Topic Page: Planck, Max (1858 - 1947)

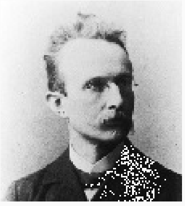

Image from: **Max Planck in 1895** in *The Cambridge Dictionary of Scientists*

Summary Article: **Planck, Max Karl Ernst Ludwig (1858-1947)**
From *The Hutchinson Dictionary of Scientific Biography*

Place: Germany

Subject: biography, physics

German physicist who discovered that energy consists of fundamental indivisible units, which he called quanta. This discovery, made in 1900, marked the foundation of the quantum theory that revolutionized physics in the early 1900s. For this achievement, Planck gained the 1918 Nobel Prize for Physics.

Planck was born in Kiel on 23 April 1858. In 1867, his family moved to Munich, where Planck studied at the Maximilian Gymnasium before entering the University of Munich in 1874. Planck studied mathematics and physics, spending some time 1877-78 with Gustav Kirchhoff and Hermann von Helmholtz at the University of Berlin. Planck gained his PhD at Munich with a dissertation on thermodynamics in 1879 and became a lecturer there in the following year. In 1885, he was appointed extraordinary professor of physics at Kiel and then in 1888 moved to Berlin, where he became assistant professor of physics and director of the newly founded Institute for Theoretical Physics. Planck rose to become professor of physics at Berlin in 1892, a position he retained until 1926. In 1930, he was appointed president of the Kaiser Wilhelm Institute but resigned in 1937 in protest at the Nazis' treatment of Jewish scientists. In 1945, the institute was renamed the Max Planck Institute and moved to Göttingen. Planck was reappointed its president, a position he retained until he died in Göttingen on 4 October 1947.

In 1862, Kirchhoff had introduced the idea of a perfect black body that would absorb and emit radiation at all frequencies, reaching an equilibrium that depended on temperature and not the nature of the surface of the body. A series of investigations were then undertaken into the nature of the thermal radiation emitted by black bodies following the discovery by Josef Stefan in 1879 that the total energy emitted is proportional to the fourth power of the absolute temperature. Measurements of the frequency distribution of black-body radiation by Wilhelm Wien (1864-1928) in 1893 produced the result that the distribution is a function of the frequency and the temperature. A plot of the energy of the radiation against the frequency resulted in a series of curves at different temperatures, the peak value of energy occurring at a higher frequency with greater temperature. This may be observed in the varying colour produced by a glowing object. At low temperatures, it glows red but as the temperature rises the peak energy is emitted at a greater frequency, and the colour become yellow and then white.

Wien found an expression to relate peak frequency and temperature in his displacement law, and then attempted to derive a radiation law that would relate the energy to frequency and temperature. He discovered a radiation law in 1896 that was valid at high frequencies only, while Lord Rayleigh later found a similar equation that held for radiation emitted at low frequencies. Planck was able to combine these two radiation laws to arrive at a formula that represented the observed energy of the radiation at any given frequency and temperature. This entailed making the assumption that the energy consists of the sum of a finite number of discrete units of energy, which he called quanta, and that the energy ε of each quantum is given by the equation $\varepsilon = h\nu$, where ν is the frequency of the radiation and h is a constant now recognized to be a fundamental constant of nature and called Planck's constant. By thus directly relating the energy of a radiation to its frequency, an explanation was found for the observation that radiation of greater energy has a higher frequency distribution.

Classical physics had been unable to account for the distribution of radiation, for Planck's idea that energy must consist of indivisible particles was revolutionary, totally contravening the accepted belief that radiation consisted of waves. But it found rapid acceptance because an explanation for photoelectricity was provided by Albert Einstein in 1905 using Planck's quantum theory, and in 1913, Niels Bohr applied the quantum theory to the atom and evidence was at last obtained of the behaviour of electrons in the atom. This was later developed into a full system of quantum mechanics in the 1920s, when it also became clear that energy and matter have both a particle and wave nature. Thus the year 1900 marked not only the beginning of a new century but, with the discovery of the quantum theory, the end of the era of classical physics and the founding of modern physics.

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