Qiskit | Fall Fest 2023

Presentation by Lorraine Tsitsi Majiri

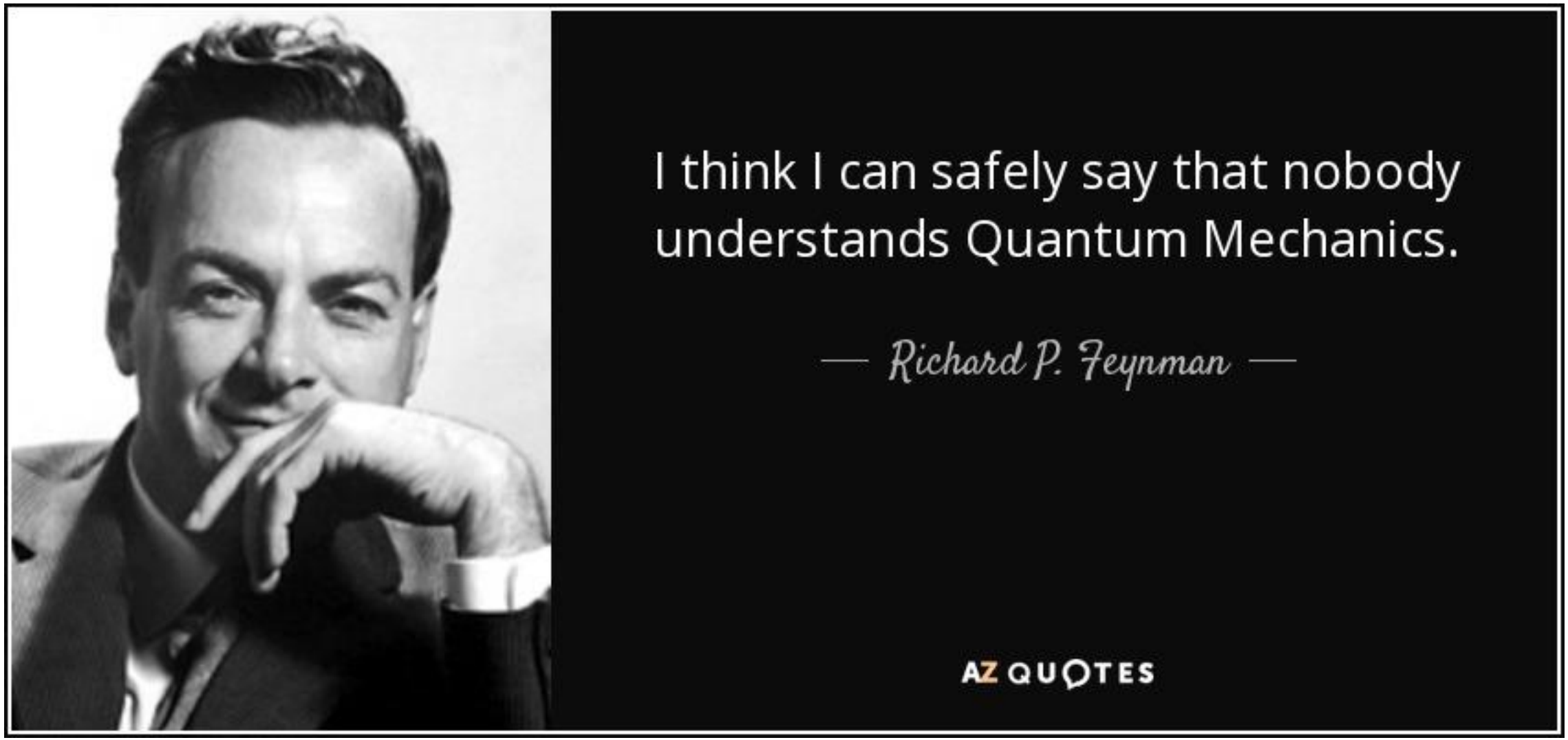
WELCOME TO THE INTRODUCTION OF QUANTUM COMPUTING

PURPOSE OF THIS PRESENTATION

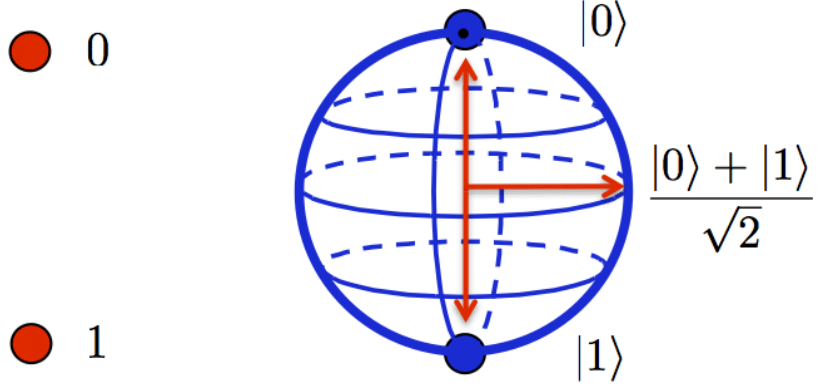
To help you get started with quantum computing.

What will be covered:

- What is quantum
- From bit to qubit
- Entanglement, interference and superposition
- Some applications

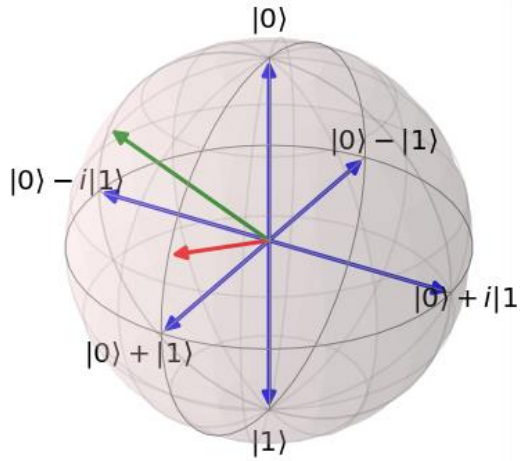

I think I can safely say that nobody understands Quantum Mechanics.
— Richard P. Feynman —
AZ QUOTES

BIT TO QUBITS



Classical Bit **Qubit**

- A bit (binary digit) is the smallest unit of data that a computer can process and store. A bit is always in one of two physical states, similar to an on/off light switch. The state is represented by a single binary value, usually a 0 or 1. However, the state might also be represented by yes/no, on/off or true/false.
- A qubit(short for quantum bit) is the fundamental unit of information in quantum computing. It can be represented using the Bloch sphere, a geometric representation that visualizes the qubit's state. Qubits can be in a superposition of states, represented by a combination of 0 and 1 with complex coefficients.



ELEMENTS OF A QUANTUM COMPUTER

Every computation has three elements: data, operations

and results

In quantum circuits:

1. Data = qubits
2. Operations = quantum gates (eg Hadamard gate, X gate and Z gate)
3. Results = measurements

FUNDAMENTALS IN QUANTUM

- Quantum Computing: Quantum computing represents a paradigm shift in computation by harnessing the principles of quantum mechanics. Unlike classical computers that use bits to represent information as 0s and 1s, quantum computers use qubits, which can exist in multiple states simultaneously, thanks to the phenomenon of superposition. This unique property allows quantum computers to perform computations in parallel, **potentially** providing exponential speedup for **certain** problems.

PRINCIPLES OF QUANTUM MECHANICS:

Quantum mechanics is a branch of physics that describes the behavior of particles at the quantum level. Three key principles are superposition, entanglement and interference. Superposition allows qubits to exist in a combination of states, representing both 0 and 1 simultaneously. Entanglement refers to the correlation between qubits, even when separated by large distances. Interference refers to the intrinsic behavior of a qubit due to superposition to influence the probability of it collapsing one way or another. These principles provide quantum computers with the ability to process information in a fundamentally different way than classical computers.

LAWS OF QUANTUM MECHANICS

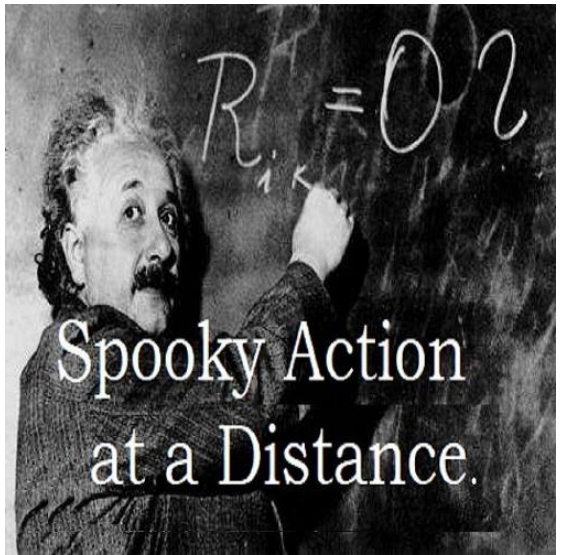
Superposition

- Superposition refers to a combination of states we would ordinarily describe independently
- A classical analogy: spinning a coin
- Schrodingers cat: the cat is dead but alive and alive but dead.

LAWS OF QUANTUM MECHANICS

Entanglement

- The ability of quantum particles to correlate their measurement results with each other.
- Quantum entanglement is referred to when particles remain connected so that actions performed on one particle affect the other even when separated by great distances.
- Einstein referred to as "spooky action at a distance."
- Classical-gloves

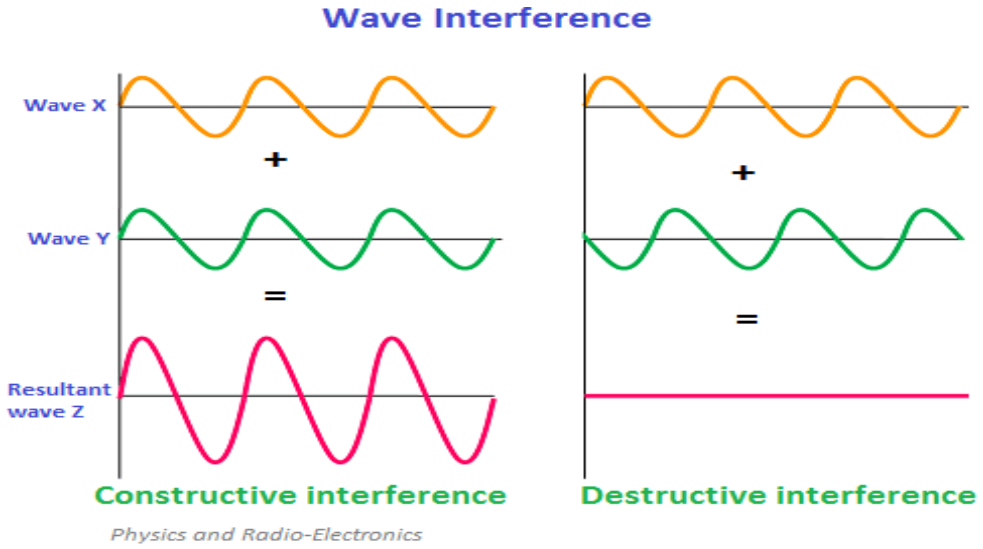


LAWS OF QUANTUM MECHANICS

Interference

A phenomenon in which two waves superpose to form a resultant wave of greater, lower or same amplitude

Resultant of two or more waves at a point

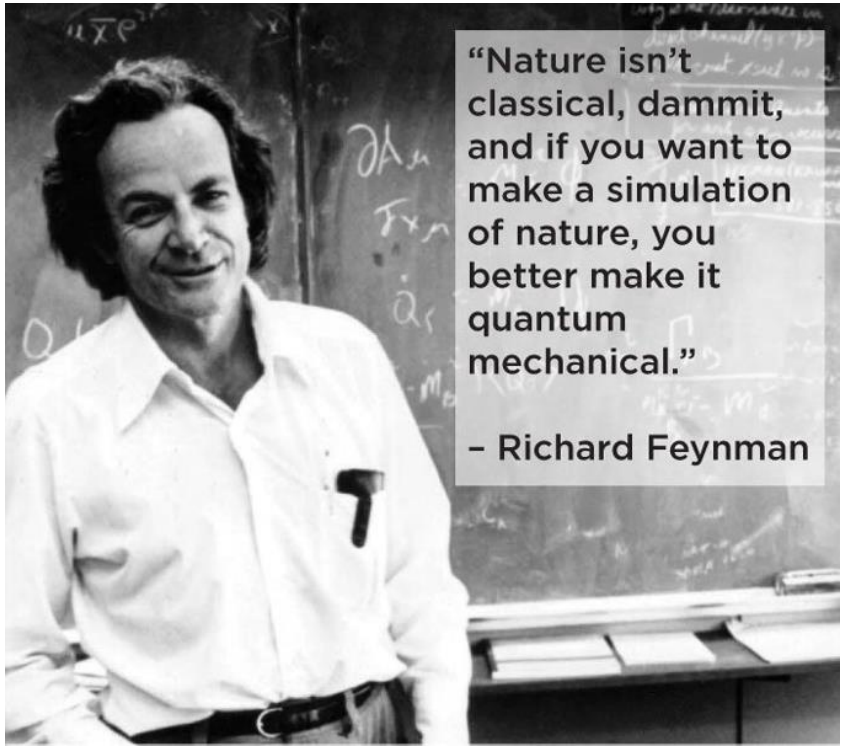


LINEAR ALGEBRA

Linear algebra is fundamental for explain objects such as lines, planes or rotations e.g: a qubit may be visualised as a unit vector thus in such cases and in order to understand its behaviour we need linear algebra.

WHAT THEN IS QUANTUM COMPUTING?

- Mimicking the way in which nature computes.
- The use of quantum phenomena such as superposition and entanglement to perform computation.



APPLICATIONS OF QUANTUM COMPUTING:

Quantum computing has the potential to revolutionize various fields.

- In cryptography, it can break classical encryption algorithms, posing a challenge to secure communication.
- In optimization, quantum algorithms can provide efficient solutions for complex optimization problems, such as portfolio optimization or logistical planning.
- In drug discovery, quantum computing can accelerate the simulation of molecular interactions, leading to faster and more effective drug development.
- In materials science, it can aid in the design of new materials with desired properties, such as superconductors or lightweight alloys.
- In artificial intelligence, quantum computing can enhance machine learning by improving pattern recognition and optimization tasks.

AREAS OF APPLICATION

- Cybersecurity
- Drug Development
- Financial Modeling
- Better Batteries
- Cleaner Fertilization
- Traffic Optimization
- Weather Forecasting and Climate Change
- Artificial Intelligence
- Solar Capture
- Electronic Materials Discovery

More on this, click.

CHALLENGES AND FUTURE DIRECTIONS:

Despite the promising potential of quantum computing, several challenges exist.

- One major challenge is maintaining qubit stability and reducing errors caused by environmental noise. Error correction techniques are being developed to address this issue.
- Scalability- as quantum systems with more qubits become increasingly complex to build and control. Collaborative efforts between academia, industry, and governments are underway to advance quantum technologies and overcome these challenges.
- The future direction of quantum computing involves research and development to build practical, fault-tolerant quantum computers and explore new applications across various industries.

MOST COMMON QUESTIONS

Here are some of the answers to the questions you might have.

WHAT ARE THESE SKILLS ONE MIGHT ASK?

To understand quantum mechanics as a first...you can't program quantum computers without intuitively understanding quantum as it were. It's very different from classical computing and that is why it matters and how it delivers the difference.

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