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The nature of light

Light is everywhere. It extends from the large scale of the universe into our ordinary world. However, the physical understanding of the most common phenomenon, the light, has involved significant scientific ideas: classical mechanics, wave theories, quantum particles, relativity. Some of the greatest physicists made definitive studies on the nature of light.


Figure 1

In 1666, Isaac Newton performed the best-known experiment in the history of light: he inserted a glass prism into a sunbeam and he observed that the white light was separated into a rainbow of colours (figure 1). He noticed that what split the colours in the prism was the process of refraction, which causes light rays to bend as they move from one medium, such as air, to another, such as glass. The first theory of light was born. He stated that the light consists of little, hard particles which obey the same laws of motions as planets do. The colours are explained by supposing that the light particles have different sizes; red light particles are the largest and violet ones are the smallest. He explained refraction as a pull near the surface of separation between two medium that changes the trajectory of a light particle. His theory also implied that the speed of light in water would be greater than in the air.[1] However, in 1850, Foucault conducted an experiment that showed that light travels more slowly through water than through air and hence a key prediction of Newton's corpuscular theory of light is wrong.[2]

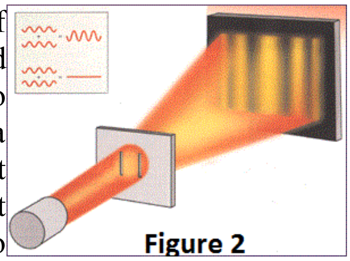
Figure 2

In the early 1800s, Thomas Young shone red light on a pair of closely-spaced slits in an opaque card. A striking feature appeared on the wall: although there were only two slits, more than two bright lines appeared (figure 2). If we suppose that the light is a periodic wave of some sort, we can make sense of the many bright lines. Where the waves interfered constructively it produced bright lines, and where the waves interfered destructively it produced no light.[3] Thus, he showed that light has wavelength properties. Each colour in the rainbow corresponds to a specific wavelength. The weakness of the this theory was that light waves, like sound waves, would need a medium for transmission. A hypothetical substance called ether was proposed, but its existance was cast into strong doubt by the Michelson-Morley experiment[4]. However, the solution came when Maxwell presented his electromagnetic theory. The speed of the electromagnetic wave was so close to the speed of light that it seemed a strong reason to conclude that light itself is an electromagnetic wave.[5]

Finally, after discovering the photoelectric effect and developing the concept of photon, the genius of Einsten was that he acknowledged that, perhaps, both theories about light are correct. Newton showed that light has particle properties and Young showed that light has wavelength properties, and the two are different manifestations of the same thing. The two pictures, light as a wave and light as a particle complement each other. This complementarity is called the wave-particle duality.[6]

Therefore, light is a more complicated phenomenon than any other that our everyday concepts can describe. It took the combined effort of many geniuses across three centuries to understand its nature. Einstein himself refered to it: "*For the rest of my life I will reflect on what light is*".[7]

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References

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