A BRIEF EARLY HISTORY OF **QUANTUM PHYSICS**

QUANTUM PHYSICS

Historically
Wave or particle?

In the 17th Century, the works of Isaac Newton and Rene Descartes have debated whether light was a particle or a wave.

1801
Young's Double Slit experiment

Thomas Young's Double Slit experiment showed light to diffract and interfere, two well understood properties of waves.

Interference and diffraction

The ability of waves to diffract around objects and constructively and destructively interfere with one another.

1862
Electromagnetic waves

James Clerk Maxwell demonstrated that electric and magnetic fields travel through space as waves propogating at the speed of light. He stated his conclusion that light was a "transverse undulation" of the same medium from which electric and magnetic phenomenon arise.

1887
Photoelectric effect

Heinrich Hertz first documented the photoelectric effect in 1887. The results contradicted those expected by classical wave theory. A new physical model was needed.

Classical wave theory predictions

1. The intensity of the radiation should have a proportional relationship with the resulting maximum kinetic energy.
2. The photoelectric effect should occur for any light, regardless of frequency or wavelength.
3. There should be a delay on the order of seconds between the radiation's contact with the metal and the initial release of photoelectrons.

Experimental results

1. The intensity of the light source had no effect on the maximum kinetic energy of the photoelectrons.
2. Below a certain frequency, the photoelectric effect does not occur at all.
3. There is no significant delay between the light source activation and the emission of the first photoelectrons.

1900
Blackbody radiation

Lord Rayleigh and Sir James Jeans presented the Rayleigh-Jeans law, which describes how an ideal blackbody will emit thermal radiation within a narrow band of wavelengths.

It also predicted the total power emitted would become unlimited at the ultra-violet frequencies. This came to be known as the ultraviolet catastrophe. Another piece in the puzzle.

A perfect black object capable of absorbing all frequencies of electromagnetic radiation.

1900
Plank's quantisation: the beginning of Quantum Mechanics

Separate from the ultraviolet catastrophe, Max Planck postulated that energy could only be emitted or absorbed in discrete packets or quanta.

The energy will be proportional to the frequency of the radiation $E=hf$.

1905
Einstein's debut

Albert Einstein continued from Planck's theory of blackbody radiation and postulated that the energy carried by light was not distributed across the wavefront but is a localised bundle, later named the photon.

He completed the theory of the photoelectric effect: single electrons are ejected by single photons and the excess of energy is transferred to the electron's movement.

1915
Millikan's confirmation

Robert Millikan disagreed with Einstein's photon but through experiment, verified it.

He also verified Planck's constant, h, through the photoelectric effect.

1924
de Broglie's Matter waves

In his Phd thesis Louis de Broglie suggested that light was not the only thing in nature that exhibited wave-particle duality. He proposed that all "particles" have an associated wavelength.

1927
Electron diffraction

Clinton Davisson and Lester Germer conducted the Davisson-Germer experiment, where an electron beam was fired at a nickel crystal and a diffraction pattern similar to that of a wave was first observed with light. This was the first confirmation of de Broglie's "matter waves".

1927
Heisenberg's Uncertainty principle

Werner Heisenberg derived the uncertainty principle - if a system is measured in one variable (position), measurements in a related variable (momentum) become uncertain. This is a property of the inherent "fuzziness" of nature, not how well the experimentalist can measure!

There have been other significant discoveries in quantum physics including quantum entanglement, quantum tunnelling and quantum electrodynamics. Applications of quantum physics include the laser, the transistor and the semiconductor, which can be found in modern electronics such as the smartphone. Where will quantum physics take us next?

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