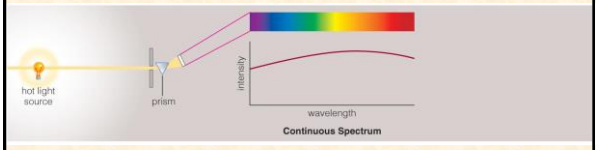
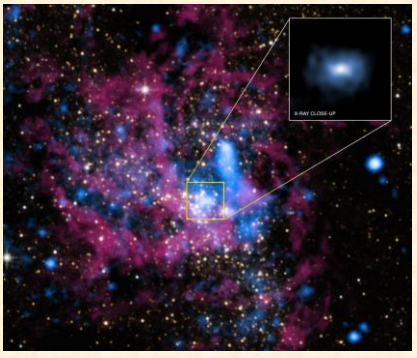
ASTR 1020: Stars & Galaxies

September 9, 2013

- Reading: Chapter 5, section 5.3
- *MasteringAstronomy* Homework on Light & Matter due Sep. 13th.
- Volunteer for "Astronomy in the News".
- Attend one of SBO Observing Nights to complete Observing Worksheet: Sep. 10, 12 this week.



Astronomy Picture of the Day

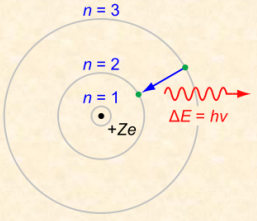


The center of the Milky Way. Infrared and X-ray views of the region containing a $4x10^6$ solar mass black hole in direction of Sagittarius.

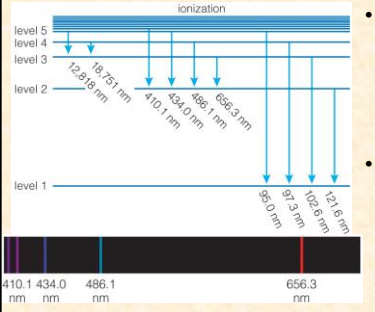
Today's Class

Chapter 5: Review of Light & Matter

- Light and Atoms
- Types of Spectra
- Doppler Shift



Chemical Fingerprints



Energy levels of hydrogen

- Each type of atom has a unique set of energy levels.
- Each transition corresponds to a unique photon energy, frequency, and wavelength.

- Each atom has a different set of energy levels → different emission/absorption spectrum
- Examples: mercury, sodium, neon, hydrogen, helium….
- Demo: diffraction grating spectroscopes

Clicker Reading Question: The light we see from stars is mostly thermal radiation. Antares is a star with a distinct reddish color. How is its surface temperature different from the Sun?

a) It's greater than the Sun.
b) It's the same as the Sun.
c) It's less than the Sun.

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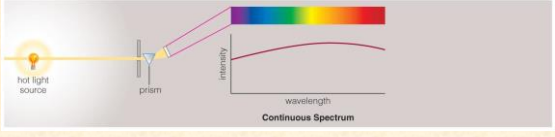
Continuous (thermal) Spectrum



- The spectrum of a common (incandescent) light bulb spans all visible wavelengths, without interruption.

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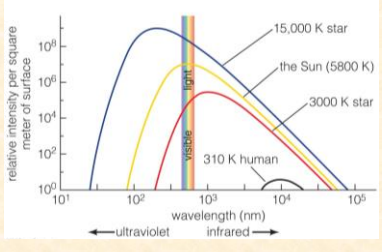
Properties of Thermal Radiation

1. Hotter objects emit more light at all frequencies per unit area.
2. Hotter objects emit photons with a higher average energy.

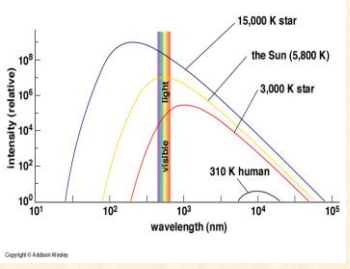


Wien's law:

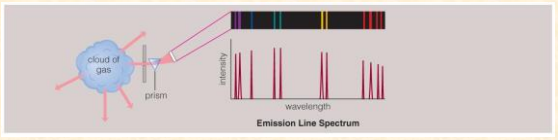
- λ (maximum) =

$$\frac{2{,}900{,}000 \text{ nm}}{T \text{ (K)}}$$

$$= \frac{0.0029 \text{ meters}}{T \text{ (K)}}$$

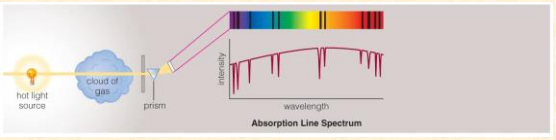


Emission Line Spectrum



- 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



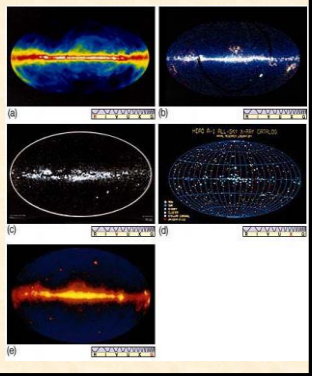
- A cloud of gas between us and a light bulb can absorb light of specific wavelengths, leaving dark absorption lines in the spectrum.

Quick guide to thermal spectra (be familiar with these)

- 3 K (coldest natural things): 1mm (microwaves)
- 300 K (people, planets, warm dust): 10^{-5} meters (IR)
- 3000-30,000 K (stars): 10^{-6} m to 10^{-7} m = 1000 to 100 nm (IR – visible –UV)
- 300,000- 30,000,000 K: weird and intense places (UV through X-rays)

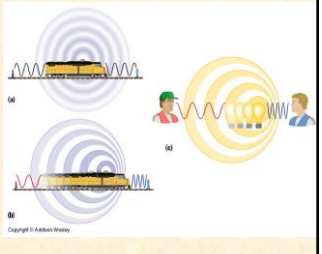
Images of the Milky Way

- IR: emission from dust warmed by starlight (e)
- Optical- emission from the stars; dust absorbs light and causes dark bands (c)
- UV/X-ray points: black holes, other intense regions (d)
- Radio, some X-ray and gamma-ray light comes from non-thermal sources- we'll talk about these soon! (a)



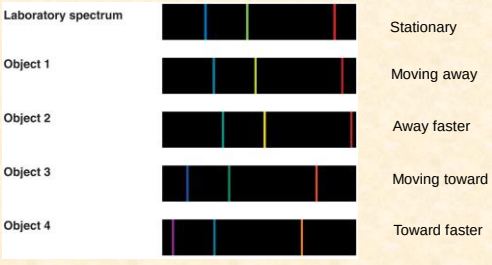
Measuring velocities without a stopwatch: the Doppler Shift

- Familiar shift in pitch of SOUND: higher when approaching, lower when receding
- Similar shift in frequency of light: higher (blueshift) when approaching, lower (redshift) when receding



Doppler Movie

Measuring the Shift



- We generally measure the Doppler effect from shifts in the wavelengths of spectral lines.

- **Clicker Question:** A brave student volunteer swings the "Doppler ball" in a circle directly over her head. What does she hear?

a) A changing pitch, higher and lower, with each circular swing
b) no change in pitch
c) nothing at all

(c) Nothing at all!

If the ball is swung directly over her head, the ball is never moving TOWARDS or AWAY from her, only tangentially around her. There should be no doppler change in pitch.

Doppler effect is limited to only motions towards or away from the listener/viewer. No Doppler shift if object is moving tangentially (across or in a perfect circle around)

Astronomer's Toolbox

- Temperature of opaque objects: thermal spectrum, Wien's law.
- Chemical composition, some info on density and temperature of thin gasses: emission and absorption spectra.
- Velocity: Doppler shift.
- Still to come: distances, sizes and ages…