Planck's Constant Encyclopedia Article

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Light emitted by a heated solid object is a well-known phenomenon: even before he age of modern science, alchemists noted the correlation between an object's **temperature** and the kind of light it emitted. For example, if a metal object was being heated, a red glow gradually turned to white as the temperature increased.

Max Planck (1858-1947) was the first to notice, in 1900, a characteristic regularity in the behavior of heated objects. Assuming that the atoms of a particular heated object will vibrate at a particular frequency *v*, Planck noticed that only certain **energy** levels were possible. These energy levels could only be captured if the value of *v* was multiplied by a whole number (*n* and a constant (*h*) whose value was 6.63 10 ^{34} J. The upshot of Planck's discovery was that atoms, unlike objects in the macroscopic world, obeyed energy constraints that could only be explained in terms of a physical constant multiplied by a whole number. As Darrell D. Ebbing a Steven D. Gammon explained, under similar constraints, a car would, for example, increase its speed only by increments of five miles per hour: from zero to five, from five to ten, and so on. In other words, a speed of, say, seven miles per hour would be impossible. The quantum rule may seem unreasonable in our world; in the atomic world, however, energy levels are determined by Planck's constant.

While Planck himself was somewhat uncomfortable with his discovery, younger scientists quickly grasped the universality of Planck's constant. Thus, **Albert Einstein** (1879-1955) posited that Planck's formula $E = hv$ could be applied to light. According to Einstein, Planck's formula accurately expresses the wave-particle duality of light: *E* represents the energy of a light particle (photon), and *v* represents the frequency of light as a wave. By introducing the concept of light particle, or **photon**, in 1905, Einstein explained the **photoelectric effect**, or the process whereby an object emits electrons when exposed to light. Einstein theorized that electrons are ejected by photons. According to Einstein, the photoelectric effect clearly manifests the dual nature of light: light approaches an object as a particle (photon) but is absorbed as a wave by the **electron** that is about to be ejected. Following Einstein's insight, scientists later realized that the wave-particle duality applied to **subatomic particles** in general.