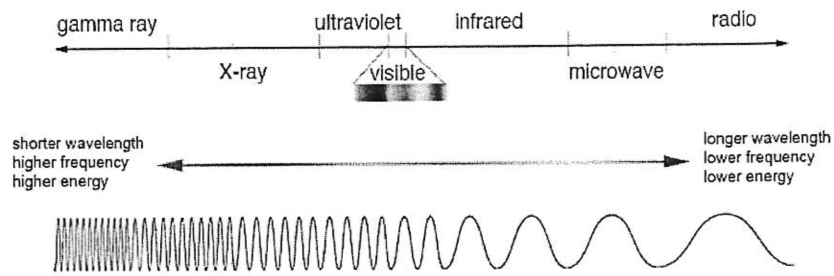
ESS 200 Name: A 7/8

Notes: Stars and The Universe, Part 1

1. Electromagnetic radiation:
   a. What is visible light? **Electromagnetic waves with wavelengths that allow them to be seen by human eyes.**



   b. Define Wavelength: **The distance from the crest of one wave to the crest of the next wave.**
   c. Order the colors of visible light according to their wavelength. **Longest wavelength to shortest wavelength: ROYGBIV (Red, orange, yellow, green, blue, indigo, violet)**
   d. Which wavelengths of electromagnetic radiation have more energy, shorter wavelengths or longer wavelengths? **Shorter wavelength = higher energy**
   e. Objects give off radiation with wavelengths that depend on the objects' temperature. This is true for stars, hot metal, humans, and all other objects. The wavelength of this radiation is based on the temperature of the object. Rank these star colors from hottest to coolest. Red, Blue, Orange, Yellow, White. **Hottest to Coolest: Blue, White, Yellow, Orange, Red**
   f. Some objects are just a little too hot for their radiation to be visible. Others are a little too cool for us to see their radiation. What type of electromagnetic radiation do these slightly-too-hot objects emit? **Ultraviolet radiation** What type of radiation do these slightly-too-cool objects emit? **Infrared radiation**
   g. What is the speed of light? **671 million miles per hour**
   h. What is special about the speed of light?
      i. **All electromagnetic radiation travels at this speed in a vacuum.**
      ii. **Nothing can travel through space faster than the speed of light.**
      iii. **And there's more (for later).**
   i. What is a light year? **The distance light travels in one year (5.879×10^{12} miles). A Light year is a unit of distance, not a unit of time.**
   j. The distance from the Earth to the Sun is about 8 light minutes. What does that mean? **It means light takes 8 minutes to travel from the sun to the Earth.**
   k. We always see things as they were in the past. The farther away we look, the farther into the past we see. Explain why. **Light travels fast, but it does not travel instantaneously. We see an object as it looked when the light that is now reaching our eyes left that object.**
2. How we know what elements are in stars:
   a. What is an element's absorption spectrum? **An absorption spectrum is a *fingerprint* of specific wavelengths of light that are absorbed by that element.**
   b. How can we tell which elements are in stars? **Stars emit radiation because they are hot, but some of that radiation gets absorbed by the elements in the star. We look at the absorption spectra of the light that is coming from stars and use those *fingerprints* to identify the elements in the stars.**
   c. What does a spectrometer do? **A spectrometer works like a prism. It separates light into individual wavelengths so that we can see the spectrum of wavelengths coming from a star.**
3. Star Life Cycles
   a. Small to Medium Stars (less than 1.4 solar masses):
      i. Describe the stages:
         1. **Nebula – cold cloud of dust and frozen gas**
         2. **Main Sequence Star – Hydrogen is fusing to Helium**

3. **Red Giant – Fuseable Hydrogen is used up. Helium and other elements are fusing.**
4. **White Dwarf – Nuclear fusion stops. The star collapses but then heats back up due to compression. This heating causes the color to change from red to white.**
5. **Black Dwarf – Eventually the star radiates all of its heat into space . It is cold and dark.**

ii. When a star is "on the main sequence" there is a balance keeping its energy output fairly constant.

1. What are the forces that are balanced? **Gravity (causing the star to contract) is balanced by pressure (pushing outward).**
2. Which force changes first? Why? **As the star uses up fuel, it cools, so its particles move more slowly and their pressure decreases. As pressure decreases, fusion decreases, and more cooling occurs. Pressure drops more.**
3. How does the second force react when the first force changes? **When the gas pressure decreases, it no longer pushes outward with as much force, so gravity is now able to further compress the star, heating it back up and again raising the pressure. The star is stabilized.**

iii. When a star turns into a red giant, why does it get bigger? **Helium is building up in the star's core. As hydrogen fusion stops in the core (because there is only helium there), hydrogen begins to fuse in a shell outside the core.**

iv. When a star turns into a red giant, why does it turn red? **When hydrogen fusion takes place farther from the star's core, there is less pressure, so the fusion is less intense. The surface of the star is cooler, so it turns red (a cooler color, for stars).**

b. Large Stars (1.4 solar masses or greater):

i. **Nebula – cold cloud of dust and frozen gas**

ii. **Main Sequence Star – Hydrogen is fusing to Helium**

iii. **Red Supergiant –Core Hydrogen is used up. Helium and other elements are fusing into elements up to the weight of iron.**

iv. **Supernova – Nuclear fusion stops. The star collapses and slams into its iron core with explosive pressure. The compression fuses elements heavier than iron. The core rebounds, causing material to explode outward into space.**

4. Describe the three possible fates of stellar material *after* a supernova occurs.

a. **<u>Recycling</u>: Some matter is blasted into space. This matter mixes with the interstellar medium (the mostly hydrogen that is in empty space) to create new nebulas, and new solar systems like ours.**

b. **<u>Black Hole:</u> If the matter left behind is more than 3 solar masses, a black hole will form.**

c. **<u>Neutron Star:</u> If the matter left behind is between 1.4 and 3 solar masses, a neutron star will form.**

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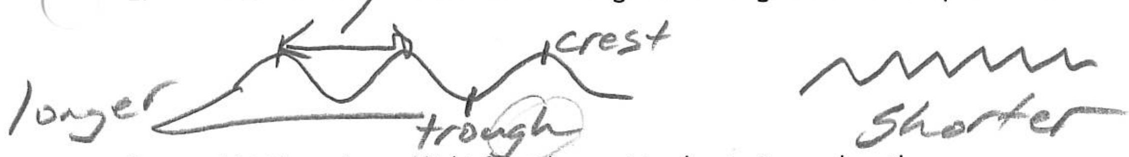
Review Questions: wavelength

1. Draw waves with shorter and longer wavelengths. Label the parts of the wave. Show "one wavelength."



2. List the colors of light from longest to shortest wavelength.

ROYG.BIV — indigo, violet

3. List the star colors in order, from hottest to coolest.

Blue, White, Yellow, Orange, Red

4. How do we know what elements are in stars?

We observe stars with spectroscopes and note which wavelengths of light are emitted. Each element emits specific wavelengths of light.

5. What is a light year?

the distance light travels in one year.

6. Why is no one a light year old?

distance, not time

7. List the life stages of a medium-sized star, like our sun.

Nebula → Main Sequence → Red Giant → (Planetary Nebula) → White Dwarf → Black Dwarf

8. A main sequence star is kept burning at a fairly constant rate due to a balance of forces. What are these forces? Gravity and gas pressure

9. Choose one of those forces and tell what happens to stabilize the star if that force changes.

Gas pressure decreases → Gravity will compress star → heat up → gas pressure increases back to normal.

10. When our sun becomes a red giant, why will it expand?

Hydrogen is fusing in a shell farther out from the core. The core is now full of ~~he~~ helium, which is more dense than hydrogen.

11. When our sun becomes a red giant, why will it turn red?

It's red, because it is cooler. It cools because the fusion is farther from the high pressure of the core, so it is less intense.

12. When our sun becomes a white dwarf, why will it turn white?

Sun will shrink, compressing itself and therefore heating up.

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13. How is energy production in a large star (25 solar masses or larger) different than in a smaller star, like our sun?

CHNOPS

Large stars fuse elements heavier than hydrogen and helium. They fuse elements up to the weight of iron.

14. Where are light elements (up the mass of iron) created?

Inside stars. Formed by nuclear fusion (Except Hydrogen and Some Helium)

15. Where are heavier elements (heavier than iron) created?

Supernovae

16. Our solar system formed from a nebula. Where did the nebula come from? [bad grammar, I know]

Our nebula formed from material that was blasted outward during a supernova. Plus

This mixed with the Hydrogen and helium that is floating around everywhere in space.