The Nature of Light

(with Keith Hannabuss)

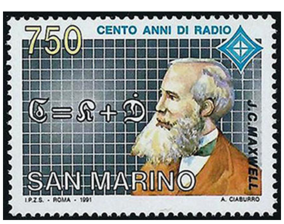
In 1831, Michael Faraday's experiments led to the discovery of electromagnetic induction, whereby electricity is induced by changes in a magnetic field.

Using the most advanced vector methods of his day, **James Clerk Maxwell** (1831–1879) synthesized Faraday's laws of electromagnetism into a coherent mathematical theory, confirming Faraday's intuition that light consists of electromagnetic waves. Maxwell's 1873 book *Electricity and Magnetism* contained his fundamental mathematical laws of electromagnetism (**Maxwell's laws**) and predicted the existence of such phenomena as radio waves. In 1888, **Heinrich Hertz** (1857–1894) confirmed this; his "Hertzian waves" later formed the basis of Marconi's work on radio telegraphy.

Hendrik Lorentz (1853–1928) showed how Maxwell's electromagnetic waves interact with matter consisting of atoms within which are distributions of electric charge. He predicted that magnetic fields modify the spectral lines of atoms, and this was confirmed by his pupil Pieter Zeeman, with whom he shared the 1902 Nobel Prize in Physics.

Maxwell's electromagnetic theory of light and experiments on the newly invented light bulb led scientists to consider how atoms emit light. At first, it seemed that all light should have very high frequency. Reconciling theory with experiment, **Max Planck** (1858–1947) announced the first steps toward "quantum theory" by postulating that atoms can emit light only in small packets (called "quanta") whose energy E is proportional to their frequency v. Thus $E = hv$, where h is "Planck's constant."

In 1905, **Albert Einstein** explained the "photoelectric effect," that light behaves like particles and can liberate electrons on impact with a metal surface. His paper, which led to his 1921 Nobel Prize in Physics, showed that Planck's equation $E = hv$ is a fundamental feature of light itself rather than of the atoms.



James Clerk Maxwell

One of Maxwell's laws

Heinrich Hertz

Hendrik Lorentz

Max Planck

Einstein's photoelectric effect

Planck's constant

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