

DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J-Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module 3- Lecture-I

Inadequacies of Classical Mechanics & Introduction to quantum mechanics and Particle nature of light

Topics to be Discussed:--

Inadequacies of Classical Mechanics & Introduction to quantum mechanics

Particle nature of light

Inadequacies of Classical Mechanics

- ❑ The first scientific attempt to understand the nature of light radiation was that of Sir Isaac Newton who proposed the corpuscular theory of light.
- ❑ According to this theory, light consists of tiny perfectly elastic particles, called corpuscles which travel in all directions in straight lines with the velocity of light.
- ❑ It could not explain phenomena such as interference diffraction and polarization. It predicted that the velocity of light is more in a denser medium than that in a rarer medium.
- ❑ The theory that light is propagated as a wave through a hypothetical elastic medium called ether was developed by Huygens, Young and Fresnel.

- They considered light as propagation of mechanical energy. It got established as it could explain most of the experimentally observed phenomena including the velocity of light in different media.
- A completely different concept regarding the nature of light was proposed by Maxwell in the second half of the nineteenth century. According to him, light consists of electromagnetic waves with their electric and magnetic fields in planes perpendicular to the direction of propagation.
- The electric and magnetic fields associated with the wave are governed by Maxwell's equations. Prediction of Maxwell were confirmed experimentally by Hertz.

- The electromagnetic theory of light was received well though it had failed to explain phenomena such as photoelectric effect and emission of light.
- Then came a series of important experimental discoveries starting with X-rays in 1895, radioactivity in 1896 and electron in 1897, which could not be explained, on the basis of classical physics.
- In addition, lot of experimental observations starting with black-body radiation and optical spectra accumulated could not be explained by the classical theory.

Particle nature of light

- Max Planck a renowned German scientist found in 1900 that particular types of metals ejected free electrons on contact with light. This experiment duly dealt with the photoelectric effect. Later on, Albert Einstein followed upon this experiment and discovered the particle nature of light.
- According to the observations of the former, wavelength of light had a massive influence on the ejected electrons. Also, the intensity of light has a direct Impact on the electrons thus released. This fact pointed to the particle nature of light, which scientists previously considered as a wave.

What is Particle Nature of Light?

- Until 1900, physicists assumed that light travelled in the form of waves. However, the photoelectric effect experiment suggested that it also possesses energy packets.
- What we call ‘photon’ today is nothing but constituents of energy. It, in turn, helped them to arrive at the particle nature of light.
- Moreover, scientists such as Albert Einstein observed a few highlights mentioned below.
- ❖ Light sources with longer wavelengths contain lesser energy. This mainly refers to red and orange.

- ❖ Contrarily, shorter wavelengths contain higher photons or packets of energy.
- ❖ Consequently, wavelengths with higher energy content displaced a greater number of free electrons from metal surfaces.
- This last observation helped Planck find out that the frequency of a source of light was directly proportional to the radiation of such electrons.