Agenda for Ast 309N, Sep. 13

- Quiz 1, on The Sun
- Continue review of light and spectra
- Spectroscopy Demonstration
- Thermal emitters, laws of thermal emission
- Card Activity: “You are a star!”
- Next week: review light, matter, force, energy

  reading: Kaler, pages 3 – 8

  Wheeler, pages 1 – 11 + Fig. on 12

Honor Code of the University of Texas

“The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect towards peers and community.”

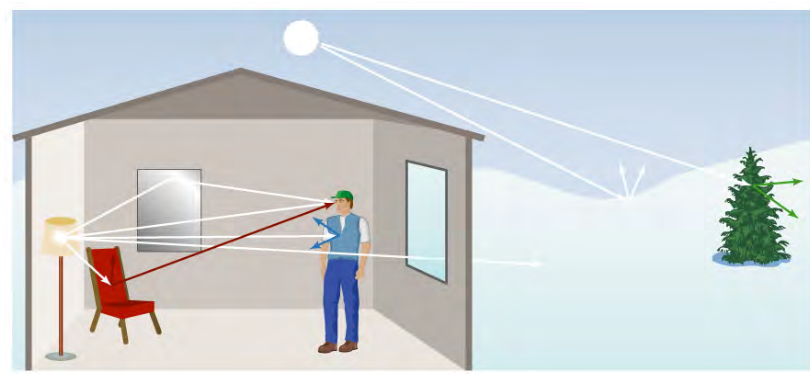
The Nature of Light: A Form of Energy

- Energy vs. power
- **Power** = rate at which energy is produced, emitted (for light), or used (utility bill)
- It is usually measured in **Watts**, where

  1 Watt = 1 Joule per second
- For example, a 100 Watt light bulb radiates 100 Joules of energy every second.

- What’s a more appropriate unit to use for the light output of stars?

Interactions of Light and Matter

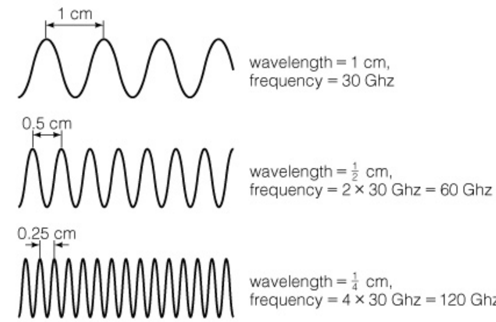


Interactions between light and matter determine the appearance of everything around us.

Ways Light and Matter Can Interact

- **Emission:** when matter gives off, *radiates,* light.
- **Absorption**: *opaque* material "soaks up" or *absorbs* energy in the form of light.
- **Transmission**: light passes (at least partially) through *transparent or translucent* matter.
- **(Coherent) Reflection**: light hits matter and bounces in another direction, retaining an image.
- **Scattering:** light hits matter and bounces off diffusely (see the object, not a mirrored image).

The Inverse Relation between Wavelength and Frequency



wavelength x frequency = $\lambda \times \nu = c$

Wavelength, Frequency, & Energy

λ = wavelength ν = frequency e = energy

$c = 3 \times 10^8$ m/s $h = 6.626 \times 10^{-34}$ Joule • s

$$\lambda \times \nu = c$$

This says: as λ increases, ν decreases, and vice versa.

$$e = h \times \nu$$

This says: as ν increases, e increases, and vice versa

The Electromagnetic Spectrum

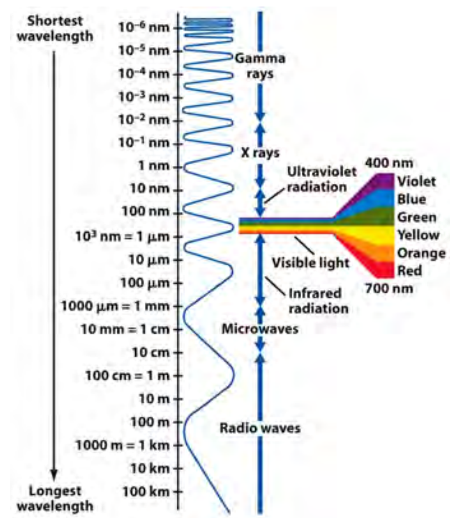


Figure 5-7
Universe, Eighth Edition
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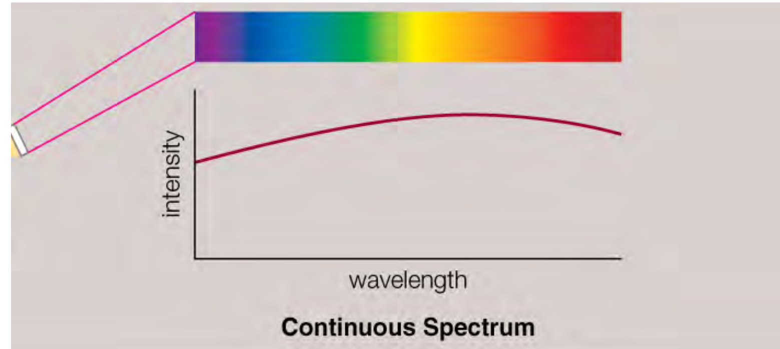
Thermal ("Blackbody") Radiation

- Thermal radiation is an example (one form) of *continuous* spectrum (smooth variation over wavelength range; no gaps or bright spots).
- Nearly all large or dense (opaque) objects emit thermal radiation, including stars, planets, you…
- An object's thermal radiation spectrum depends on only one property: its **temperature.**

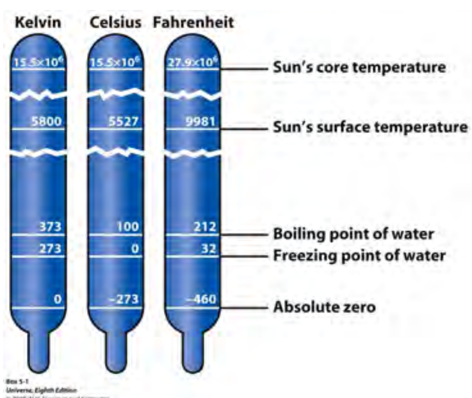
Two Representations of a Spectrum



Why might you use a graph to represent a spectrum rather than showing the top view, as it appears?

The Laws of Thermal Radiation

Reminder: These "laws" assume that the temperature is in Kelvins.

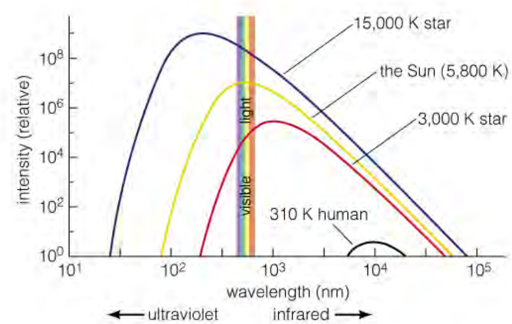


Room temperature (68° F) corresponds to 20 C or 293 K.

Laws of Thermal Radiation

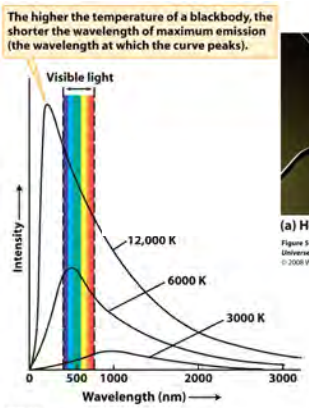
1. Hotter objects emit more light *per unit surface area*, at all frequencies of light. The total power increases in proportion to temperature to the 4th power!

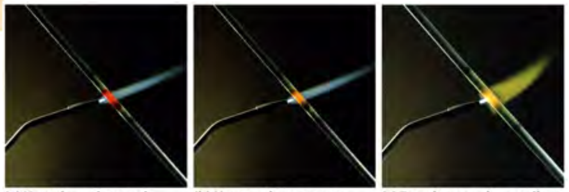
Note: scale is powers of 10



Laws of Thermal Emission

2. Hotter objects emit more intensely at shorter (bluer), cooler objects at longer wavelengths. (Wien's Law)

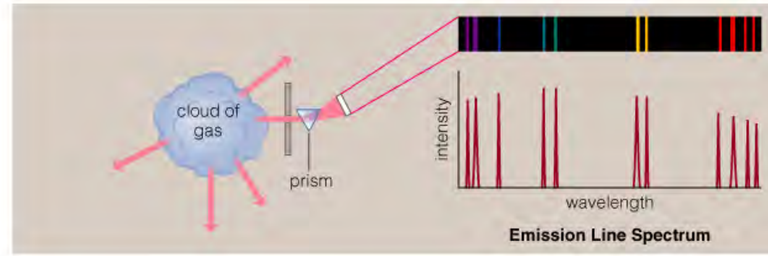




(a) Hot: glows deep red (b) Hotter: glows orange (c) Even hotter: glows yellow

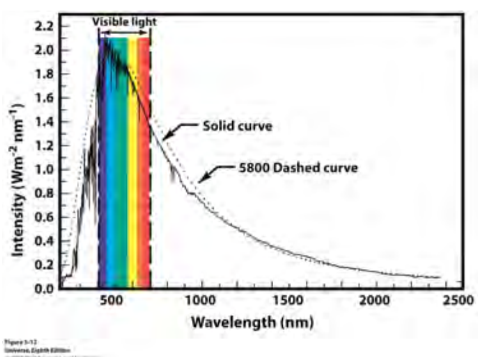
Humans "peak" in infrared light.

Emission Line Spectrum



A low-density cloud of hot gas emits only at a few specific wavelengths that depend on what elements are present, producing a spectrum with bright, narrow emission lines.

Example: the Sun as a thermal emitter



Wien's Law: Sunlight is most intense in yellow-green light, λ = 500 nm

Stefan-Boltzmann Law: Sun's luminosity is given by its surface area (= $4\pi R^2$) times energy emitted per unit surface area (= σT^4)

$$L = 4\pi (7 \times 10^8)^2 \times (5.67 \times 10^{-8}) (5800)^4 = 3.9 \times 10^{26} \text{ W}$$

Example: the Sun as a thermal emitter

$$L = Surface\,Area \times Energy\,per\,unit\,S.A.$$
$$= (4\pi R^2) \times (\sigma T^4)$$
$$= 4\pi (7\times 10^8)^2 \times (5.7 \times 10^{-8})(6 \times 10^3)^4$$
$$= 3.9 \times 10^{26}\ W$$