Quantum Computing

Quantum Computer:

a computer that utilizes the quantum states of subatomic particles to store information

What’s The Main Difference?

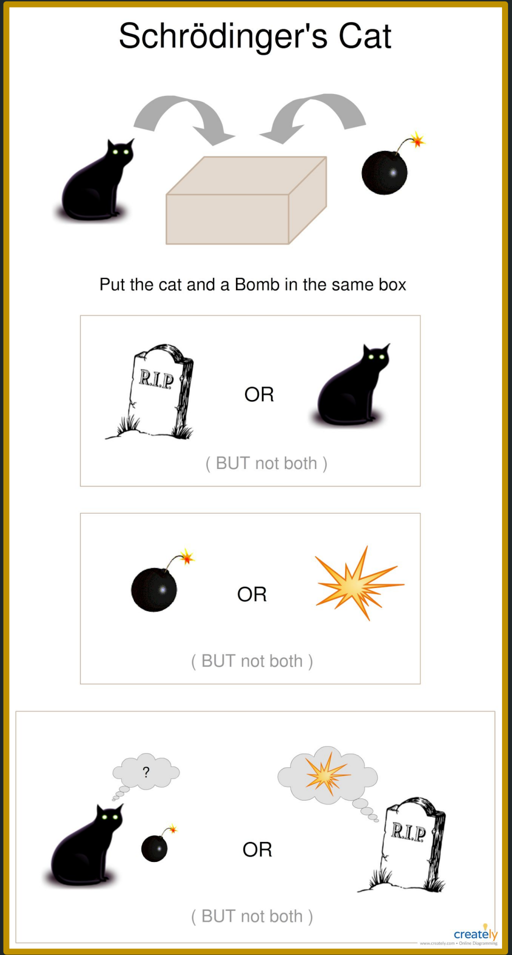
- All computers code in binary
- Classical (regular) computers program using **bits** - 0 & 1
  - 0 means no electricity through a wire, 1 means electricity
  - 8 bits make a byte, 1024 bytes make a kilobyte (KB), etc.
- Quantum computers use **qubits**
  - It could be 0, 1, or any combination of both until collapsed
  - This means much more information can be stored

How Do Qubits Work?

- The electron going through the wire can be in a **superposition**
  - The state of being in two or more quantum states at once
- It remains superimposed until observed, when it collapses into a 0 or 1
  - Completely random, except if the superposition is in a ratio
- Observation in quantum mechanics: when the particle can’t be superimposed to interact with an instrument
  - We never see the superposition, just what it collapses into after passing through a filter
- A superposition is created in two different ways:
  - **Spin**
  - **Photon polarization**

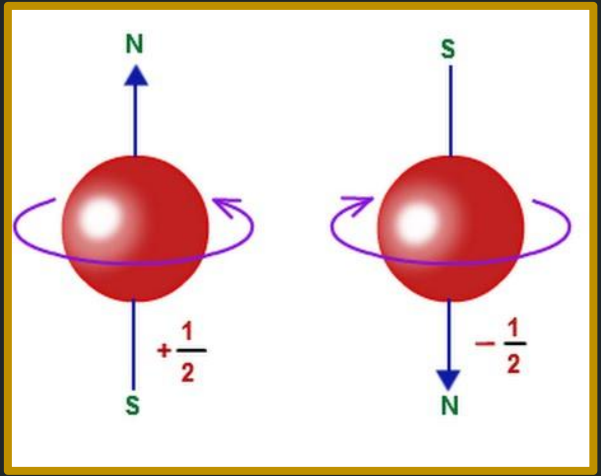
What is Schrödinger's Cat?

- A thought experiment created by Erwin Schrödinger
- The cat is placed into a box with a dangerous object
    - 50% likely to kill the cat, 50% likely to not kill the cat
- Until observed, the cat is in a “superposition” of being alive and dead
- An analogy for quantum superposition



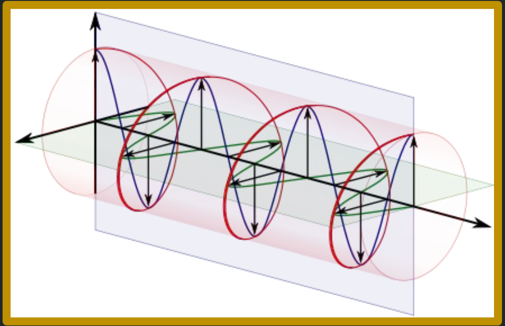
What Is Spin?

- **Spin:** the description of a tiny magnetic field created by the apparent spin of a subatomic particle
- Electrons have two spins:
  - Spin up
  - Spin down
- Like how the Earth spinning creates a magnetic field



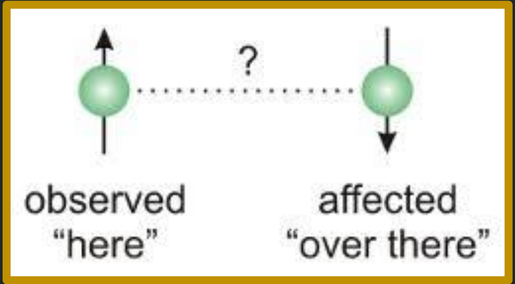
What Is Photon Polarization?

- **Photon Polarization:** the spin of a photon
- Two types of polarization:
  - *Right* or *left* **circular** polarization: direction of the electric field vector rotation
  - *Horizontal* or *vertical* **linear** polarization: direction of the electric field vector
- Reason why waves can reflect light differently - based on the polarization



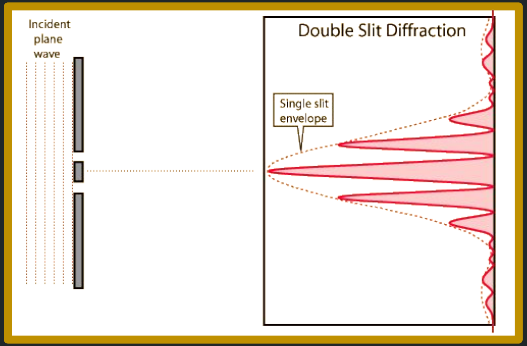
What is Entanglement?

- **Entanglement:** when the quantum states of two particles are linked
- If two electrons are entangled, then that means two qubits are linked before they collapse
  - $a = 0 \therefore b = 1$; $a = 1 \therefore b = 0$
  - The causation is faster than the speed of light
- This allows for two data sets to be linked with less data, or for two calculations to occur simultaneously



What is Interference?

- **Interference:** elementary particles can be in a superposition of places and interfere with another one of its own trajectories
- Illustrated in the **double slit experiment**
  - All possible paths of a single photon interact with each other, creating stripes of light and dark



What Can We Use Quantum Computers For?

- To compute with large numbers
- To crack classical encryption
  - Encryption is based on finding prime factors (keys) of a *very* large number
- To possibly can create more advanced encryption
- To search through large databases quickly

When Will We Have Them?

- We already have quantum computers, not very fast though
- By the 2020s, quantum computers will be MUCH better
- In use by governments in the 2030s
- Commercial quantum computers available in the 2040s