Quantum Ideas – Max Planck starts it all!

Newtonian physics ruled until about 1900. Then...the troubling Black Body Radiation problem. (Don't worry about the specifics of the 'UV catastrophe'; suffice it to say that Classical Physics could not explain this phenomenon.

Black Body Radiation

When things heat up, they emit light in a predictable way.

$$\lambda_{max} = \frac{2.898 \times 10^{-3}}{T}$$

where T = temp in Kelvinb

°C + 273 = °K

λ_{max} = peak wavelength emitted

There was a problem with this formula in the UV area. ('UV catastrophe') Max Planck was working on this problem and found a mathematical solution.

Solution: Energy can only be emitted in discreet bundles or 'quanta'. Each wavelength in the EMR has a specific quantum of energy. **Quantum** = discrete bundle of energy. This was revolutionary.

Planck's formula

$$E = hf$$

where E = Energy (J)

h = Planck's constant 6.626×10^{-34} J•s

f = frequency (Hz)

$c = 3.0 \times 10^{8}$ m/s

When you plug in universal wave equation for f, you also get: ($f = v\lambda$ or $f = c\lambda$)

$$E = hc/\lambda$$

These 2 formulas calculate how much energy is in a bundle of EMR. It calculates the size of the energy quanta based on the wavelength of the electromagnetic radiation.

Example: Red light has a wavelength 660 nm. What is the size of the quanta emitted by a red laser?

$\lambda = 660\ nm = 6.60 \times 10^{-7}\ m$ $h = 6.626 \times 10^{-34}$ J•s $c = 3.0 \times 10^{8}$ m/s

$$E = \frac{6.626 \times 10^{-34} \times 3.0 \times 10^{8}}{6.60 \times 10^{-7}}$$

$E = 3.0 \times 10^{-19}$ J in each quantum of red light.

Einstein coined the term ‘photon’ to mean a quantum of light energy. So, a red laser of 660 nm emits photons with 3.0×10^{-19} J of energy each.

Max Planck was troubled by his discovery and thought someone else would discover what was truly going on. However, he did start the age of quantum physics! He earned the Nobel Prize for his work in 1918.