What makes Microsoft's new quantum computing chip 'Majorana 1' different?

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Written by Karan Mahadik
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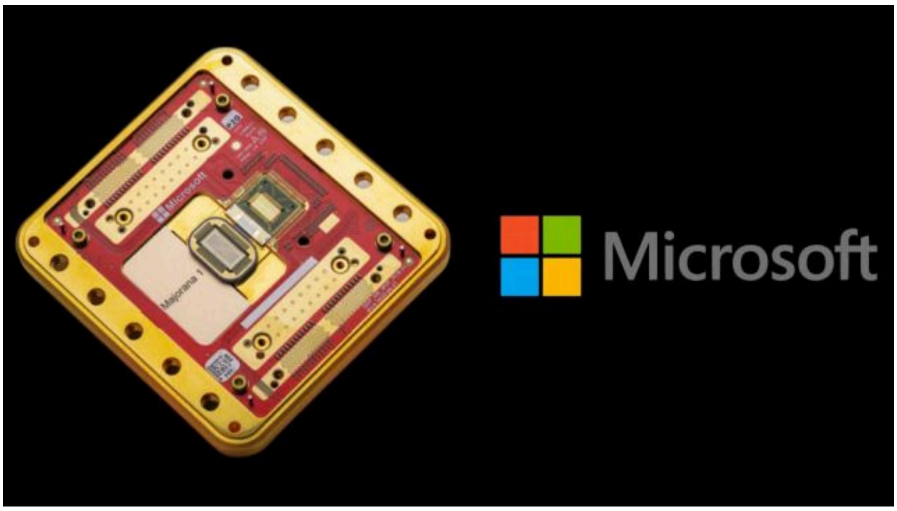

Microsoft said its new quantum computing chip can fit in the palm of a hand and be easily deployed in Azure data centres. (Express Image/Microsoft)

Microsoft has announced the arrival of Majorana 1, a new quantum chip that produces more reliable and scalable qubits than its predecessors. Qubits are the building blocks of quantum computers.

The tech giant considers Majorana 1 to be a major milestone in the road to the future of useful quantum computing. Appearing on a podcast on YouTube, Microsoft CEO Satya Nadella said that the company will be able to build quantum computers for commercial use between 2027-29.

Microsoft's purported breakthrough revolves around engineering a new type of quasiparticle known as Majorana. These Majorana particles have been fabricated using topological conductors, leading to qubits that exist in a topological state, which differs from traditional states of matter such as solid, liquid, and gas.

"In the same way that the invention of semiconductors made today's smartphones, computers and electronics possible, topoconductors and the new type of chip they enable offer a path to developing quantum systems that can scale to a million qubits and are capable of tackling the most complex industrial and societal problems," Microsoft said in a blog post published on Wednesday, February 19.

Though, the company has not released any performance data on its quantum chip yet.

What we know about Majorana 1

Over the past 20 years, Microsoft researchers have taken a unique approach by focusing on developing topological qubits, which are said to be more stable than traditional qubits and require less error correction from the start.

However, the company said that it faced many challenges in creating topological qubits as it "posed a steep learning curve". "The disadvantage [was] that until recently the exotic particles Microsoft sought to use, called Majoranas, had never been seen or made," the company said.

First theorised over 80 years ago by Italian physicist Ettore Majorana, Majorana fermions are particles that are their own anti-particles. But, there was no physical evidence of such particles.

In the past decade or so, researchers have detected signs of a kind of Majorana fermion known as a Majorana zero mode (MZM), where groups of electrons and other particles act as a single particle, according to science publication *IEEE Spectrum.*

To bring these new particles into existence, Microsoft said it first set out to build topological conductors or topoconductors. Unlike traditional semiconductors that are usually made of silicon, Microsoft's topoconductor is made of indium arsenide. This is the same material used in infrared detectors.

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Topoconductors are made by combining indium arsenide (a semiconductor) and aluminium (a superconductor). When cooled to near absolute zero and tuned with magnetic fields, the semiconductor is married with superconductivity.

"We took a step back and said 'OK, let's invent the transistor for the quantum age. What properties does it need to have?'" said Chetan Nayak, a Microsoft technical fellow specialising in quantum computing. "And that's really how we got here – it's the particular combination, the quality and the important details in our new materials stack that have enabled a new kind of qubit and ultimately our entire architecture," Nayak said.

Majorana 1 is an eight-qubit chip, which may seem modest when compared to quantum chips developed by rivals such as Google's Willow (106-qubit chip) and IBM's R2 Heron (156-qubit chip).

However, the company said that Majorana 1's underlying Topological Core architecture allows for the **quantum chip to be potentially scaled to a million qubits**.

"This is a needed threshold for quantum computers to deliver transformative, real-world solutions – such as breaking down microplastics into harmless byproducts or inventing self-healing materials for construction, manufacturing or healthcare," the company said.

Quantum computers vs supercomputers vs classical computers

Everything that is typed into classical computers such as words and numbers get translated into binary code comprising bits, with a value of 0 (ground state) or 1 (excited state). A qubit, on the other hand, leverages the principles of quantum mechanics to exist in both states simultaneously.

For instance, a qubit could have a 25 per cent probability of having a value of 0 and a 75 per cent probability of having a value of 1. This means that a single qubit can represent a greater amount of information than a single classical bit.

As a result, quantum computers are able to process information in ways that are impossible for classical computers to do so. This means that they are capable of solving problems that classical computers cannot.

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But how are quantum computers different from supercomputers?

With advanced architectures and relying on acceleration techniques such as graphic processing units (GPUs) and multi-core processing, supercomputers excel at performing calculations at a faster pace. That said, they are still bound by the constraints of classical computing principles and depend on logic gates such as AND, OR, XOR, and NOT gates to manipulate classical bits.

Quantum computers, on the other hand, use quantum gates such as H-gate and Pauli gates that are designed to process qubits and are also reversible in nature. These quantum gates can be used to develop circuits and algorithms and solve problems that are otherwise impossible to solve.

Majorana 1's architecture features aluminum nanowires joined together to form an H. Each H has four controllable Majorana particles and makes one qubit, Microsoft said.

How could quantum computers be used?

Quantum computers have long-been considered to be the tools that are needed to unlock new scientific discoveries. Since quantum computers are based on the principles of quantum mechanics, they are able to mathematically map the behaviour of nature with greater precision.

"For instance, they could help solve the difficult chemistry question of why materials suffer corrosion or cracks. This could lead to self-healing materials that repair cracks in bridges or airplane parts, shattered phone screens or scratched car doors," Microsoft said.

The company also envisions combining quantum computers with its generative AI tools. "This would allow someone to describe what kind of new material or molecule they want to create in plain language and get an answer that works straightaway," it added.

"If you have AI plus quantum, maybe you'll use quantum to generate synthetic data that then gets used […] to train better AI models," Nadella said in the YouTube interview.

But, according to the Microsoft CEO, the first thing a quantum computer would allow researchers to do is build better quantum computers by making it easier to simulate atom-by-atom construction of new quantum gates.

However, one of the biggest hurdles in bringing quantum computing into reality are errors.

"Error correction is essential for quantum computers to function well and become useful. Errors occur when a quantum system interacts with its external environment and loses its delicate quantum characteristics," Daniel Lidar, a professor of electrical and computer engineering at University of Southern California (USC), said in a statement.

In December last year, Google announced that it has developed [a state-of-the-art quantum computing chip called Willow] that can solve in under five minutes a computation so complex, it would have taken a supercomputer around 10 septillion (10^25) years to complete.

Notably, the search giant claimed to have found a way to exponentially reduce errors in quantum computers while using more qubits to scale up the technology.

"They demonstrated that quantum error correction works as theoreticians have predicted: as they made their error-corrected `logical qubit' larger, the results improved. Previously, in most cases, errors only increased." Lidar said.

On the other hand, the Microsoft team claimed on Wednesday that it has devised a new approach that can measure the amount of quantum information stored in Majorana particles. "This new measurement approach is so precise, it can detect the difference between one billion and one billion and one electrons in a superconducting wire…" the company said, adding that this measurement process makes it possible to build a more scalable quantum machine.

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