

EN / LEARNING SERIES

Quantum Fundamentals

A clear introduction to quantum information

SCIENCE · TECHNOLOGY · TALENT · FUTURE

Independent educational publication. Concepts are presented for learning and should be validated against primary technical sources for research, engineering or security decisions.

1. Why quantum information is different

Classical information uses bits with values 0 or 1. Quantum information uses qubits, physical systems whose state is described by amplitudes. These amplitudes determine the probabilities observed during measurement.

Quantum computers do not try every answer at once. Useful algorithms carefully create interference so that desirable outcomes become more likely and undesirable paths cancel.

KEY TERMS

bit • qubit • amplitude • measurement

2. Superposition, phase and interference

A qubit can occupy a superposition of basis states. The relative phase between amplitudes is essential because it controls how computational paths interfere.

Two states may produce identical measurement probabilities and still behave differently in a later circuit because their phases differ.

KEY TERMS

superposition • relative phase • constructive interference • destructive interference

3. Entanglement

Entanglement describes joint quantum states that cannot be factored into independent states of their parts. Measurement outcomes can be strongly correlated even when each individual result is random.

Entanglement is a resource for algorithms, communication and sensing, but it does not allow faster-than-light communication.

KEY TERMS

Bell state • correlation • joint state

4. A responsible next step

Start with a one-qubit simulator. Apply X and H gates, measure repeatedly and compare the observed frequencies with predicted probabilities.

Then create a two-qubit Bell state using H followed by a controlled-NOT gate. Record assumptions, circuit depth, shot count and noise before drawing conclusions.

KEY TERMS

simulate • predict • measure • compare

Suggested practice

Use the interactive modules at quantumserbia.com to test the ideas in this guide. Write down a prediction before every simulation, then compare the result and explain any difference.