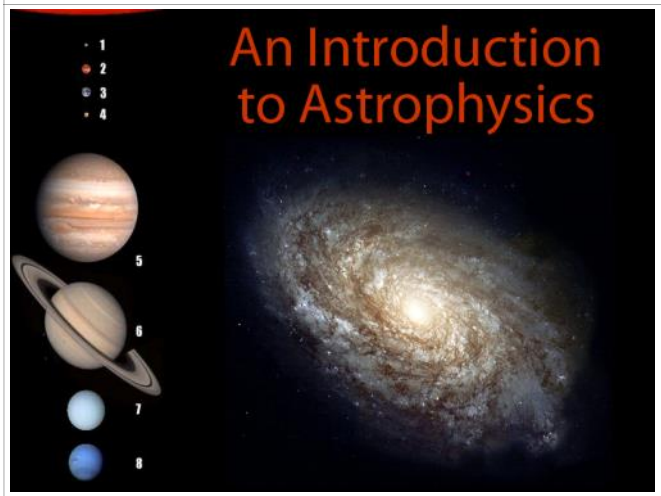
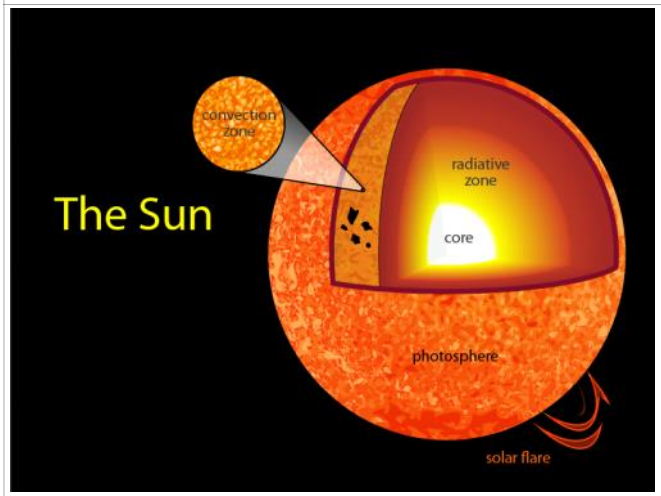
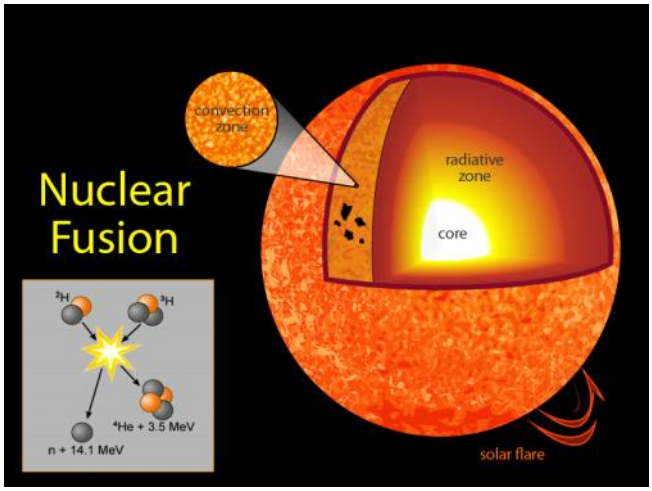
M16 Lecture - revised, verified, VT:T

Friday, July 16, 2010
7:16 AM

30 minute lecture

VoiceThread	http://voicethread.com/share/2041512/

Slide	Notes
	N01 Introduction In the introduction, see how many students can name the planets in order (and can identify significant ones by sight on the chart to the left)… Mercury Venus Earth Mars Jupiter (largest planet) Saturn (has rings) Uranus Neptune … and if they know that Pluto was downgraded from planetary status a few years ago. phET My Solar System simulation https://phet.colorado.edu/en/simulation/my-solar-system
	N02 The Sun The closest star to us. Diameter of 864,950 miles Composed entirely of gas, 90% of which is hydrogen. Most of the rest is helium. Four zones (one is labeled in the fly-out circle): • Core - Hottest level • Radiative zone - • Convection zone - • Photosphere - There at the bottom right is a solar flare. Scientists are not sure exactly what causes those, but they think that it has something to do with the sun's magnetic fields. These flares release a large amount of high-energy particles, some of which reach earth. These solar flare high energy particles can mess up some electromagnetic communications and other electromagnetic phenomenon. NOVA's sun lab: http://video.pbs.org/video/2221363813/



N03 Nuclear Fusion

In the core of the sun, the hydrogen is under so much pressure that it cannot keep its electrons in a normal way. Without the electrons, they are called deuterium and are written with an H with a little two superscript before it. When two of these collide the neclei can fuse together. The result is an isotope of helium, a free neutron, and a release of energy. This is nuclear fusion.

There is more matter before the collision than after because some of the matter was converted to energy. There is a relationship between mass and energy ...

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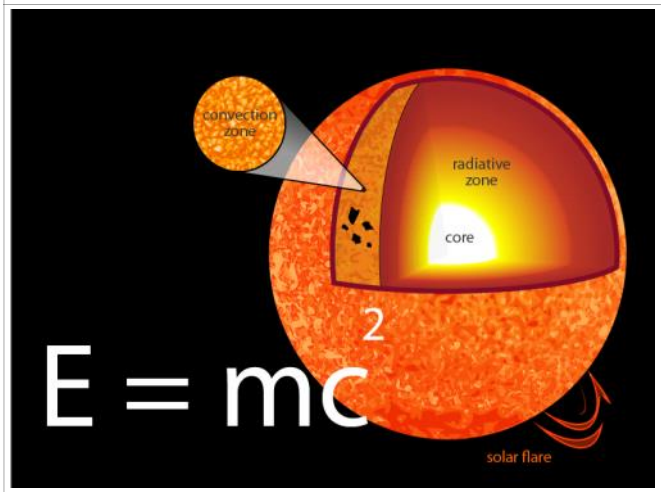
1 A ^{4}He nucleus and a ^{7}Li nucleus collide and form a ^{10}B nucleus and a neutron. Is this nuclear fusion or nuclear fission?

Choose one answer.
- a. Nuclear fusion
- b. Nuclear fission

What nuclear process occurs in the sun's core?

Choose one answer.
- a. Nuclear fission
- b. Nuclear fusion

The process by which two or more small nuclei fuse to make a bigger nucleus. — Nuclear fusion



$E = mc^2$

That relationship was discovered by Albert Einstein and we all know it as the famous equation …

$E = mc^2$

In the equation, E is energy, m is mass, and c is the speed of light. Light travels pretty fast. The distance it can travel in a year is called a light year which is about 6 trillion miles. This equation mathematically states that matter, or mass, is converted to energy. Because the speed of light is so large, just a small amount of matter mass change makes for a lot of energy. One ounce of matter undergoing nuclear fusion is enough energy to run a 100 watt light bulb for 750,000 years.

What happens to this energy?
Some is converted to heat. Most of it is converted to photons of light. These travel through the sun's layers until they get to the convection zone where they heat up the gasses

VARIABLE STARS

Stars

Of course, our sun is just a star, very much like the stars we see in the night sky. Let's start taking a look at how they are categorized.

Though we can see the stars with our own eyes, the principle tool for scientists has been the telescope which can help us understand structures that emit or reflect light. Let's take a look at a night sky by doing the interactive at ...

http://www.neave.com/planetarium/

Whatever scientists study, they must be able to share their knowledge amongst themselves so they need to classify what they know so that they can organize the data. Stars are no different.

One thing that was easy to base a classification system on was the star's color. There are stars that are slightly red/orange, some are yellow, some are blue, and so on. This observation of color made scientists wonder why they are different colors. This led scientists to theorize that the color was based on the internal temperature of the star. Blue being the hottest and red being the coolest just like what you have with fire here on earth.

Take a look at the image here and see if you can see different colors in the stars.

We will start with variable stars. Variable stars vary in their brightness. These are

pulsating variable and nova stars.

Variable stars expand and contract and therefor the brightness changes like a pulse. Some cephid stars pulse in as little as a day while some take up to a year.

Some stars are close enough to each other that they actually orbit each other. Sometimes these are mistaken for pulsating variable stars. These are called binary stars now. One can eclipse the other from our earth's perspective.

Novas are stars that seem to suddenly blink into existence. What we know now is that it isn't a birth but an explosion of a star. Novas can explode many times. Most novas explode every few days to every few years.

Supernovas are a little different than a nova. Supernovas are truly an explosion of a star. These fade away permanently and do not come back.

What are the two main types of variable stars?

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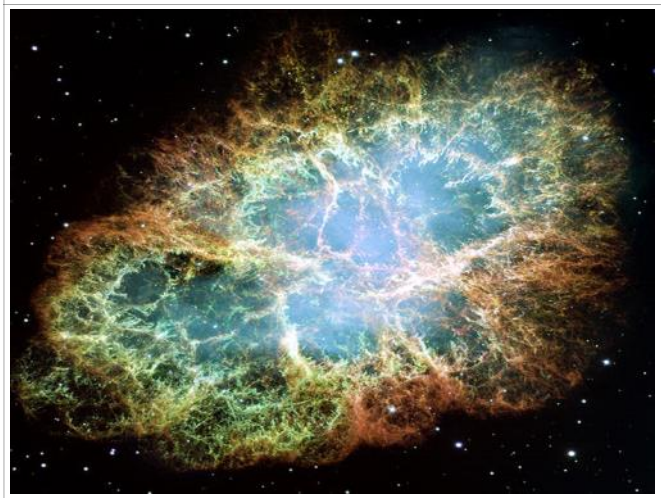
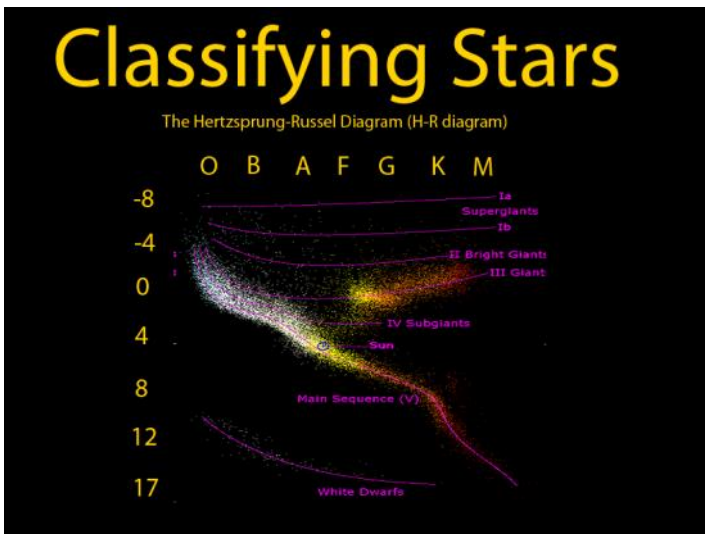
Choose at least one answer.

- [ ] a. White dwarfs
- [x] b. Pulsating variables
- [ ] c. Main sequence stars
- [ ] d. Supergiants
- [x] e. Novas
- [ ] f. Red giants



Crab Nebula

The crab nebula is the debris left over after a star has exploded and died. Supernovas are rare in the universe. Only 3 where known before 1987 and one more was actually observed exploding since then.



N07 Classifying Stars

When astronomers analyze stars they place them into one of 7 classes. Each class designated by a letter called a spectral letter. The star's temperature determines which letter is assigned.

M for stars less than 5,500 degrees Fahrenheit
K continues the scale up to 8,000 degrees
G goes from there up to 10,300
F to 12500
A to 17000
B to 37000
Anything more than 37000 gets the O

There are two factors that impact the brightness of a star: intensity of the light and distance. The distance has to be corrected for to get to the real intensity of the star's light. The result is called the magnitude. Small magnitudes are very bright.

The sun gets a spot right in the middle at +5.

In 1910, two astronomers, Einar Hertzsrung and Henry Russell, noticed that when they plotted the stars on a graph where the temperature along the top was graphed along with the magnitude on the side they got the pattern that you see here. This type of a graph is often named a H-R Diagram. Stars that are hotter and bluer are more to the left and the cooler red stars are further to the right. There is a pattern. There is a band that goes diagonal, our sun is there in the middle, that is called main sequence. Below the band you find the white dwarf stars. Above the main sequence you see the red giants and

the supergiants are going along the very top in a band.

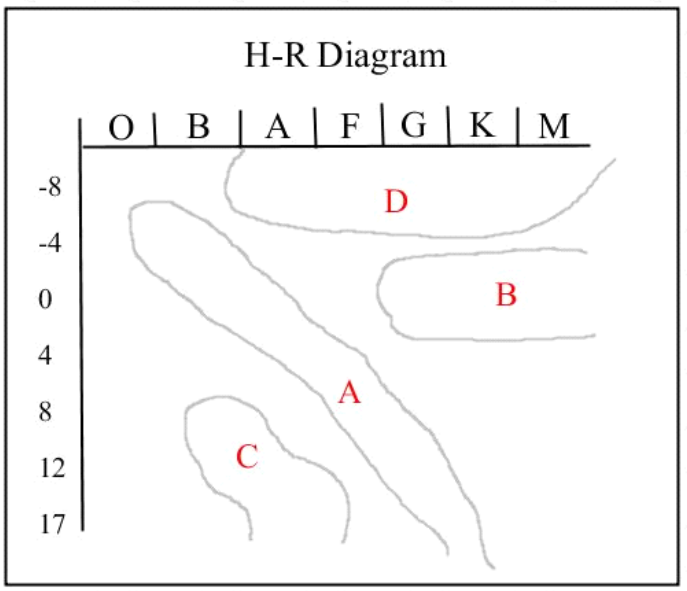
In the main sequence, you can see that the more massive the star the brighter it is. 90% of the stars we have studied are in this band.

Supergiants are the largest stars in the universe. To give you a feel for how big these are, if our sun was one, it would extend all the way out to the orbit of Saturn. Despite the large size, these stars are very cool by comparison to the other stars. There are not many of these.

White dwarfs are small stars - even smaller than the earth. The matter in them are tightly packed though.

What are Cepheid variables, and why are they important in astronomy?
Chepheid variables are variable stars whose magnitude and period have a direct relationship. The are important in astronomy because that relationship can be used to measure long distances in the universe.

Using the H-R diagram below, classify the following stars:



Magnitude 11, Spectral Letter B	White dwarf
Magnitude -6, Spectral Letter A	Supergiant
Magnitude 5, Spectral Letter G	Main sequence
Magnitude 2, Spectral Letter K	Red giant

The brightness of a star as seen in the night sky. The smaller the number, the brighter the star.	Apparent magnitude
The brightness of a star, corrected for distance, on a scale of -8 to +19. The smaller the number the brighter the star.	Absolute magnitude

What are Cepheid variables, and why are they important in astronomy?
Chepheid variables are variable stars whose magnitude and period have a direct relationship. The are important in astronomy because that relationship can be used to measure long distances in the universe.

Parallax effect demo (used to measure distance to stars)
http://www.youtube.com/watch?v=KZF8n0opmW8

N08 Distance and Galaxies

You might have wondered how the distanced where figured out. Astronomers have two ways to know. The apparent magnitude method uses geometry based on its positions at two points. If it is far away the points don't change much. The parallax method measures the angle between two stars and waits for 6 months and measures again. Geometry is put to use again and the distance can be determines.

Betelgeuse is about 30 billion light years. The universe is about 100 light years across. In 1912 Vesto M. Slipher determined that the spectral lines of stars outside of our universe were different than expected. Some were red, called red shift. In 1929, Edwin Hubble combined that with what was known about the Doppler effect and determined that our universe is expanding. You know the Doppler effect as it relates to sound when a car speeding toward you sounds different after it passes. It works with light too. Interestingly, since all galaxies are shifted away from us, some scientists have surmised that ours is at the center of the universe. Other scientists say that the effect is because the universe is more like a balloon that is expanding. If you place one dot as a reference dot and then many around it and blow the balloon up more. All the dots seem to move away from the reverence dot yet the reference dot isn't necessarily the center.

The stars then were once much closer to our planet. This could explain why we can see light from stars that are so far away from us even if we think that the universe itself is quite young.

Within the universe are several galaxies. These are groups of stars that interact through their gravitational forces orbiting a common center.

All the stars we see with our own eyes are in our own Milky Way Galaxy which is about 120,000 light years across and about 2,000 light years thick. Our sun is along an inner arm of a spiral called the Orion arm. The Milky Way is part of a group of about 20 galaxies known as the local group. The next closest galaxy is the Andromeda galaxy. We are part of a cluster of galaxies inside the local group called the Virgo cluster.

There are spiral galaxies, elliptical galaxies, lenticular, and irregular galaxies all names according to their shapes.

What is the name of the galaxy to which earth's solar system belongs? What type of galaxy is it?

Choose one answer.

- a. Andromada Galaxy, spiral galaxy
- b. Milky Way Galaxy, spiral galaxy
- c. Milky Way Galaxy, irregular galaxy
- d. Andromada Galaxy, irregular galaxy

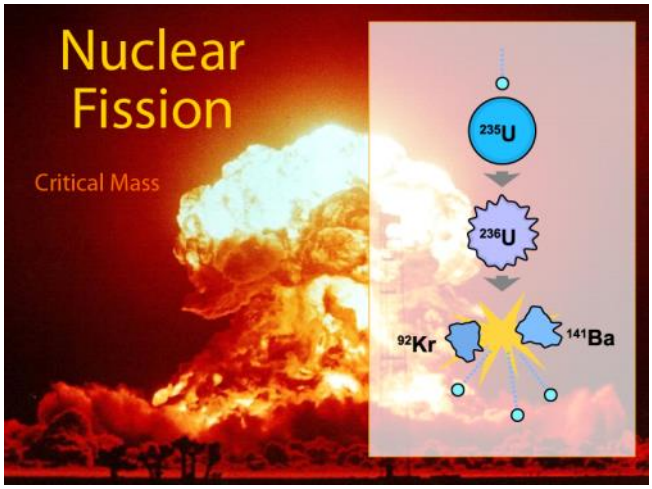
A large ensemble of stars, all interacting through the gravitational force and orbiting around a common center. — Galaxy

The distance light could travel along in a straight line in one year. — Light year

Red Shift:
The red shift is the phenomenon in which light that comes to the earth from other galaxies ends up having longer wavelengths than it should. Most astronomers interpret that as a Doppler shift resulting from the expansion of the universe.

Doppler effect interactive
http://www.pbs.org/wgbh/nova/physics/doppler-effect.html

Constellations of the zodiac - 12 zodiac signs
http://www.youtube.com/watch?v=ElTdCP5wWSU&feature=related



N09 Nuclear Fission

Before we leave this module, I want to talk about another form of nuclear energy, fission. In fission, instead of combining nuclei, they are split. Just as in nuclear fission, some mass is lost and energy is released. This is what happens in nuclear bombs and nuclear power plants.

A free neutron is needed. That is the little blue thing there at the top of the diagram. It must strike a very large nucleus for fission to get started. Notice that the end products of the fission produced three neutrons. This lets the process have free what it needs for the reaction to keep going so ling as there are more large nucleuses around. This is called a chain reaction.

Having enough of the large nucleuses is called critical mass. Without critical mass the reaction cannot go to a chain reaction to cause a large explosion like you have with the nuclear bomb. In power plants, they have under the amount of critical mass so that they can get a lot of heat but not a huge explosion. You may be wondering if they followed those guidelines in Japan when the nuclear power plants that were damaged by the tsunami blew. Those explosions were not nuclear explosions. The heat increased enough without the cooling systems that the coating that is placed on the nuclear power rods melted creating hydrogen gas. It was the hydrogen gas that exploded and with the structure being damaged, the natural radioactivity from nuclear power reactions was able to escape. Even in Chernobyl, it wasn't a nuclear explosion that blew the building. The heat generated by uncooled power rods can get so hot that it can melt the reactor this is called a meltdown or the China Syndrome. The idea behind the China syndrome is that it will melt all the way through the earth which is a bit fanciful but definitely makes the name stick in your mind.

A byproduct of the spent fuel rods is that they remain radioactive. This is problematic because where do you dispose of the radioactive waste matter?

Scientists are trying to figure out how to create energy in the way the sun does, nuclear fusion instead of fission. It wouldn't have radioactive byproducts. Helium and a free neutron are the only byproducts. It is also much easier to halt, they believe. The fuel needed for fusion is hydrogen which we have lots of. We haven't yet figured out how to do it yet and get more energy out that what is needed to get the process to make a quick start.

Most of what I have told you comes from scientists making indeirect observations. That means that there is a pretty high chance that some of these facts will later be proven incorrect as scientist continue to study the sun and develop new technologies to look deeper into the processes the sun uses to create its energy.

The process by which a large nucleus is split into smaller nuclei. — Nuclear fission

The amount of isotope necessary to sustain a chain reaction. — Critical mass

A scientist studies a process in which a neutron strikes a ^{216}Pu nucleus to make a ^{104}Cd nucleus, a ^{110}Pd nucleus, and 3 neutrons. If the scientist measures the mass of the ^{216}Pu nucleus and the original neutron and then subtracts the mass of the ^{104}Cd nucleus, the ^{110}Pd nucleus, and the mass of 3 neutrons, what type of number will the scientist get as a result?

Choose one answer.

- a. Zero
- b. Positive number
- c. Negative number

Is it possible for a nuclear power plant to experience a nuclear explosion? Why or why not?

No, it is not possible, because a power plant does not have significantly more than the critical mass of the large nucleus.
However, often the rods are coated and the coating can break down into hydrogen gas if the rods overheat. Hydrogen gas is explosive.

Credits Star Field by European Space Agency Sun diagram by Pbroks13	Credits:

2011-12 Quiz link: http://www.virtualhomeschoolgroup.com/mod/quiz/view.php?id=17749
20012/13 - http://www.virtualhomeschoolgroup.com/mod/quiz/view.php?id=30485