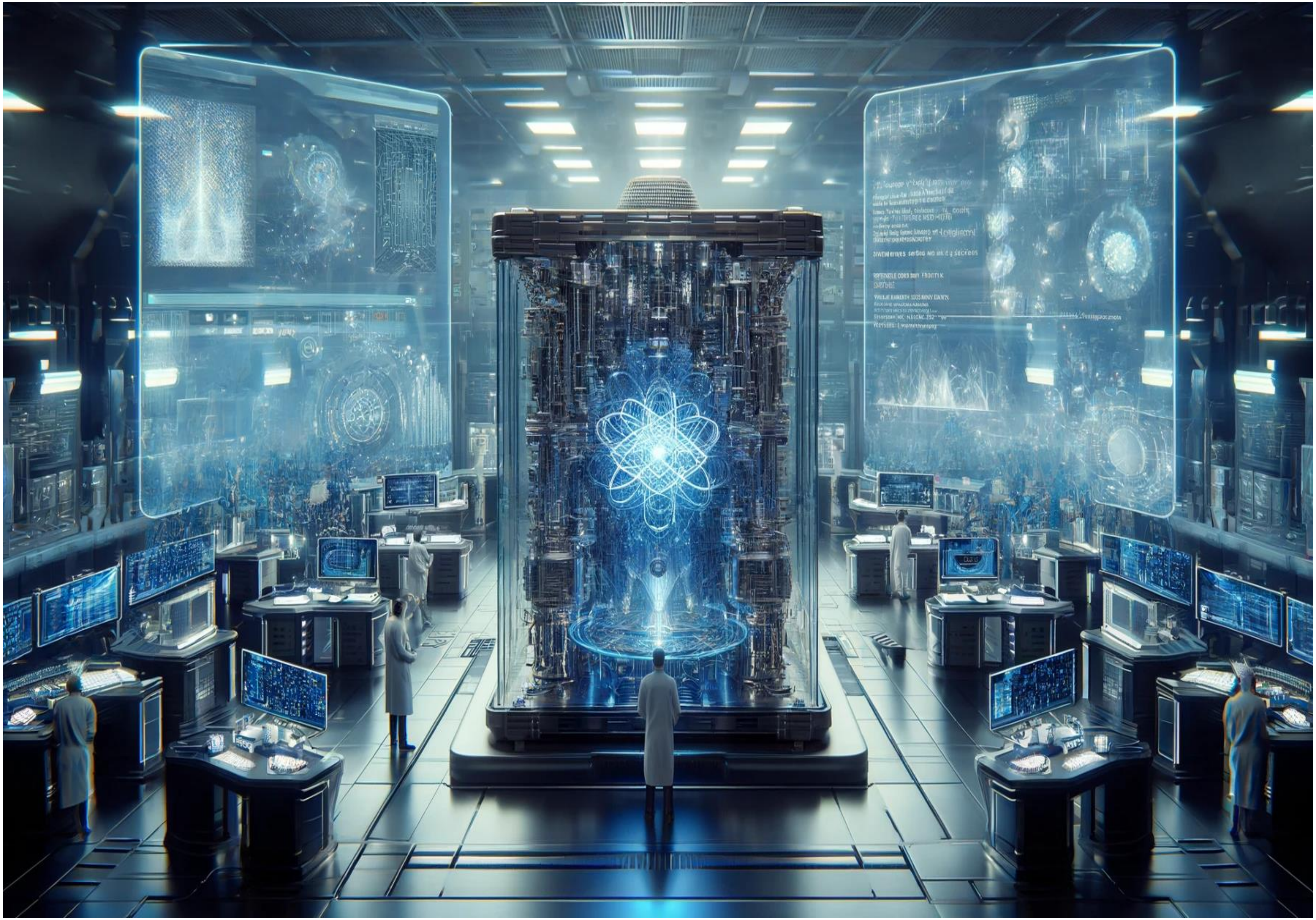
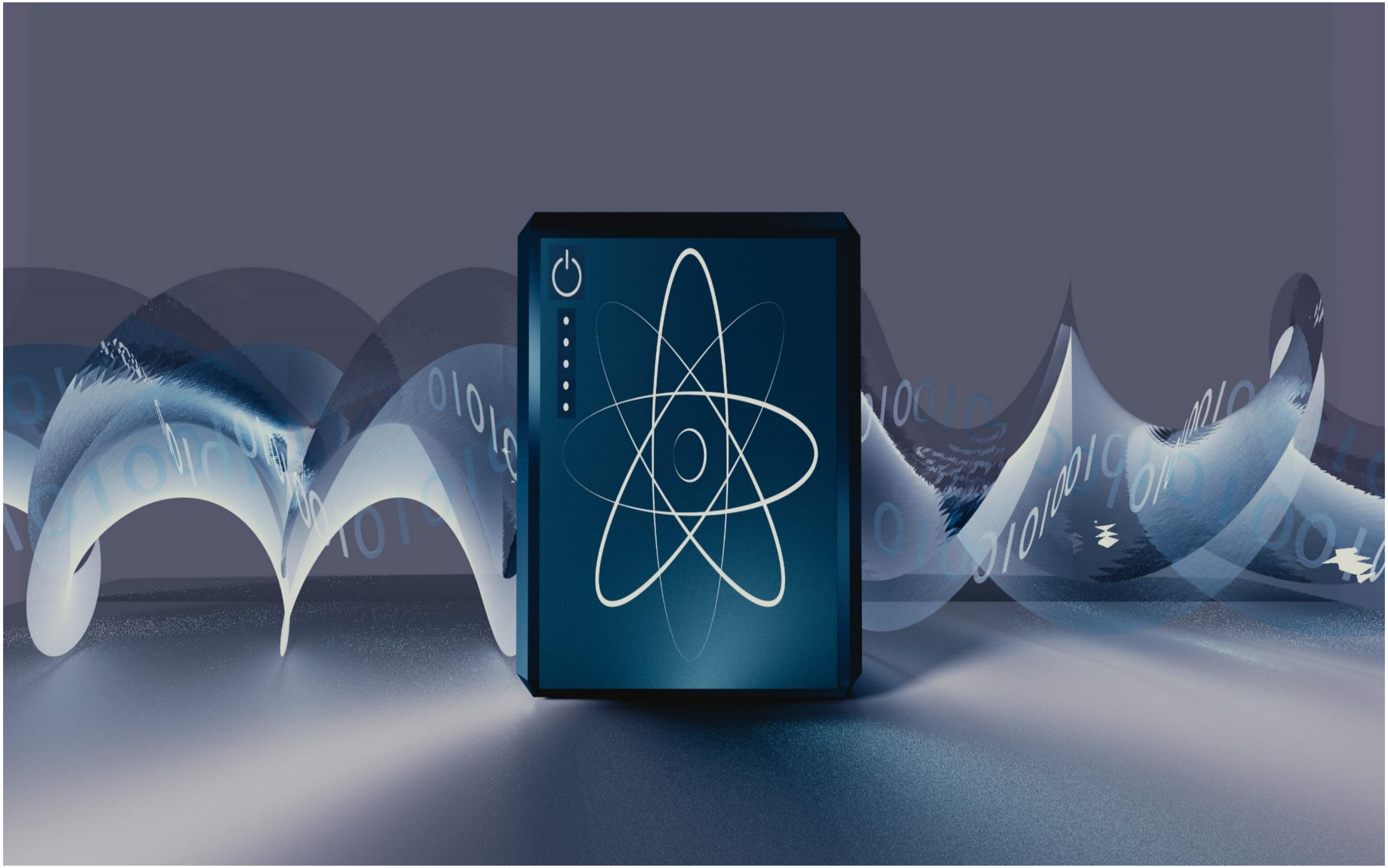
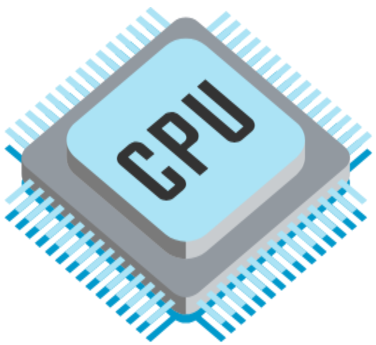




Agenda

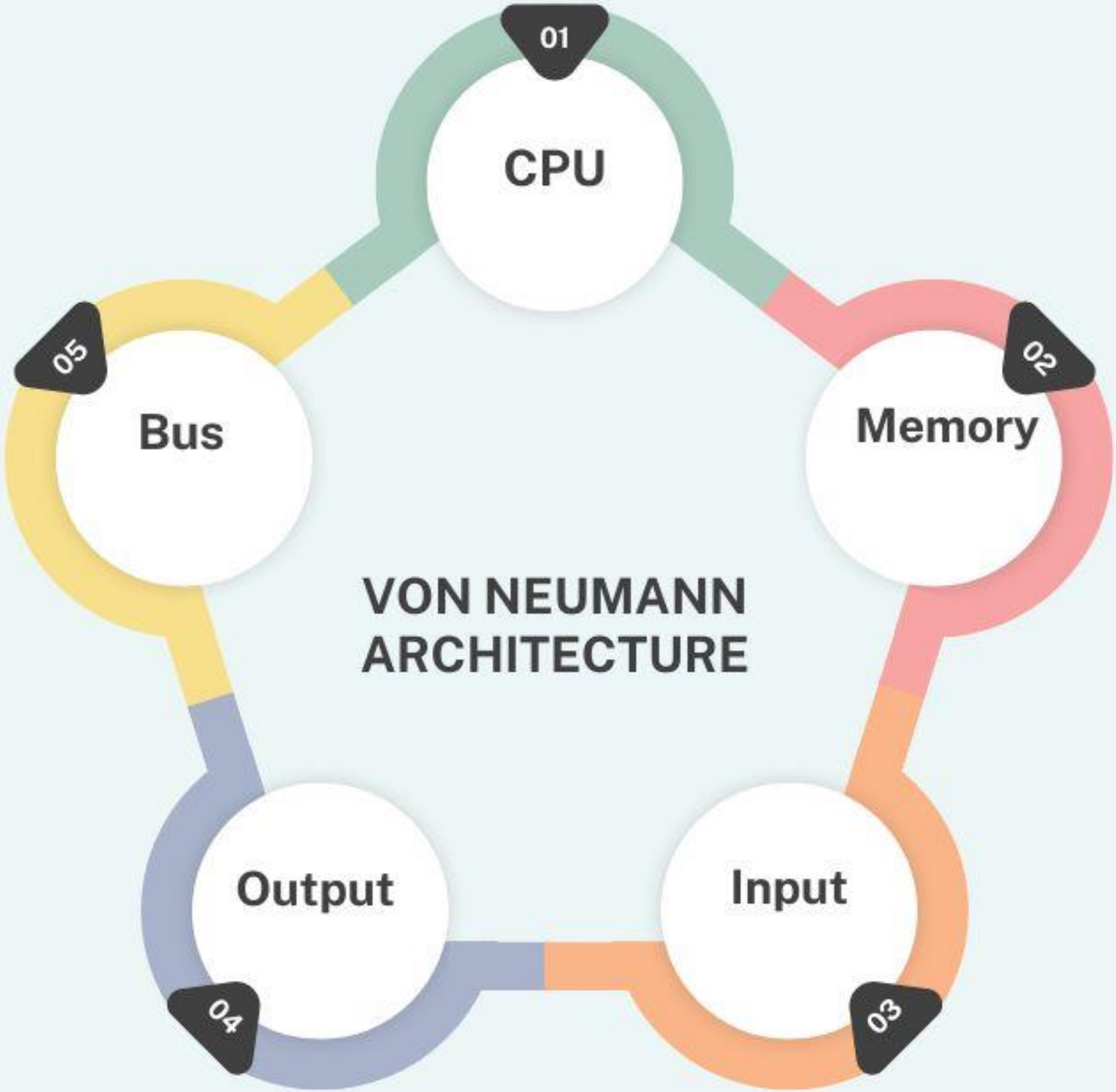
- Classical Computers VS Quantum computers
- Overview of Quantum Computing
- Properties of Quantum Computing
- Quantum Gates and Circuits
- Quantum Computing Hardware
- Quantum Algorithms
- Quantum Computing frameworks
- Quantum Programming
- Current Trends and Future Directions

Classical Computing

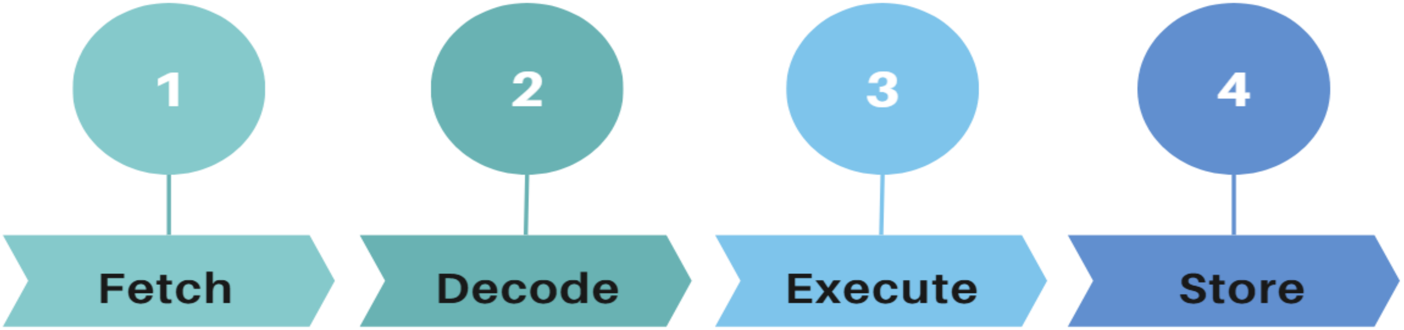


CPU + Memory

Von Neumann Architecture


01
CPU
02
Memory
03
Input
04
Output
05
Bus
VON NEUMANN
ARCHITECTURE

Operation of Conventional Computing



Classical computing processes information step-by-step using a well-defined architecture

The speed of fetching instructions is limited by the memory bandwidth and latency.

Decoding complex instructions can be time-consuming and may require multiple cycles.

Sequential execution of instructions can be inefficient for concurrent tasks.

Writing data back to memory can be slow due to memory latency and bandwidth limitations.

Bits

Classical Computing: Uses bits as the basic unit of information, which can be either 0 or 1.

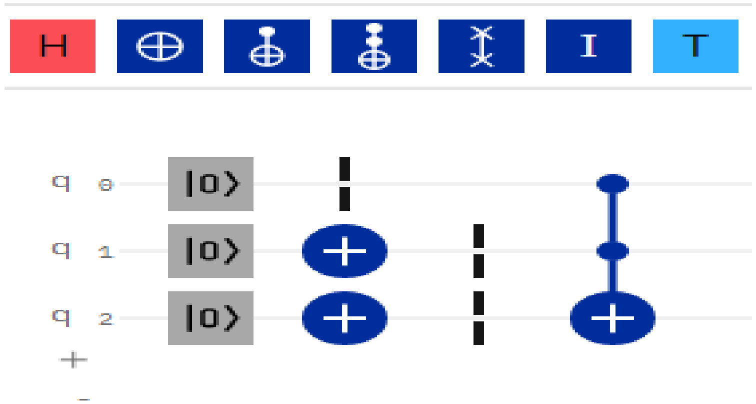
Bits operate independently of each other.

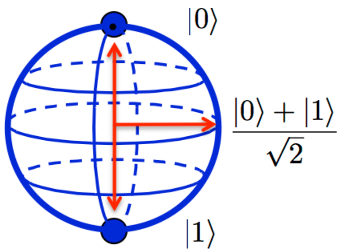
Two Distinct State

Quantum computers

Circuits with Quantum Gates

Qubits

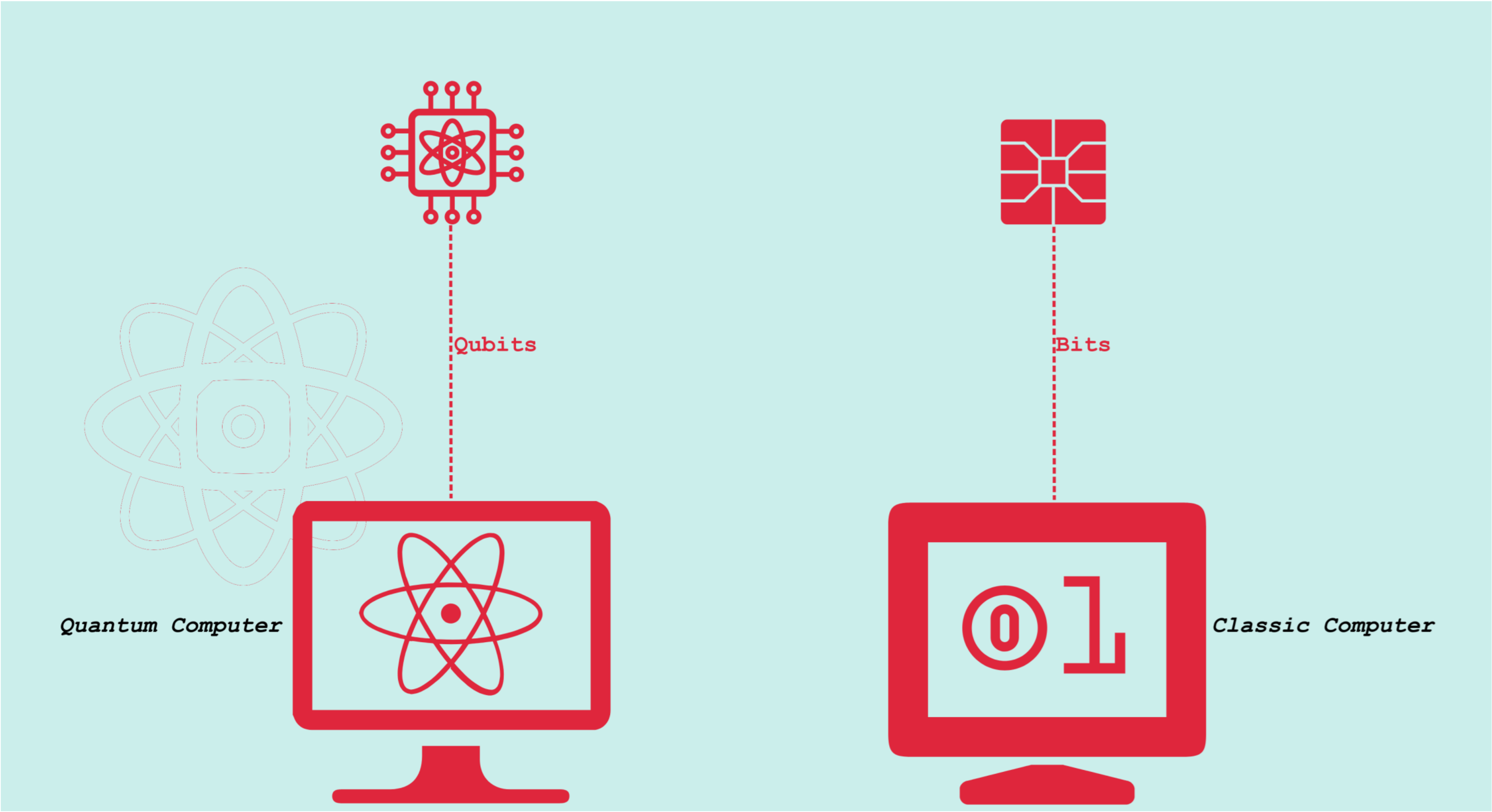




Qubit

Qubits

The basic unit of information is the qubit, which can be in a state of 0, 1, or any quantum superposition of these state


Qubits
Bits
Quantum Computer
Classic Computer

Dirac Notation

Dirac notation, also known as **bra-ket notation**, is a standard notation used in quantum mechanics to describe quantum states

Classical Bits in Dirac Notation

- **$|0\rangle$:** The state representing the classical bit being 0.
- **$|1\rangle$:** The state representing the classical bit being 1.

Quantum Bits (Qubits) in Dirac Notation

$$|\psi\rangle=\alpha|0\rangle+\beta|1\rangle$$

$|\psi\rangle$ is the state vector of the qubit.
α and β are complex numbers representing the probability amplitudes.
$|\alpha|^2+|\beta|^2=1$, ensuring the total probability is 1.

Classical Bit

State 0:

$|0\rangle$

This represents a classical bit in the 0 state.

State 1:

$|1\rangle$

This represents a classical bit in the 1 state.

Quantum Bit (Qubit)

State $|0\rangle$:

$|0\rangle$

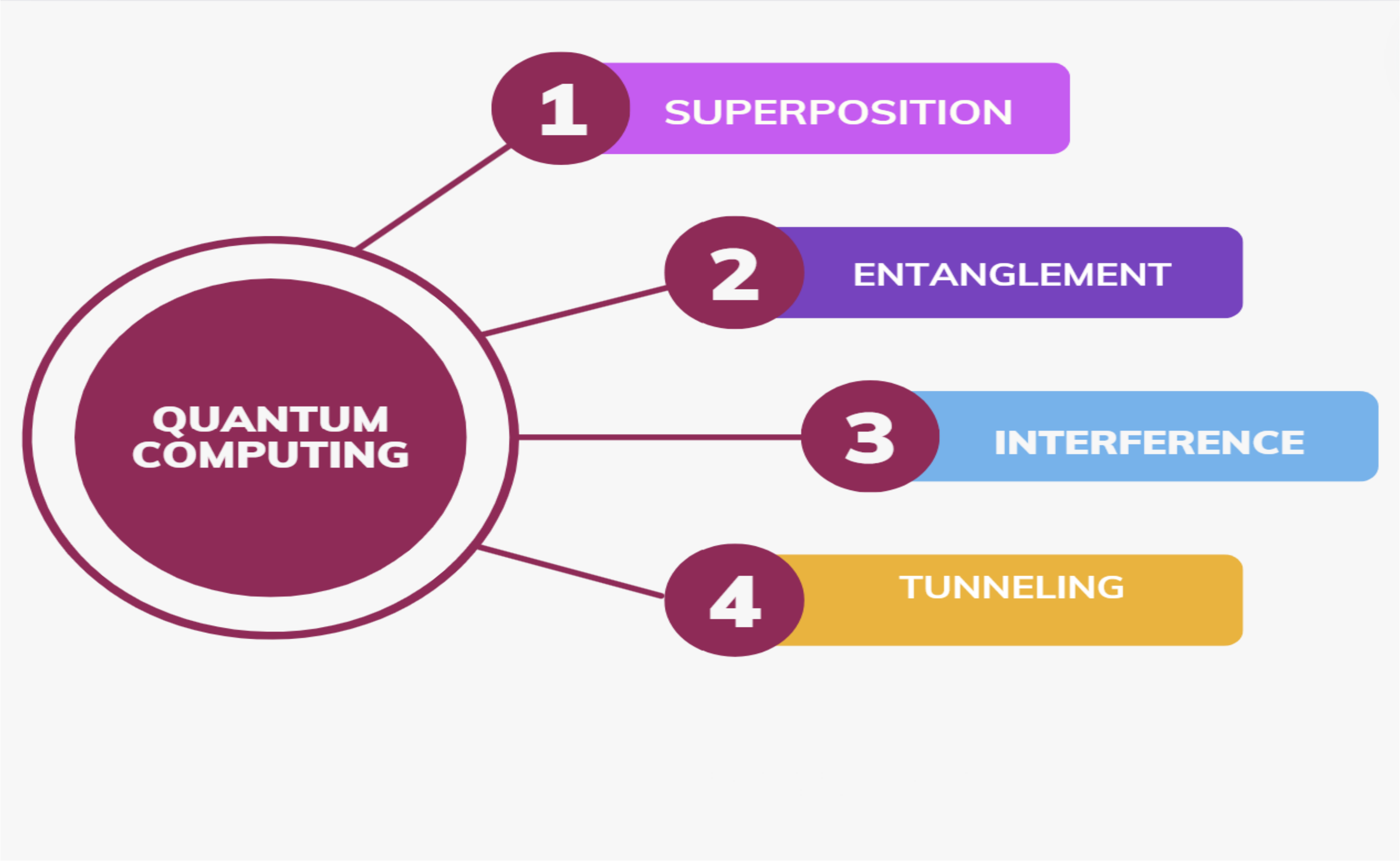
This represents a qubit in the pure state corresponding to the classical bit 0.

State $|1\rangle$:

$|1\rangle$

This represents a qubit in the pure state corresponding to the classical bit 1.

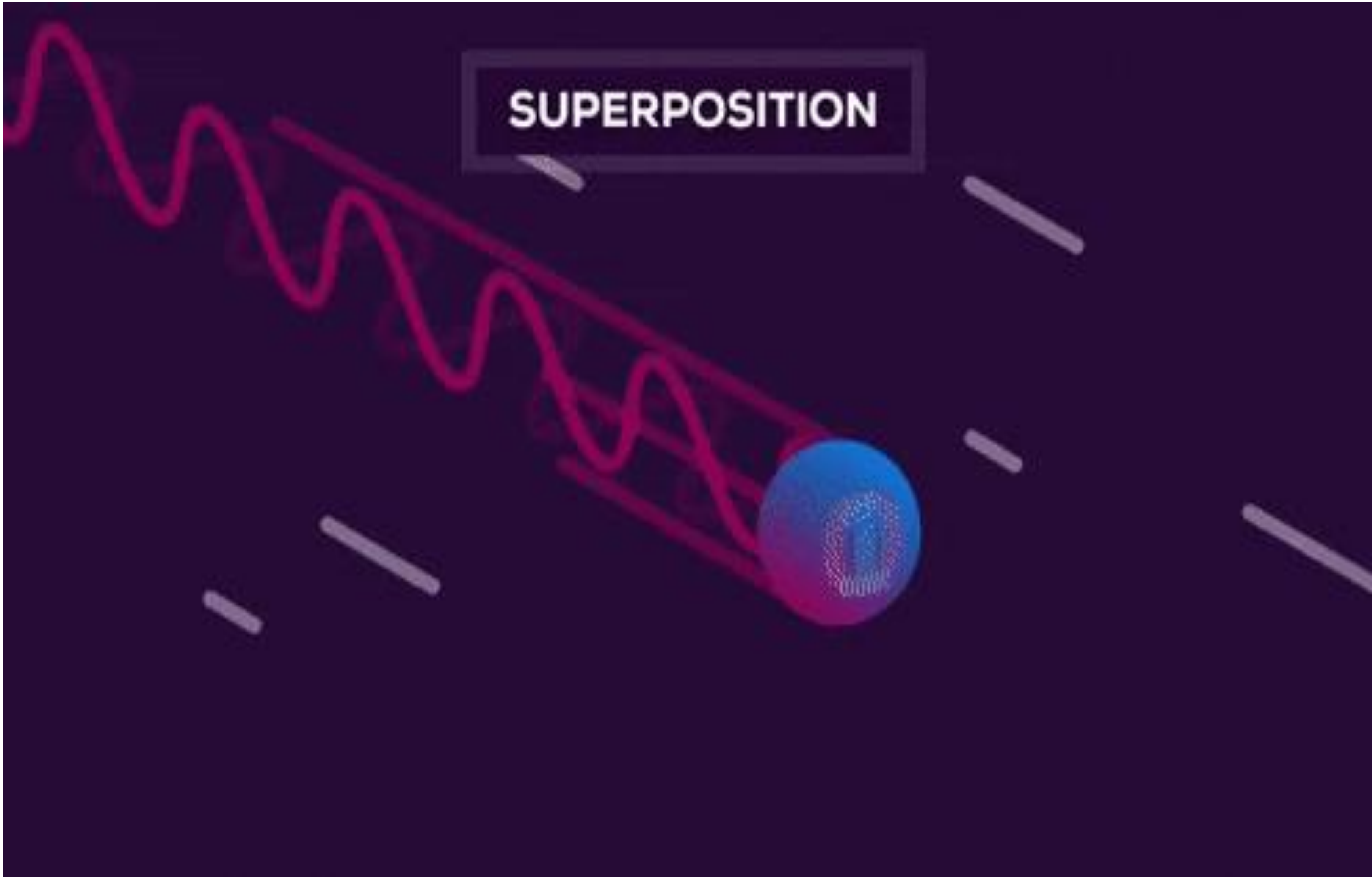
Properties of Quantum Computing



Superposition State

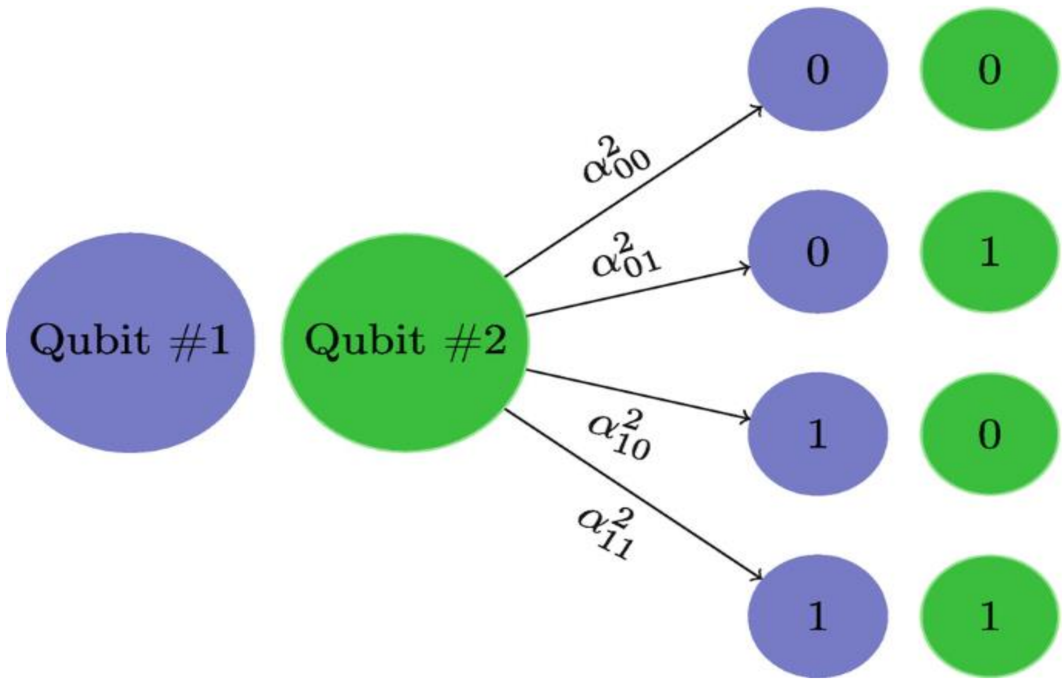
$$|\psi\rangle = \frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{2}}|1\rangle$$

This represents a qubit in an equal superposition of the states $|0\rangle$ and $|1\rangle$. If measured, there is a 50% probability of finding the qubit in state $|0\rangle$ and a 50% probability of finding it in state $|1\rangle$.


SUPERPOSITION

Entanglement

Qubits can become entangled, meaning the state of one qubit is dependent on the state of another, regardless of the distance between them



Aspect	Classical Computing	Quantum Computing
Basic Unit	Bit (0 or 1)	Qubit (0, 1, or both simultaneously)
Processing Method	Sequential, one step at a time	Parallel, many steps at once
Architecture	Von Neumann (CPU, memory)	Quantum circuits (quantum gates, qubits)
Key Features	Deterministic, follows classical physics	Superposition, entanglement, follows quantum mechanics
Efficiency	Efficient for straightforward, linear tasks	Potentially much faster for complex tasks like factoring
Example	Adding two numbers sequentially (3 + 5 = 8)	Considering all possible sums at once (quantum parallelism)

Quantum computing frameworks

Qiskit

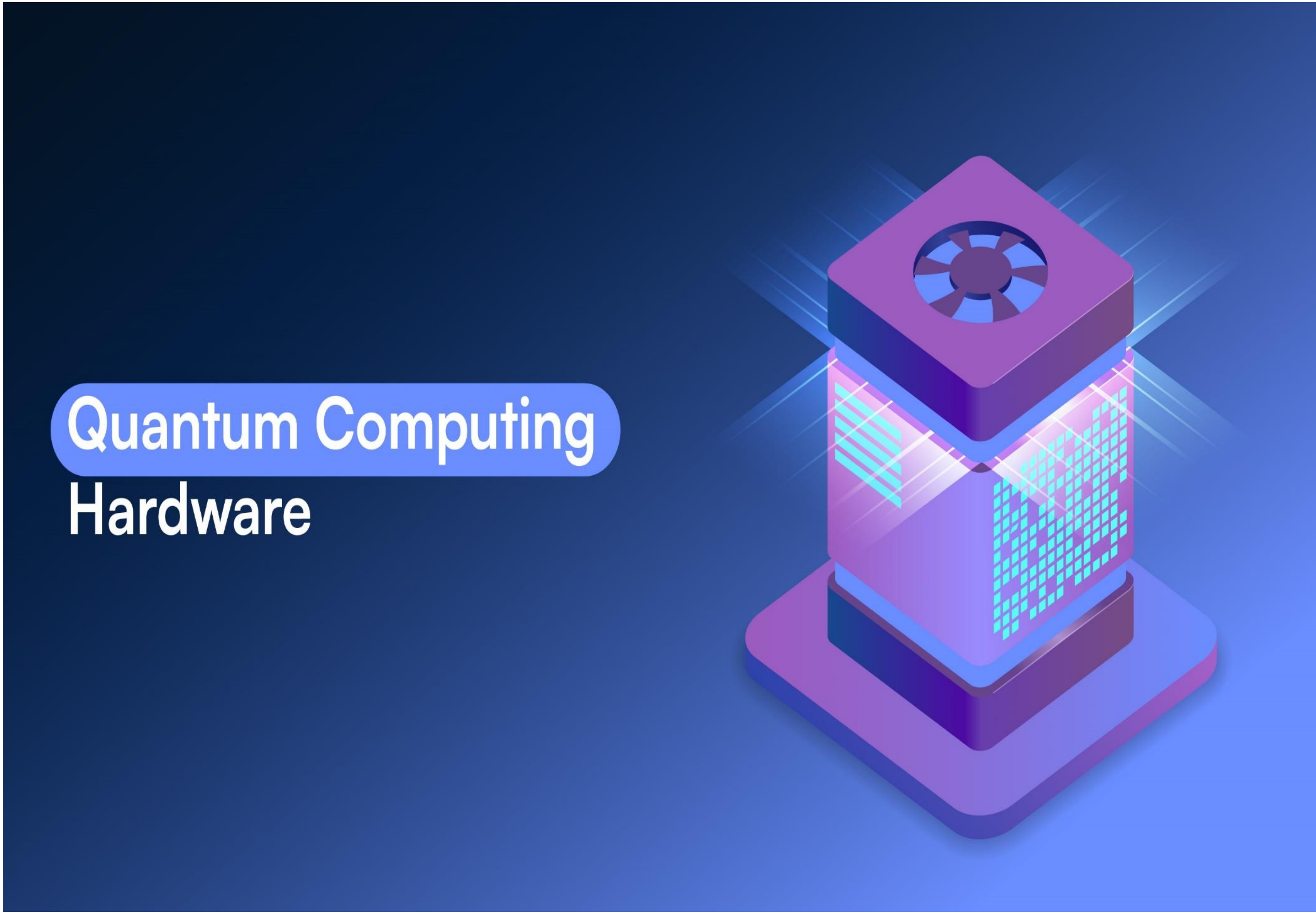
Cirq

PYQUIL

Azure Quantum

pennylane

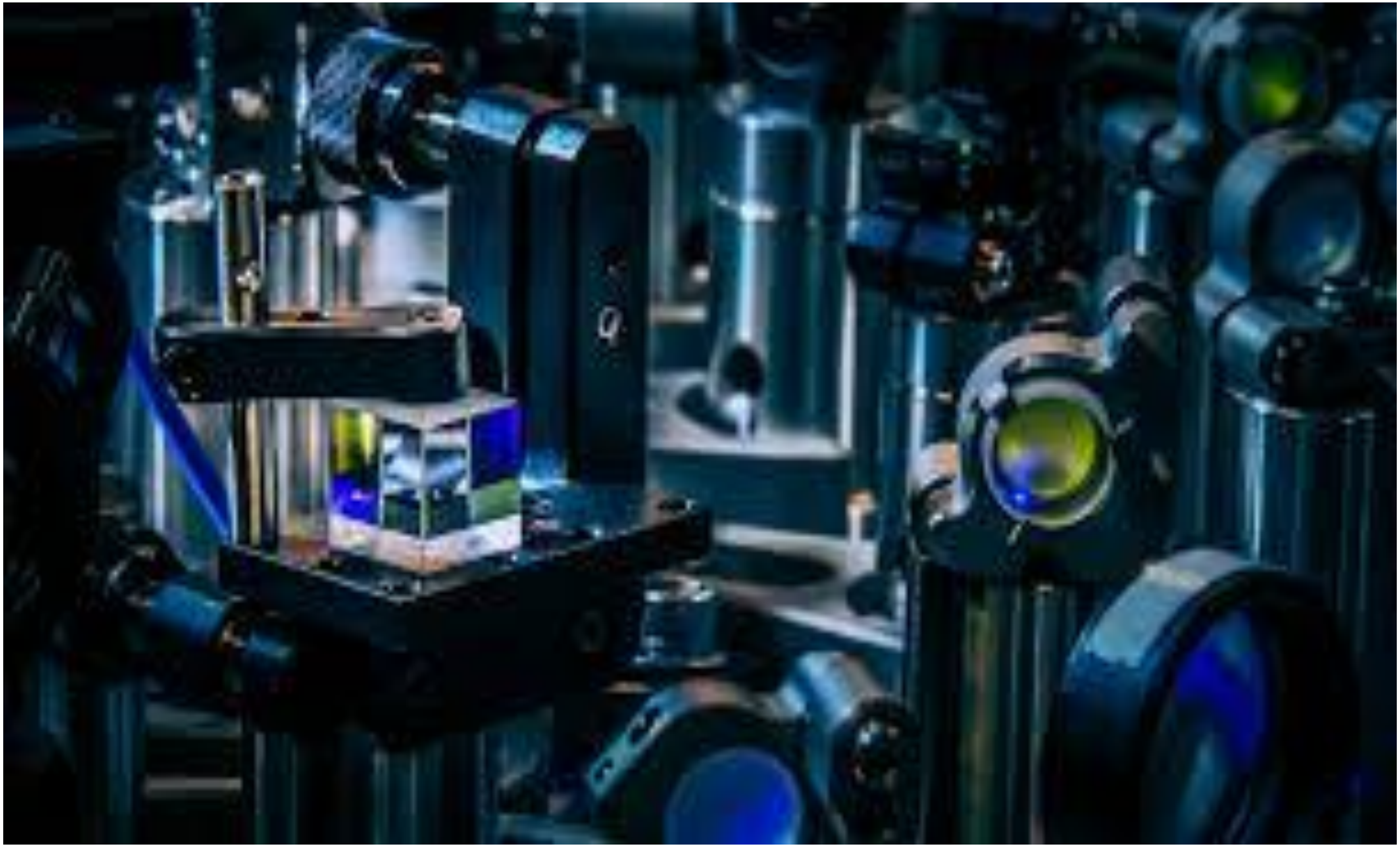
TensorFlow Quantum


Quantum Computing
Hardware

IBM Quantum System One

Google Sycamore

Honeywell Quantum Solutions H1



IonQ System


XANADU

Microsoft StationQ