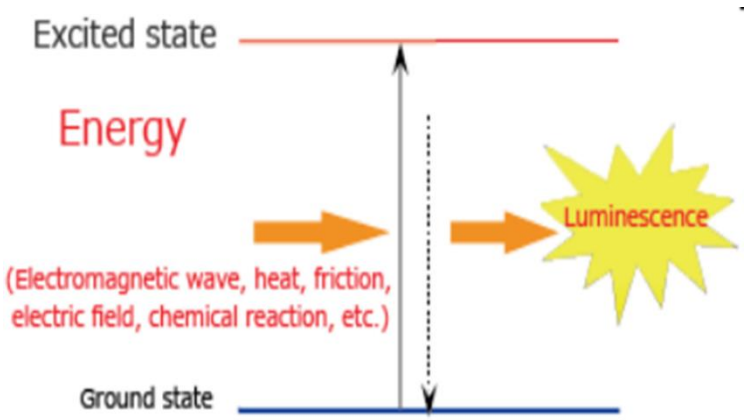
Electro-Magnetic Nature of Light

Light enables us to see things around us.

Sources of Light: Light is produced by one of two methods:

1) **Incandescence** is the emission of light from hot matter ($T \gtrsim 800$ K).
2) **Luminescence** is the emission of light when excited electrons fall to lower energy levels.

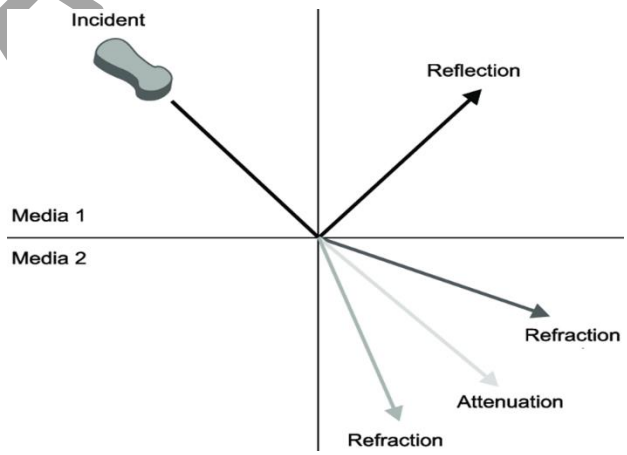


When an atom absorbs energy, its electrons become excited. The excited electron jumps to higher energy orbits. As the excited electron loses energy, it falls back to its original orbit and releases a photon. A photon is a packet of energy that contains the exact amount of energy absorbed by the atom.

The amount of energy a photon contains determines what type of light is emitted.

Theories of Light

The corpuscular theory of light was put forward by Descartes in 1637. It states that light is made up of small discrete particles called corpuscles (little particles) which travel in a straight line with a finite velocity.



Newton developed this theory in 1672. According to Newton;

a) Reflection occurs due to repulsion of light corpuscles from interface separating two media.
b) Refraction occurs because of attraction from the interface.

But the fact the light gets partially reflected and refracted from the interface separating two media could not be explained by the corpuscular theory.

In 1678, Huygens put forth the wave theory of light. Luminiferous (light-bearing) ether was the postulated medium for the propagation of light.

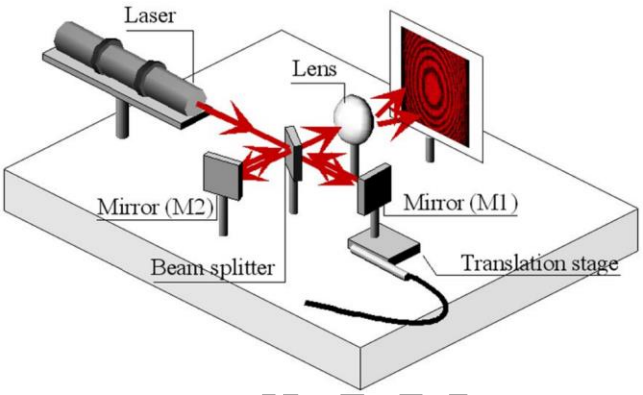
The speed of a longitudinal wave is given by;

$$c = \sqrt{\frac{B}{\rho}}$$

Here B is bulk modulus and ρ density of the medium.

The large value of speed of light meant the ether medium to have large bulk modulus (highly rigid) but at the same time extremely low density, which was not possible.

Michelson Morley Experiment



In 1887, Michelson and Morley built a device known as an interferometer to detect the ether. The experiment proved that the ether medium does not exist.

Young's double slit experiment (1801) verified wave-nature of nature.

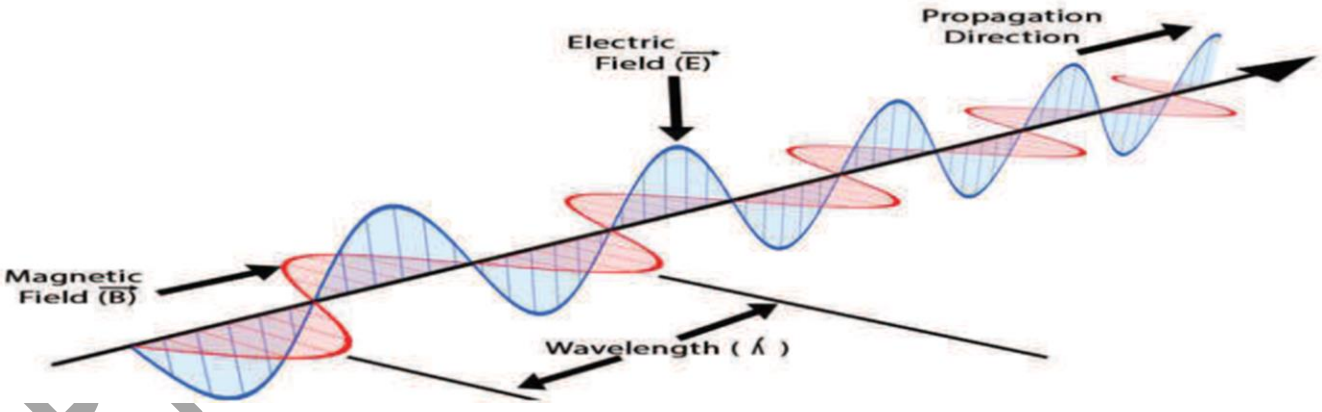
The first connection between electric and magnetic effects was discovered by Oersted in 1820 when he found that electric currents produce magnetic forces.

Soon after, Ampère developed a mathematical formulation (Ampère's law) relating currents to magnetic effects.

In 1831, Faraday discovered electromagnetic induction, in which a changing magnetic flux induces an electric current in a conducting circuit.

In the 1860s, James Clerk Maxwell unified the fields of electricity, magnetism, and optics. Maxwell described light as a propagating wave of electric and magnetic fields. More generally, he predicted the existence of electromagnetic radiation: coupled electric and magnetic fields traveling as waves at a speed equal to the known speed of light.

Electromagnetic waves represent propagating oscillations in the strengths of electric and magnetic fields.



In 1887, Heinrich Hertz succeeded in demonstrating the existence of long-wavelength electromagnetic waves. And showed that their properties are consistent with those of the shorter-wavelength visible light.

So, we conclude that light is a transverse, electromagnetic wave. Like all electromagnetic waves, light can travel through a vacuum.

The wave nature of light was first illustrated through experiments on diffraction and interference. The transverse nature of light can be demonstrated through polarization.