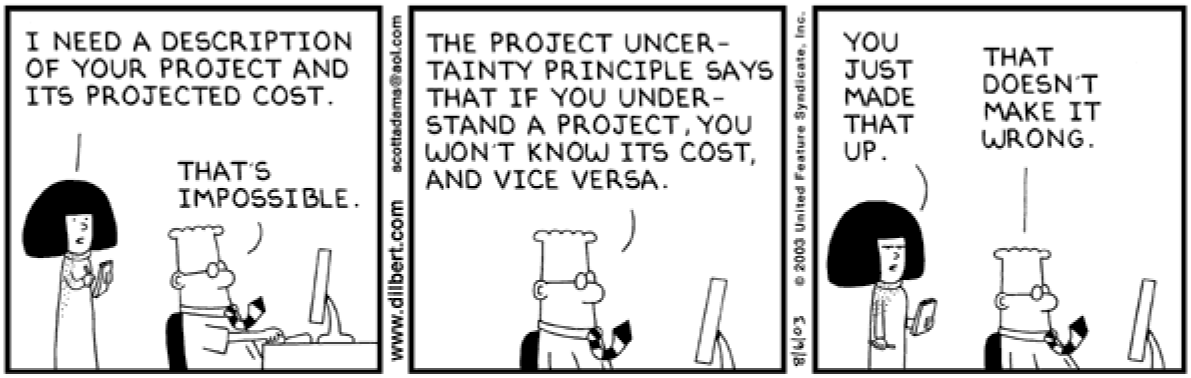
Heisenberg's Uncertainty Principle

Scientists soon abandoned the well-established classical physics, otherwise known as **Newtonian mechanics**, and adapted it with the new physics of **Quantum mechanics**. A world where energy was quantized, light and particles behaved both as waves and particles, energy and mass were equivalent, and that space and time were relative concepts. Another ground breaking theory was on the horizon.



Uncertainty Principle

Werner Heisenberg, in 1927, proposed a new way of looking at systems. He theorized that there is always some **inherent uncertainty** in the determination of a particles **momentum and position**. The uncertainty was inherent and originated from the quantum-mechanical nature of subatomic particles.

In general terms, the momentum and position of a particle cannot be known simultaneously to a 100% degree of accuracy. The better you measure a particles momentum, the less you know about its position (where it is). The better you measure a particles position, the less you know about its momentum (i.e. where it's going and how fast).

This uncertainty can be expressed mathematically as:

$$\boxed{\Delta x \Delta p \geq \frac{h}{4\pi}}$$

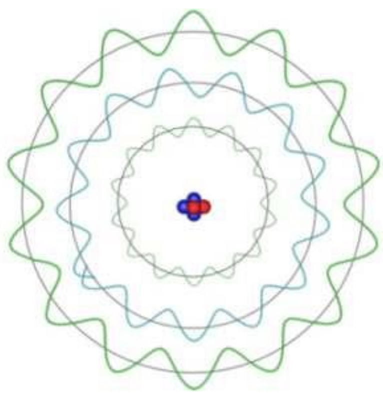
Where, Δx is the uncertainty in the particles position, and Δp is the uncertainty in its momentum and h is Planck's constant.

Probability vs. Determinism

Newtonian mechanics dealt with absolutes and determinism. Given enough information about a system and the forces acting on it, the future speed and position of the particles could be calculated. Everything could be determined from the beginning state. The contrary is true about the real world and quantum-mechanics. Because the exact position and momentum of a particle cannot be known at the same time (to an accuracy better than $\frac{h}{4\pi}$) this means that the world is subject to probability and chance. This means that even if you did know the initial speeds and momentums of all the particles in the universe (which is not possible in this model) you would not be able to determine their exact future positions and momentums which means that the future state of the universe cannot be known absolutely.

Quantum Model of the Atom

The quantum model of the atom makes sense in terms of resonance and the wave-nature of particles (i.e. Electrons). Electrons have a wavelength associated with its energy and thus only certain energy values (wavelengths) will “fit” or resonate within an orbit. **The wavelength of the electrons must fit in integer values of the circumference of the orbit.** This worked with the quantum view of the atom and lead to Bohr’s Theory for the atom.



Orbitals and Probability

Electrons <u>do not</u> orbit the atom in circular paths! Electrons exist rather in defined discrete energy levels with different shapes based on **Schroedinger’s Equations** (based on Wave-functions). Electrons exist is probability density clouds. High probability regions of electron position can be defined where the electron (based on its energy) is most likely to be found.