



Wave Theory Of Light

Theory of propagation of light energy: Energy can be transferred from one point to another in two different ways.

(1) Through a particle

(2) Through a wave (i.e. vibration of particles in the medium)

Wave: The mode of propagation of energy from one point to another through the vibration of the particles in the medium. The particles do not carry the energy leaving their position but simply vibrate about their mean position.

Propagation of light energy:

Newton corpuscular theory: According to Newton light energy propagates from one point to another in the form of particle. From the source of light very small tiny particles are emitted in all directions which travel with a tremendous speed 3×10^8 m/sec and when these corpuscles strike the retina of eye we feel the sensation of light. Newton attributed different colors to the different size of the corpuscles. With the help of corpuscular theory Newton could explain both the phenomenon of reflection and refraction but while explaining refraction Newton proved that the light would travel faster in a denser medium. But experimental results showed that light would travel slower in the denser medium. After few years phenomenon of interference and diffraction were discovered. Newton's corpuscular theory could not explain this phenomenon. Due to this failures Newton's corpuscular theory was discarded.

Huygens's wave theory of light: Huygens put forward his wave theory according to which light energy propagated in the form of wave, with the help of wave theory he could successfully explain the phenomenon of reflection and refraction, interference and diffraction all. But light was known to travel through vacuum & the definition of wave requires a material medium for its propagation. Hence Huygens had to assume the existence of an all pervading hypothetical medium known as luminiferous ether. The question was raised about the nature of light wave whether it is longitudinal or transverse.

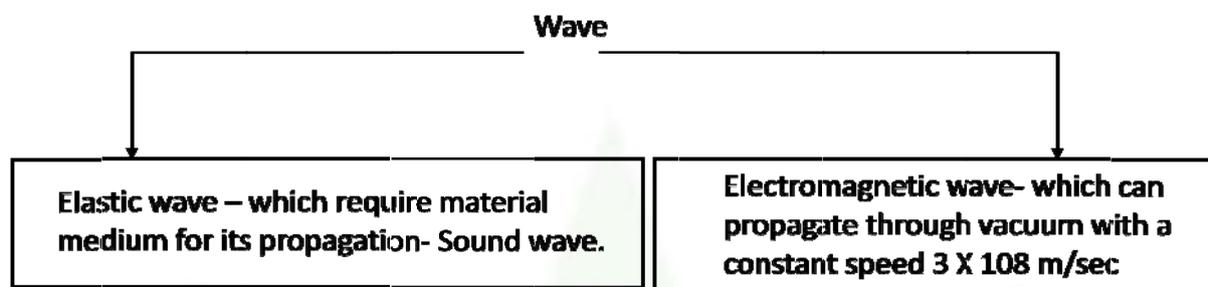
If the direction of vibration is along the direction of propagation it is known as longitudinal and if the direction of vibration is perpendicular to the direction of propagation it is known as transverse. Since the phenomenon of reflection, refraction, interference and diffraction all could be explained by longitudinal as well as transverse nature of wave hence Huygens could not arrive at any conclusion. Then phenomenon of polarization was discovered and Fresnel showed that polarization could only be explained by transverse nature of wave and not by longitudinal nature. Hence it was concluded that light is a transverse wave.

Michelson and Morley tried to detect ether medium but experimental results was negative with this result the wave theory of light became a very doubtful proposition. Maxwell in England was doing experiment on electromagnetic induction and there he found a new type of energy propagation which travel through the vibration of electromagnetic field vectors at right angle to each other and the vibration could pass through vacuum with a speed of 3×10^8 m/sec. This new wave was known as electromagnetic wave. Maxwell said that since light is travel through vacuum with a speed 3×10^8



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m/sec hence it must be electromagnetic wave. Thus light is an electromagnetic wave which can travel through vacuum and is transverse in nature.



Electromagnetic wave:

γ – ray | X – ray | visible | Infra red | Micro waves | Radio waves

$\lambda \rightarrow$ increases, $\nu \rightarrow$ decreases

Newton at the time of his death did not agree his corpuscular theory to be wrong. In 1905 a new phenomenon of light known as photo electric effect was discovered. Huygens wave theory of light could not explain this photo electric effect. Einstein then modified Newton's corpuscular theory with Planck's quantum mechanics and said that light energy was not ordinary particles but were quantum mechanical particles known as photon. Ordinary particles have non-zero rest mass but photon does not exist rest. A photon exist only when it carrying light energy and each photon can carry an energy

$h =$ Planks constant $= 6.625 \times 10^{-34}$ Jules Sec, $\nu =$ frequency of light.

Assuming light energy to travel in the form of photon, Einstein could explain the cause of photo electric effect (when light falls on certain substances electrons are emitted). This is known as Quantum theory of light (which is a modification of corpuscular theory with quantum ideas).

In 1924 Compton's effect in X ray was discovered Huygens's wave theory failed to explain Compton's effect but the quantum theory of light could explain successfully the Compton's effect. Then a question was raised wave theory or particle theory – which one was correct for the propagation of light energy? Scientists said both the theories to be correct and this was said to be the Dual Nature of Light i.e. light behave both as wave as well as particle.

In 1927 de-Broglie discovered matter waves according to de-Broglie hypothesis every moving particle is associated with a wave i.e. every moving particle is equivalent to a wave of wave length.



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$$\lambda = \frac{h}{mv}$$

$h = \text{Plank 's constant}$

$m = \text{mass of the particle}$

$v = \text{velocity of the particle}$

Thus there is no difference between wave and particle theory.