Chapter 6. The Nature of Light

Note. In this section we describe some of the physical properties of light.

Note. Light acts as a wave. So we can talk about *wavelength* λ, velocity c, and frequency f. We then have $f = c/\lambda$. The units of these are:

Quantity	**Units**
wavelength	Angstrom Å$= 10^{-10}$ m
frequency	hertz = 1wave/sec = 1/sec
speed	$c = 300,000$km/sec $= 3 \times 10^8$m/sec

Note. The entire collection of wavelengths of "light" is called the *electromagnetic spectrum*. From longest to shortest wavelengths we have:

$$\text{radio} \longrightarrow \text{infrared} \longrightarrow \text{visible} \longrightarrow \text{ultraviolet} \longrightarrow \text{X-ray} \longrightarrow \gamma \text{ ray.}$$

In visible light, we have (longest to shortest:

red-orange-yellow-green-blue-(indigo)-violet

7000 Å 5000 Å 4000 Å

Note. Light displays both a particle and a wave nature. It undergoes *diffraction*, bending around sharp corners (in particular, slots). It carries energy in individual packets, called *photons*. Light can be *polarized* in which waves oscillate in parallel planes.

Note. Returning to the spectrum of light, we may have *continuous radiation* with a smooth transition from one color to another without the appearance of dark lines (*absorption lines*) or particularly bright lines (*emission lines*).

Note. Kirchoff's three laws help explain the occurrence of absorption lines and emission lines:

1. A hot, dense gas or solid produces a continuous spectrum.

2. A hot, rarefied gas produces emission lines.

3. A cool gas in front of a continuous source produces aborption lines.

Note. There can be certain areas that are brighter than others. The continuous radiation produced by the temperature of an object in its *thermal radiation*. *Wein's law* says that the wavelength of maximum emission is inversely proportional to the (absolute) temperature. So hotter objects emit light at shorter wavelengths ("blue is hotter than red"). So the color of a star is a good indicator of its temperature. The *Stefan-Boltzmann law* states that the total energy radiated per area is proportional to the fourth power of temperature. So if temperature changes a little, energy changes a lot. The total energy emitted by an object per second is called the *luminosity*.

Note. We now give a very brief description of the quantum theory of atoms. Consider a *model* of the atom in which the electrons orbit the nucleus in circular orbitals, and cannot be in between the orbitals. If an electron absorbs a photon (or quantum) of light of the proper frequency, it moves to a higher orbital (this is called *excitation*). If it absorbs a photon of sufficient energy, it may be removed from the atom (this is called *ionization*). Similarly, an electron may emit a photon and drip from a higher to a lower orbital.

Note. Light undergoes a *Doppler effect* much like sound. An approaching light source has a *blueshift* and a receding source has a *redshift*. If we measure this shift, then we can determine the radial velocity.

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