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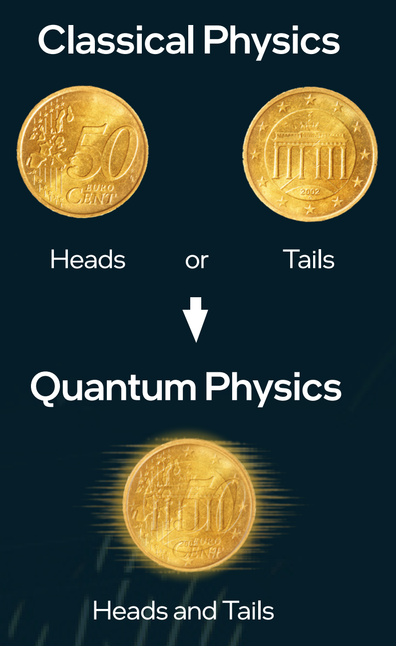
A Quantum Computing Primer

Quantum computers are different from the digital computing that drives today's data centers, cloud environments, PCs and other devices. Digital computation requires data to be encoded into binary digits (bits), each of which is always in one of two definite states (0 or 1). However, quantum computing uses quantum bits (qubits), which can be in multiple states simultaneously. As a result, operations on qubits can amount to a large number of calculations in parallel. It has been shown that in theory, some specific problems should be solvable in much less time on a quantum computer than using the best-known algorithms for a conventional computer. Here are four key concepts that are the foundation of quantum computing.

1 Superposition

Think of classical physics as a coin. It can be either heads or tails. If it were a bit, it would be 0 or 1. In quantum physics, the coin is best thought of as a constantly spinning coin. It represents heads and tails simultaneously. As a result, a qubit would have a probability of being both 0 and 1, and spin simultaneously up and down.

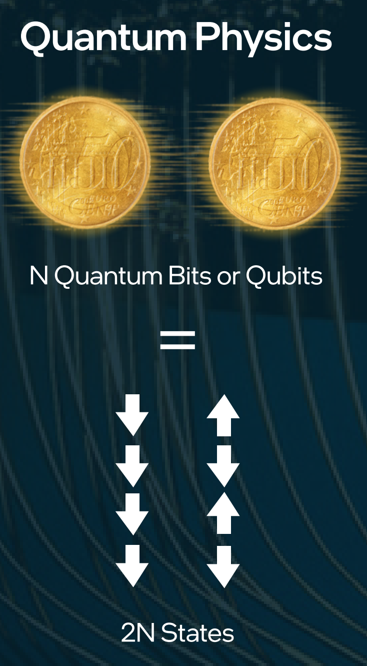
Quantum state: a simultaneous representation of multiple classical states.



2 Entanglement

Entanglement gives quantum computing the ability to scale exponentially. If one qubit simultaneously represents two states, two qubits represent four states when coupled together. They can no longer be treated independently; they now form a coupled, or entangled, super state. As more qubits link together, the number of states exponentially increases, which could lead to a computer with astronomically large computing power.

The **two qubits** can no longer be treated independently. They form a **super state**.



3 Fragility

Quantum states are quite fragile. If you measure, observe, touch or perturb any of these states, they collapse to a classical state. The states don't stick around for very long, which is why quantum computers are currently hard to build.

A quantum state collapses to a classical state if disturbed by noise or measurement.

4 No Cloning

A corollary to fragility is the "No Cloning Theorem." In classical physics, if two bits are represented by the coins right, one can copy or eavesdrop and recreate the information. In contrast, the information entangled within a set of qubits will be lost if someone tries to observe or copy them. A quantum state, lower right, cannot be copied without the sender or receiver realizing this. This concept serves as the basis of quantum communications.

One **cannot** copy, intercept, or steal without ruining a quantum state.

Quantum computing holds a credible promise of radically enhanced performance, with the potential to solve specific complex problems that are practically unsolvable by today's computers. Development of actual quantum computers is still in its infancy, but quantum computing has the potential to solve complex simulations such as large-scale financial analysis, cryptography and more effective drug development.