A Brief History for Unit 16

- 1865: James Clerk Maxwell proposed **that light travels as electromagnetic waves**. This unified electrical and magnetic phenomena into electromagnetism. He also determined that the speed of light in a vacuum is 3E8 m/s.
- 1887: Heinrich Hertz, exploring Maxwell's theories, first observes the **photoelectric effect** when he found that charged objects lose their charge quickly when exposed to radiation.
- 1887: A.A. Michelson and E.W. Morley devised an experiment that showed that the speed of light in air is *not* different in different inertial reference frames. In other words, regardless of the perspective from which light is observed, **the speed of light is always the same**.[1] This suggested to Einstein that light must be viewed differently with regard to reference frame.
- 1895: Wilhelm Röntgen discovered a new type of radiation, x-ray radiation. In 1901 he won the first Nobel Prize in Physics for this.
- 1897: J.J. Thomson determined the **ratio of charge and mass of an electron** using cathode ray tubes. He believed atoms were homogeneous positively-charged objects with electrons moving around inside of them.
- 1897: J.S. Townsend, Thomson's student, roughly estimated the **charge of an electron**.
- 1900: **Max Plank** determined that **all particles emit radiation in quantized amounts** according to the formula $\boldsymbol{E = nhf}$.
- 1905: **Albert Einstein** proposed that when particles emit radiation, the radiation takes the form of small quanta of energy, which he called "the light quanta," now called **photons**. He determined that photon energy is related to frequency by the formula $\boldsymbol{E = hf}$**.** In this year, Einstein also published his work on his **Special Theory of Relativity**.
- 1909: Robert Millikan determined the charge and mass of the electron and proposed that it was the smallest charge. Therefore all **charge was quantized** in amounts equal to whole integer multiples of this **fundamental charge,** $\boldsymbol{e}$.[2]
- 1909: Ernest Rutherford in his gold-foil experiment determined that the positive charges exist in a nucleus. He suggested that electrons orbit this nucleus in a planetary model, and that an atom is

[1] This is in regard to the speed of light in a vacuum and does not refer to the fact that light slows down in different materials, à la refraction.

[2] Local connections: MIlikan's doctoral advisor was Albert Michelson, who in 1887 conducted an experiment to measure the speed of light while working at Case School of Applied Science with Edward Morely, who worked at Western Reserve University. They performed their experiment in a dormitory at what is now CWRU! (Sadly, the dormitory was demolished in the 1960s.) In addition, Milikan went to Oberlin College for his undergraduate degree!

mostly space. (However, if orbiting electrons emit radiation, as Plank proposed, they should decelerate and crash into the nucleus…problem!)

- 1913: **Niels Bohr** extended Rutherford's model of the atom and Plank's idea of quantized charge to suggest that **electrons orbit in quantized orbits** where their energy is constant. **Electrons emit photons when they move from a higher energy orbit to a lower energy orbit**.
- 1915: Albert Einstein published his General Theory of Relativity, which extended his special theory to accelerated reference frames and related gravity to aspects of special relativity.
- 1923: **Arthur Compton confirmed the photon nature of light** by demonstrating what is now called the **Compton effect**. He determined that photons have momentum according to their wavelengths: $\boldsymbol{\lambda = \frac{h}{p}}$
- 1923: **Louis de Broglie**, 7th duc de Broglie, hypothesized that Bohr's quantized electron orbits exist because **electrons act as waves** within the atom and can only orbit in stable orbits of radii that allow closed standing waves. He continued that if electrons act as waves, **all particles act as waves**, extending Compton's formula to matter: $\boldsymbol{\lambda = \frac{h}{p}}$
- 1926: **Erwin Schrödinger** published four incredibly influential papers establishing the role of probability in quantum mechanics.
- 1927: **C.J. Davisson and L.H.Germer** scattered electrons off of a metal crystal and observed a diffraction pattern, experimentally indicating that the electrons behaved as waves. This **confirmed de Broglie's hypothesis**. **G.P. Thomson** (J.J. Thomson's son) performed a similar experiment with equally conclusive results.

Disclaimer: There were a LOT more people who were making major contributions during these years. The history shared here only hits on the biggest historical events related specifically to our unit 16 topics.