Quantum Workforce Development

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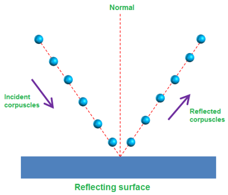
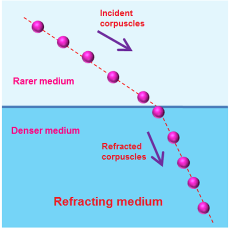
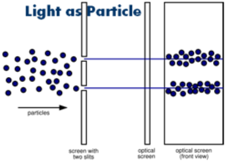
Light - a particle or a wave

Corpuscular Theory of Light

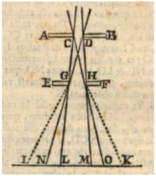
In 1675, Sir Isaac Newton hypothesized that light was made up corpuscules (small particles) with the size/mass of the corresponding to different colors.

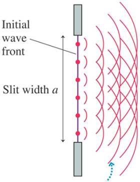






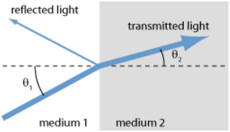
Huygens Principle

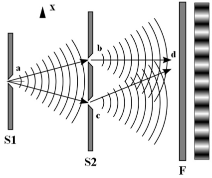




- Francesco Maria Grimaldi (mid-1600's) made accurate observations of the diffraction of light.
- In 1678, Christian Huygens, in order to explain the diffraction of light, proposed that every point on a wavefront (of light) is a wavelet that spreads.

Fresnel and Young





- In 1815, Augistine Jean Fresnel devleoped the laws of reflection and refraction.
- And, in 1817, Thomas Young calculated the wavelength of light

Maxwell's Equations: Electric $\vec{E}$ and Magnetic $\vec{B}$ Fields

In 1864, James Clerk Maxwell predicted electromagnetic waves

- Gauss's Law: $\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$, where ρ is enclosed charge
- Guass's Law for Magnets: $\nabla \cdot \vec{B} = 0$
- Farday's Law: $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
- Ampere's Law: $\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

where
$\mu_0 = 4\pi * 10^{-7} \frac{F}{m}$ and $\epsilon_0 = 8.85 * 10^{-12} \frac{Nm^2}{C}$

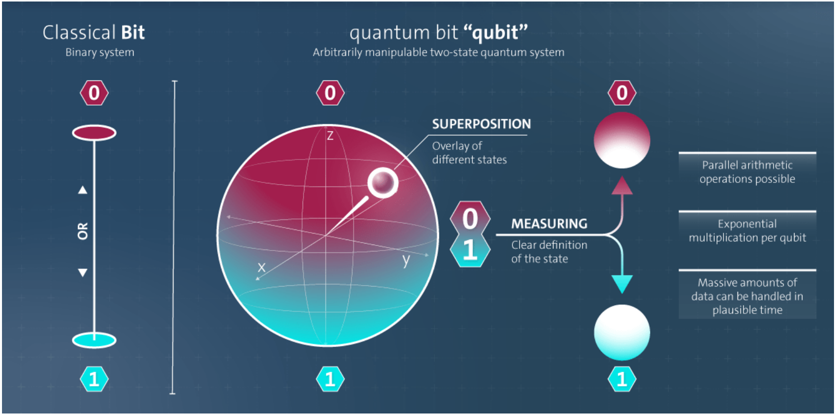
Maxwell noted that the speed of the electromagnetic wave is equal to the speed of light:
$$\frac{1}{\sqrt{\mu_0 \epsilon_0}} = \frac{1}{\sqrt{4\pi * 10^{-7} \cdot 8.85 * 10^{-12}}} = 2.99 * 10^8 \frac{m}{s} = c$$

Intro to Quantum Phenomenon

Let there be light

What is a Qubit

Bit vs Qubit


Classical Bit
Binary system
0
OR
1
quantum bit "qubit"
Arbitrarily manipulable two-state quantum system
0
z
x
y
1
SUPERPOSITION
Overlay of
different states
0
1
MEASURING
Clear definition
of the state
0
1
Parallel arithmetic
operations possible
Exponential
multiplication per qubit
Massive amounts of
data can be handled in
plausible time

Quantum Computing

Types of Quantum Computers

- Superconducting
- Photonic
- Neutral Atom
- Trapped Ion
- Quantum Dots
- Diamond Nitrogen Vacancies

Quantum Computing: Superconducting

One of the most popular types of quantum computers is a superconducting qubit quantum computer. Usually made from superconducting materials, these quantum computers utilize tiny electrical circuits to produce and manipulate qubits. When using superconducting qubits, gate operations can be performed quickly.

Companies actively researching and manufacturing superconducting quantum computers include Google, IBM, IQM and Rigetti Computing to name just a few.

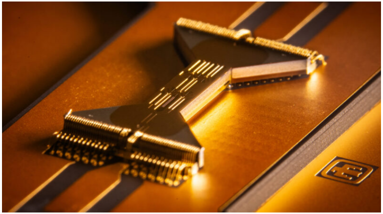
Quantum Computing: Photonics

These types of quantum computers use photons (particles of light) to carry and process quantum information. For large-scale quantum computers, photonic qubits are a promising alternative to trapped ions and neutral atoms that require cryogenic or laser cooling.

Quantum Computing: Neutral Atom

Quantum computing based on neutral atoms involves atoms suspended in an ultrahigh vacuum by arrays of tightly focused laser beams called optical tweezers, though not all neutral atom companies use optical tweezers. Neutral atom quantum computers are less sensitive to stray electric fields, which makes them a good option for quantum processors.

Trapped Ions



A trapped ion quantum computer involves using atoms or molecules with a net electrical charge known as "ions" that are trapped and manipulated using electric and magnetic fields to store and process quantum information. As trapped ions can be isolated from their environment, they are useful for precision measurements and other applications requiring high levels of stability and control. Also, the qubits can remain in a superposition state for a long time before becoming decoherent. Representing the trapped ions community of companies in the quantum space, we have Quantinuum (a company that came out of the merger between Cambridge Quantum Computing and Honeywell Quantum

Quantum Computing: Quantum Dots

A quantum dot quantum computer uses silicon qubits made up of pairs of quantum dots. In theory for quantum computers, such ‘coupled’ quantum dots could be used as robust quantum bits, or qubits.
Companies focused on this area include Diraq, Siquance and Quantum Motion.

Quantum Computing: NV Diamond