AST 103 Blackbody Radiation

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Analyzing Starlight

What can looking at an object's spectrum tell us about the object?

Analyzing Starlight

- What can an object's spectrum tell us about the object?
 - temperature

Which object is hotter, an object that is emitting mainly red light or mainly blue light?



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Hotter objects emit light that PEAKS at shorter wavelengths (bluer).
Cooler objects emit light that PEAKS at longer wavelengths (redder).



increasing temperature

Wien's Law

Relates the temperature of an object to the wavelength of the **peak** in the blackbody curve.

$$\lambda_{peak} = \frac{2 \times 10^{-3}}{T_{\text{Kelvin}}} \text{ [m]}$$

The **higher** the object's temperature, the **shorter** the wavelength of the peak for the light emitted by the object.

What color does our Sun appear? T = 5800 K

The Sun emits all wavelengths of electromagnetic radiation (light); however, the wavelengths of light it emits most intensely are in the green/yellow part of the spectrum.





Wavelength (nm) -

C

Quiz the three

Which of the three objects gives off the greatest amount of energy in the red wavelength?









Lecture-Tutorial (LT): Blackbody Radiation (pp. 57-60)

 Be sure to READ all the material between the questions!

We haven't talked about the size of stars, so you don't have to do Questions #11-15.

Light, Atoms & Spectra

• atomic structure

energy levels

• 3 basic types of spectra

An atom consists of a small, dense **nucleus** (containing protons and neutrons) surrounded by **electrons**

- Model Proposed by Niels Bohr 1913





Atoms are mostly empty space

A nucleus is about 10⁻¹⁵ **m** in size and the first electron orbits out at 10⁻¹⁰ **m** from the center of the atom

The size of the electron orbit is 100,000 times greater than the size of the nucleus



So if a nucleus the size of an orange (10 cm) was located in the classroom, where would the electron be?



If the electron's orbit is 100,000 times bigger than the nucleus, then the electron would be 10,000 m or 6.21 miles away!

Nearly the distance between Sam Boyd Stadium and UNLV campus!



The electron should be thought of as a distribution or cloud of probability around the nucleus that on average behaves like a point particle on a fixed circular path.



Electron Orbits



Photons (light-waves) are **emitted** from an atom when an electron moves from a **higher** energy level to a **lower** energy level



Photons (light-waves) can also be **absorbed** by an atom when an electron moves from a **lower** energy level to a **higher** energy level



Each chemical element produces its own unique set of spectral lines when it is excited



Atoms of different elements have unique spectral lines because each element

A) has atoms of a unique color.

B) has a unique set of neutrons.

C) has a unique set of electron orbits.

D) has unique photons.

E) none of the above; spectral lines are not unique to each type of atom.

What are the three basic types of spectra?



Spectra of astrophysical objects are usually combinations of these three basic types

Continuous Spectrum



• The spectrum of a common light bulb spans all visible wavelengths, without interruption

The excited atoms within a **hot dense object** give off light of all colors (wavelengths) and produce a *continuous spectrum* -- a complete rainbow of colors (range of wavelengths) without any spectral lines.

Emission Line Spectrum



• A thin or **low-density** cloud of gas emits light only at specific wavelengths that depend on its composition and temperature, producing a spectrum with bright **emission lines**



Absorption Line Spectrum



• A cloud of gas between us and a light bulb can absorb light of specific wavelengths, leaving dark absorption lines in the spectrum





Lecture-Tutorial (LT): Types of Spectra (pp. 61-62)

- Work with a partner!
- Read the instructions and questions <u>carefully</u>.
- Discuss the concepts and your answers with one another.
- Come to a consensus answer you both agree on.
- If you get stuck or are not sure of your answer, ask another group.
- If you get really stuck or don't understand what the LT is asking, ask the instructor for help.