technology today

Alan Pierce EdD
email: pierceaj@techtoday.us: Web: www.technologytoday.us: X: @ TechToday-US

Quantum Computer's Qubits Harness Atoms and Subatomic Particles

In August of 2024 Google Quantum AI computer scientists published a paper that describes their breakthrough logical qubits that perform quantum error correction. (https://arxiv.org/html/2408.13687v1) This plus the breakthroughs that I will explain in this column, could mean that Quantum superiority could be achieved in the near future. Quantum computers are already solving problems that are beyond the capability of today's classical computers. The classical computer designation includes your laptop, smartphone and any other computing device that derives its processing power from transistors packed into microchips.

Quantum computers channel the behavior of particles at the atomic and subatomic levels. To slow these particles down and control them, the operating temperature of these machines has to be near absolute zero. (absolute zero equals minus 459.67 degrees Fahrenheit). To create this super cold temperature a significant area of a quantum computer is actually a cryogenic cooling system, The IBM cooling system
is shown in photo 1 and the IBM Condor Qubit processor is shown in photo 2.

At this temperature, the machine's Qubit processor manipulates atomic subatomic particles so that they function like classical computer transistors on steroids. A classical transistor only has two states which is on or off (1 or 0). A quantum computer qubit, at these subzero temperatures can be in a state of on or off (1 or 0) or both on and off at the same time. A behavior that physicists have named superposition.

Superposition allows qubits to exist in multiple states at once. This is what gives quantum computers their massive potential computational power. Instead of processing a single input at a time like a classical computer, quantum computers can handle multiple possibilities simultaneously. This YouTube video graphically shows the processing differences between these two computer systems. Find it online at (https://www.youtube.com/watch?v=lypnkNm0B4A).

The race is on to build the most powerful quantum computer. The US private competitors include IBM, Google, Microsoft, and Amazon. The research is so significant that the US has many foreign competitors. When this column went to press IBM's Condor Quantum computer processor with 1,121 qubits was the most powerful quantum computer.

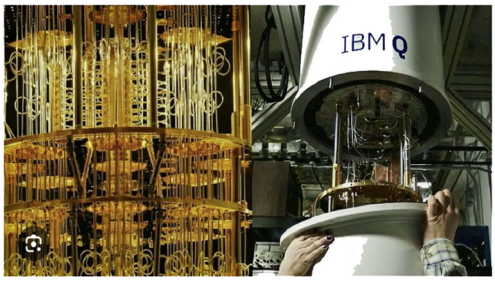

Photo Credit: IBM

IBM Q quantum computer cryostat, used to cool the Q system's quantum chip to 15 milliKelvin.

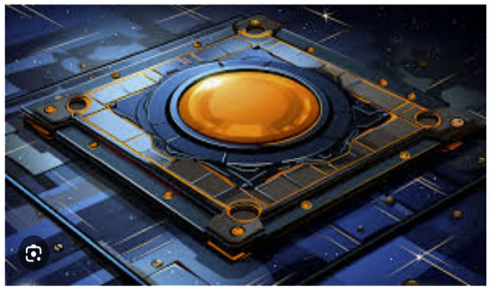

Image Credit: IBM

IBM Condor: The Quantum Computing Breakthrough

The addition of just a single qubit doubles the computational power of the computer. So, if your quantum computer is 1/10 the speed of a super computer, the addition of just 1 more qubit would make it on par and one more would make it one hundred times faster than the super computer. This is all due to quantum mechanics superposition and entanglement.

When a quantum computer qubits chip has enough qubits to surpass the processing power of a conventional supercomputer in all computational tasks, the dream of quantum superiority will be achieved. Quantum computers have already surpassed the processing speed in some areas so they can already solve problems that would take a conventional computer a million years to solve. They are already being used by biotechnologists to run simulations to find cures to diseases and to determine positive or negative outcomes if certain genes in plants, insects, or animals are altered to suppress or enhance certain species features to increase crop yield or animal longevity. Material scientists are using quantum computers to run designer material simulations to determine what would be the physical outcome if one combines the atoms of different basic materials.

This computer power also has a dark side because when it grows powerful enough, especially if it endowed with AI generative learning capabilities, it could be used to break all current security codes that protects world governments, banking, manufacturing, public utilities, and even consumer computer systems.

If this is the first time that you ever heard of the field of physics called quantum mechanics, you might find it interesting to know that prior to the development of
the quantum computer, quantum mechanics has "led to the development of things like lasers, light-emitting diodes, transistors, medical imaging, electron microscopes, and a host of other modern devices. Your cell phone would not exist without the science of quantum mechanics!". (https://www.energy.gov/science/doe-explainsquantum mechan-ics)

Taking it a Step Further

1. What makes a quantum computer so much more powerful than a classical computer?
2. Why does a quantum computer need to run at almost absolute zero?
3. Working in groups of 3 or 4 students, develop a graphic or video that shows or demonstrates the difference between a classical computer and a quantum computer.

Alan Pierce, EdD, CSIT is a technology education consultant. Visit www.technologytoday.us for past columns and teaching resources