Jorge Ramirez
Instructor of Mathematics, Physics & Astronomy

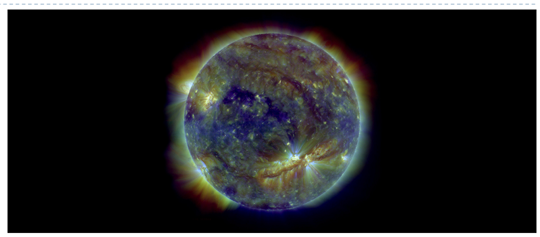
ASTRONOMY

Chapter 5 RADIATION AND SPECTRA

PowerPoint Image Slideshow

openstax

5.1 THE BEHAVIOR OF LIGHT

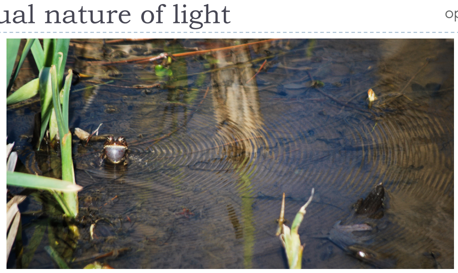


- **Our Sun in Ultraviolet Light (fig 5.1).** This photograph of the Sun was taken at several different wavelengths of ultraviolet, which our eyes cannot see, and then color coded so it reveals activity in our Sun's atmosphere that cannot be observed in visible light. This is why it is important to observe the Sun and other astronomical objects in wavelengths other than the visible band of the spectrum. This image was taken by a satellite from above Earth's atmosphere, which is necessary since Earth's atmosphere absorbs much of the ultraviolet light coming from space.

Maxwell's Theory of Electromagnetism

- **James Clerk Maxwell (1831–1879) Fig 5.2.** Maxwell unified the rules governing electricity and magnetism into a coherent theory.

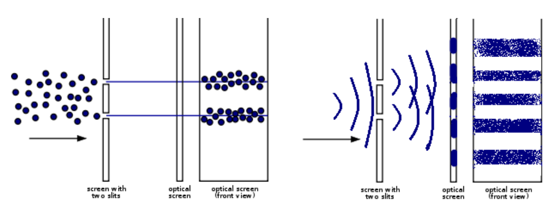
Dual nature of light



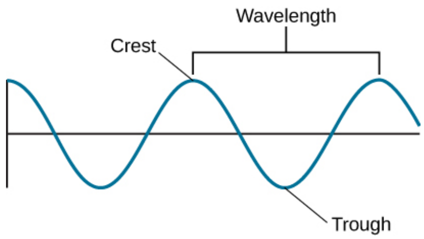
- **Making Waves (fig 5.3).** An oscillation in a pool of water creates an expanding disturbance called a wave.

Double Slit Experiment

Light as a particle | **Light as a wave**



The Wave-Like Characteristics of Light



- **Characterizing Waves (Fig 5.4).** Electromagnetic radiation has wave-like characteristics. The wavelength (λ) is the distance between crests, the frequency (*f*) is the number of cycles per second, and the speed (*c*) is the distance the wave covers during a specified period of time (e.g., kilometers per second).

Light as a Photon

- Particles of light are called **photons.**
- Each photon has a wavelength and a frequency.
- The energy of a photon depends on its frequency.

Wavelength, Frequency, and Energy

$$\lambda \times f = c$$

$$\lambda = \text{wavelength}, \quad f = \text{frequency}$$

$$c = 3.00 \times 10^8 \text{ m/s} = \text{speed of light}$$

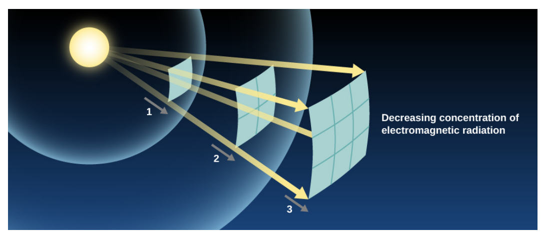
- The shorter the wavelength the higher the frequency

$$E = h \times f = \text{photon energy}$$

$$h = 6.626 \times 10^{-34} \text{ joule} \times \text{s}$$

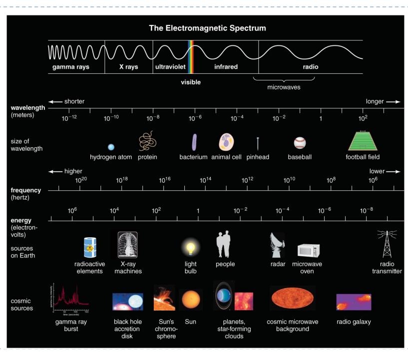
- The shorter its wavelength the higher the photon energy

Propagation of Light



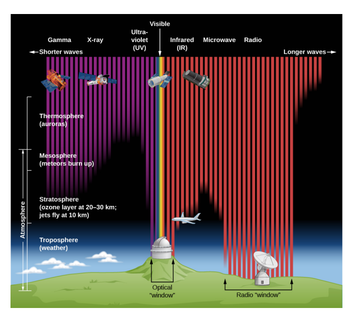
- **Inverse Square Law for Light (Fig 5.5).** As light radiates away from its source, it spreads out in such a way that the energy per unit area (the amount of energy passing through one of the small squares) decreases as the square of the distance from its source.

5.2 THE ELECTROMAGNETIC SPECTRUM



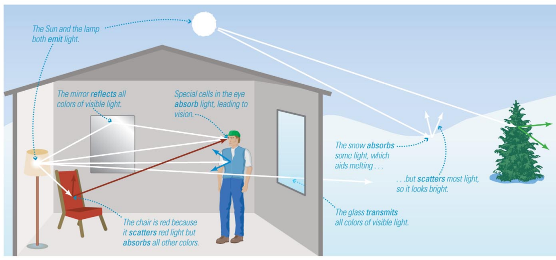
Types of Electromagnetic Radiation

- gamma rays
- X- rays.
- ultraviolet
- visible light
- infrared
- microwave
- radio waves



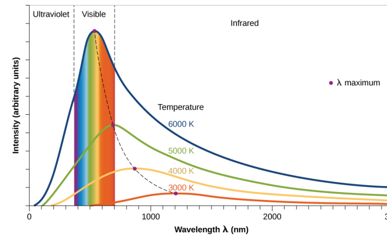
How does light interact with matter?

- Emission
  - Light bulb
- Absorption
  - Red chair
- Transmission
  - Glass (window)
- Reflection or scattering
  - Mirror or snow



Radiation and Tempatures

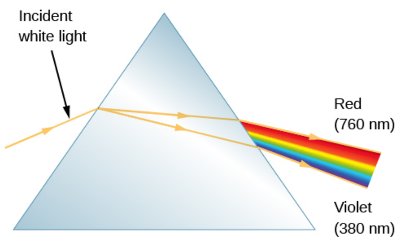
openstax



- **Radiation Laws Illustrated (Fig 5.8).** This graph shows in arbitrary units how many photons are given off at each wavelength for objects at four different temperatures. The wavelengths corresponding to visible light are shown by the colored bands. Note that at hotter temperatures, more energy (in the form of photons) is emitted at all wavelengths. The higher the temperature, the shorter the wavelength at which the peak amount of energy is radiated (this is known as Wien's law).

5.3 SPECTROSCOPY IN ASTRONOMY

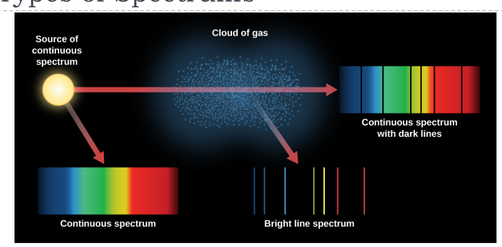
openstax



- **Action of a Prism (Fig 5.9).** When we pass a beam of white sunlight through a prism, we see a rainbow-colored band of light that we call a continuous spectrum.

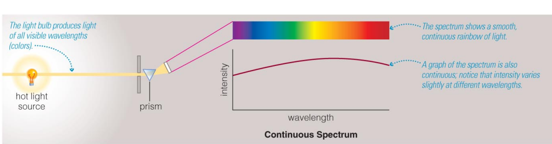
Types of Spectrums

openstax



- **Three Kinds of Spectra (Fig 5.21).** When we see a lightbulb or other source of continuous radiation, all the colors are present. When the continuous spectrum is seen through a thinner gas cloud, the cloud's atoms produce absorption lines in the continuous spectrum. When the excited cloud is seen without the continuous source behind it, its atoms produce emission lines. We can learn which types of atoms are in the gas cloud from the pattern of absorption or emission lines.

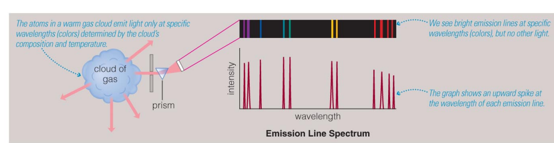
Continuous Spectrum



a

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

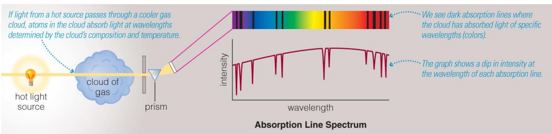
Emission Line Spectrum



b

- 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.

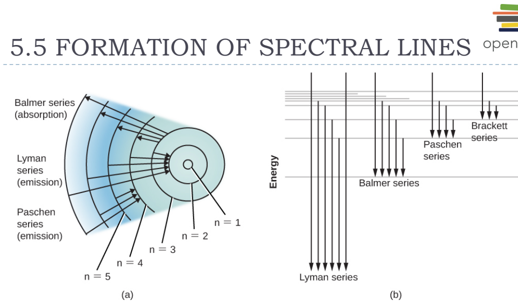
Absorption Line Spectrum



c

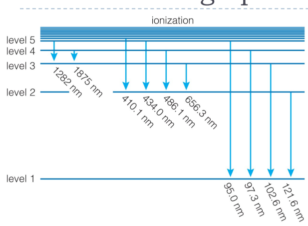
- A cloud of gas between us and a light bulb can absorb light of specific wavelengths, leaving dark absorption lines in the spectrum.

5.5 FORMATION OF SPECTRAL LINES



- Energy levels
  - ground state: An atom in it's lowest energy state
  - excitation: Atom absorbed energy thus, an electron is removed from atom "ionization"

Chemical Fingerprints



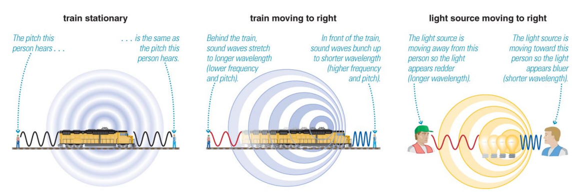
a Energy level transitions in hydrogen correspond to photons with specific wavelengths. Only a few of the many possible transitions are labeled.

c This spectrum shows absorption lines produced by upward transitions between level 2 and higher levels in hydrogen.

- Because those atoms can absorb photons with those same energies, upward transitions produce a pattern of absorption lines at the same wavelengths.

5.6 THE DOPPLER EFFECT

- The apparent change in wavelength or frequency of the radiation from a source due to its relative motion away from or toward the observer.

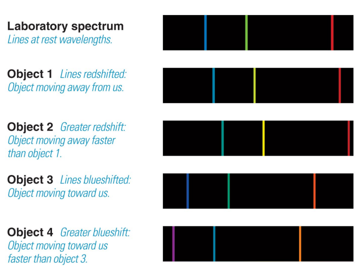


a The whistle sounds the same no matter where you stand near a stationary train.

b For a moving train, the sound you hear depends on whether the train is moving toward you or away from you.

c We get the same basic effect from a moving light source (although the shifts are usually too small to notice with our eyes).

Measuring the Shift



- Blueshift object is moving towards us.
- Redshift object is moving away from us.

Videos

- Dopler effect 5 min

Reading

- 5.1
- 5.2
- 5.3
- 5.5
- 5.6