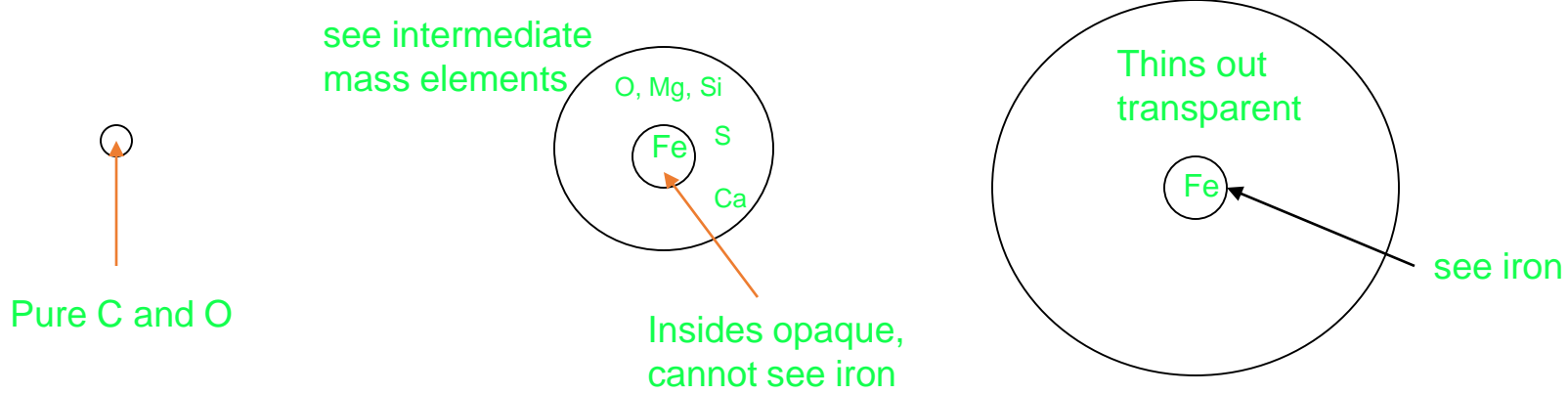
Please refrain from causing noise and disruption until class is over.

Goal

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

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

=> after the explosion, the intermediate mass elements are on the outside, iron is on the inside



Initial White Dwarf

Near maximum light

Weeks after maximum

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.

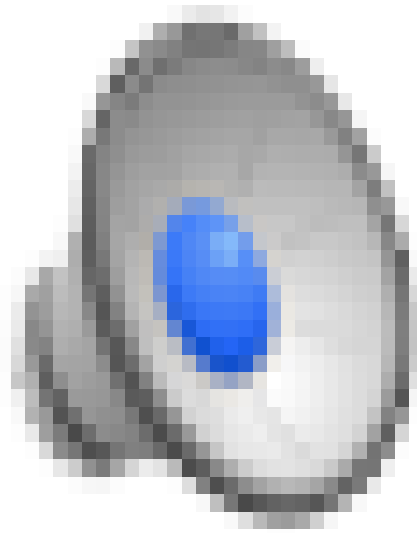
A shock wave involves a sharp, steep growth in pressure from in front to behind the shock front. Severe force and acceleration.

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

A demonstration with chemistry

Taylor Manes from the Department of Chemistry

<http://abcnews.go.com/GMA/video/baltimore-train-derailment-explosion-video-sudden-blast-strikes-19277884>



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 original white dwarf will produce *iron*.

Thermonuclear burning of carbon and oxygen at lower density characteristic of an expanded white dwarf will produce Si, etc.

Detonations, supersonic, 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 we observe intermediate mass elements on the outside, so ***Wrong!***

Deflagrations, subsonic, 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 observations show little or no remaining carbon, so ***Wrong!***

Deflagration followed by Detonation Works!

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

Produces iron on the inside

Pressure waves push 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 problem of terrestrial physics as well as supernovae.

Pipeline, mine, tanker car explosions – the recent disasters in San Bruno, California, 2010, Upper Big Branch mine in West Virginia, 2010, West, Texas fertilizer explosion 2013, oil train explosions 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, on Earth in chemical burning and nuclear burning in Type Ia supernovae.

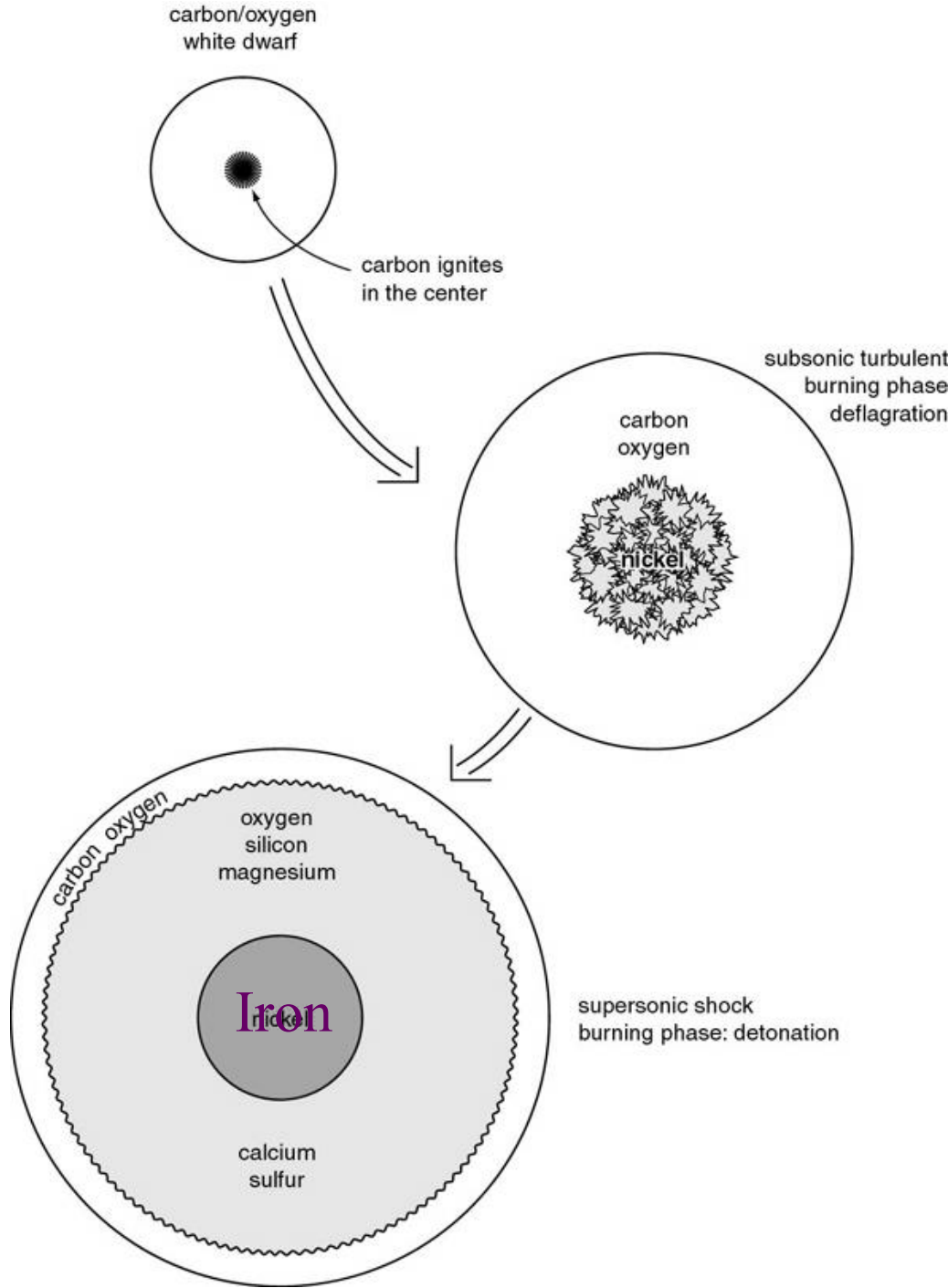


Figure 6.4

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

A detonation is more violent than a deflagration because:

 A deflagration involves a shock wave

 A detonation involves a shock wave

 A detonation moves subsonically

 A deflagration is self-propagating

One Minute Exam

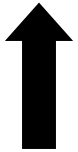
Why does a subsonic deflagration “flame” alone fail to account for the observations of a Type Ia supernova?



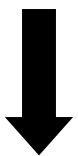
All the ejected matter would be iron.



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