ENGINEERING PHYSICS

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Basics of Quantum Computing

PES UNIVERSITY ONLINE

Class #16

- **Qubits**
- **Superposition**
- **Quantum Gates**
- **Circuit Model**

Qubits

- A quantum bit (qubit) is the basic unit of quantum information.
- Unlike classical bits, qubits can exist in superposition states.
- Mathematically represented as:

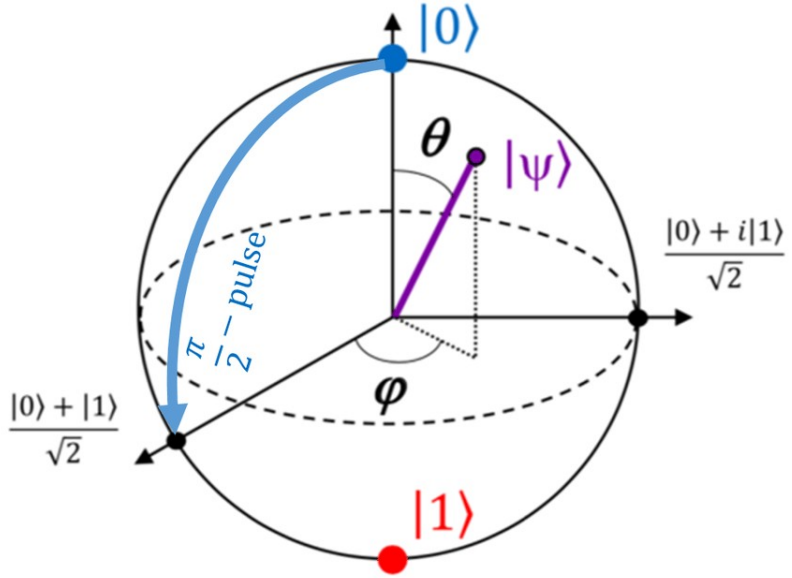
where α and β are complex amplitudes.

- Measurement collapses the qubit state to or with probabilities and .

Superposition of Qubits

- Superposition allows qubits to exist in a combination of $|0\rangle$ and $|1\rangle$ states.
- Enables parallelism in quantum computation.
- Example:

is an equal superposition state.



$$|\psi\rangle = \cos\frac{\theta}{2}|0\rangle + e^{i\varphi}\sin\frac{\theta}{2}|1\rangle$$

Basic Manipulation of Qubits

- Quantum states are manipulated using quantum gates.
- Operations are reversible (unitary transformations).
- Measurement is the only non-reversible operation.
- Manipulations include rotation, flipping, and entangling qubits.

Basic Quantum Gates

- Pauli-X gate: Flips $|0\rangle$ to $|1\rangle$ and vice versa (quantum NOT gate).
- Hadamard (H) gate: Creates superposition states.
- Pauli-Z gate: Phase flip operation.
- Controlled-NOT (CNOT): Entangles two qubits.

Operation of Quantum Gates

- Quantum gates act on qubits via matrix multiplication.
- Example: Hadamard gate
- Applying H to $|0\rangle$ yields
- Multi-qubit operations involve tensor products of matrices.

Circuit-based Quantum Computing

- Quantum computation represented using quantum circuits.
- Qubits as wires, quantum gates as operations on wires.
- Circuits show sequence of quantum operations.
- Final measurement extracts classical information.
- Circuit model is the foundation of most quantum algorithms.

THANK YOU

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