S. S. College, Jehanabad

Course B.Sc(H) Physics

Subject : Optics

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Introduction

Optics is the branch of physics that studies the behaviour and properties of light, including its interactions with matter and the construction of instruments that use or detect it.

The subject of Optics can be divided into three areas:

- Geometrical Optics where light is described by rays which show the paths of energy transfer. Geometrical optics provides a good understanding of the propagation of light in transparent media and the operation of optical imaging systems such as cameras, telescopes and microscopes.
- Physical Optics where the wave nature of light is taken into account. Physical optics covers polarisation, interference and diffraction of light. The physical optics approach is necessary for understanding the limits of resolution of optical imaging systems.
- Quantum Optics where the particle nature of light is taken into account. This description, where light is considered to consist of massless particles called photons, is needed to understand fully the interaction of light and matter. Topics which require the quantum optics approach include the photoelectric effect, photodetectors and lasers.

History of Optics

Archytas (428 BC - 347 BC) was a Greek philosopher, mathematician, astronomer and statesman. It is said that he had propounded the idea that vision arises as the effect of an invisible 'fire' emitted from the eyes so that on encountering objects it may reveal their shapes and colours.

Euclid of Alexandria was a Greek mathematician who was born between the years of 320 and 324 BC. In his Optica (about 300 BC) he noted that light travels in straight lines and described the law of reflection. He believed that vision involves rays going from the eyes to the object seen and he studied the

relationship between the apparent sizes of objects and the angles that they subtend at the eye.

Hero (or Heron) of Alexandria (c. 10 - 70 AD) lived in Alexandria, Roman Egypt and was a teacher of mathematics, physics and mechanics at the University of Alexandria. He wrote Catoptrica which described the propagation of light, reflection and the use of mirrors.

Claudius Ptolemaeus (ca. 90 -ca. 168 AD) known in English as Ptolemy, was a Hellenistic mathematician and astronomer who lived in Roman Egypt. Ptolemy's Optics is a work which survives only in a poor Arabic translation and in Latin translation of the Arabic. In it, he wrote about properties of light, including reflection, refraction and colour. He also measured the angle of refraction in water for different angles of incidence and made a table of it.

Ibn al-Haytham (965-1039) (often called as Alhazen) was born in Basra, Iraq (Mesopotamia). Alhazen is considered as "father of optics" because of the tremendous influence of his Book of Optics.

Pierre de Fermat (August 17, 1601 – January 12, 1665) was a French mathematician and never went to college. In a letter to Cureau de la Chambre (dated January 1, 1662), Fermat showed that the law of refraction can be deduced by assuming that the path of a refracted ray of light was that which takes the least time! Fermat's principle met with objections. In May 1662, Clerselier, an expert in optics, wrote, "The principle you take as a basis for your proof, to wit, that nature always acts by the shortest and simplest path, is only a moral principle, not a physical one—it is not and can not be the cause of any effect in nature.".

Christiaan Huygens (April 14, 1629 – July 8, 1695) was a Dutch mathematician, astronomer, and physicist. In 1678, in a communication to the Academie des Sciences in Paris, he proposed the wave theory of light and in particular demonstrated how waves might interfere to form a wave front, propagating in a straight line. In 1672, Huygens gave the theory of double refraction which was discovered by Bartholinus in 1669. In 1690, he produced his famous book on optics Traite de la Lumiere; the English translation of the book is now available as a Dover reprint.

Sir Isaac Newton (January 4, 1643 – March 31, 1727) is considered one of the greatest figures in the history of science. In addition to his numerous contributions to science and mathematics, he made a systematic study of light and published it in the form of a book in 1704. In this book, Newton describes his experiments, first reported in 1672, on dispersion, or the separation of light

into a spectrum of its component colours. Grimaldi had earlier observed light entering the shadow of a needle—Newton explained this by saying that the needle exerts a force that "pulled" the light from the straight-line path. Hooke had earlier observed the colours from thin sheets of mica— Newton explained this by "fits of easy transmission and reflection" of the light rays.

Thomas Young (June 13, 1773 – May 10, 1829) was an English scientist. In 1801, Young demonstrated the wave nature of light through a simple two-hole interference experiment. Thomas Young used his wave theory to explain the colours of thin films (such as soap bubbles); and relating colour to wavelength, he calculated the approximate wavelengths of the seven colors recognized by Newton. In 1817, he proposed that light waves were transverse and thus explained polarization.

James Clerk Maxwell (June 13, 1831 – November 5, 1879) was an outstanding Scottish mathematician and theoretical physicist. Around 1865, Maxwell showed that the laws of electricity of magnetism can be described by four partial differential equations; these equations are known as Maxwell's equations and appeared in his book A Treatise on Electricity and Magnetism, published in 1873. Maxwell also predicted the existence of electromagnetic waves (which were later observed by Hertz) and showed that the speed of propagation of electromagnetic waves is approximately equal to the (then) measured value of the speed of light; this made him predict that light must be an electromagnetic wave. This synthesis represents one of the great scientific achievements of the nineteenth century.

Albert Einstein (March 14, 1879 –April 18, 1955) was an outstanding theoretical physicist. Einstein is best known for his theory of relativity and specifically mass-energy equivalence E = mc2 . Einstein in 1905 put forward that light consists of quanta of energy; this eventually led to the development of quantum theory. In 1917, in a paper entitled "On the Quantum Theory of Radiation," Einstein, while rederiving Planck's law, was able to predict the process of stimulated emission, and almost 40 years later, this prediction led to the development of the laser. He received the 1921 Nobel Prize in Physics for his services to Theoretical Physics, and especially for his explanation of the photoelectric effect.

Chandrasekhara Venkata Raman (November 7, 1888 – November 21, 1970) and **Kariamanikkam Srinivasa Krishnan** (December 4, 1898 – June 13, 1961) observed the Raman effect in several organic vapours such as pentane, which they called "the new scattered radiation." Raman made a newspaper announcement on February 29, and on March 8, 1928 he communicated a paper

entitled “A Change of Wavelength in Light Scattering to Nature,” which was published on April 21, 1928. Although in the paper he acknowledged that the observations were made by K. S. Krishnan and himself, the paper had Raman as the author, and therefore the phenomenon came to be known as the Raman effect although many scientists (particularly in India) kept on referring to it as the Raman–Krishnan effect. Subsequently, there were several papers written by Raman and Krishnan. Raman got the 1930 Nobel Prize in Physics for “his work on the scattering of light and for the discovery of the effect named after him.” At about the same time, Landsberg and Mandel’shtam (in Russia) were also working on light scattering, and according to Mandel’shtam, they observed the Raman lines on February 21, 1928. But the results were presented in April 1928, and it was only on May 6, 1928, that Landsberg and Mandel’shtam communicated their results to the journal Naturwissenschaften. But by then it was too late! Much later, scientists from Russia kept calling Raman scattering as Mandel’shtam–Raman scattering. For a nice historical account of Raman effect, see Ref. 30. In 1928, the Raman effect was discovered; 70 years later it has become an important mechanism for signal amplification in optical communication systems. Today we routinely talk about Raman amplification in optical fibers.

Sources

Wikipedia

Optics by Ajoy Ghatak