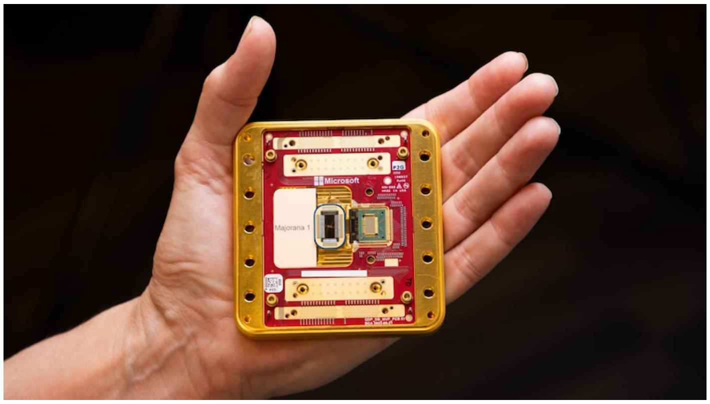
Experts Weigh in on Microsoft's Topological Qubit Claim

Tech giant Microsoft claimed in a recent press release to have made the first topological qubit–an important milestone in the development of quantum computers. But some experts say the firm's claim has not been backed up by peer-reviewed research.

By **Philip Ball**

Researchers at Microsoft in the US claim to have made the first topological quantum bit (qubit)–a potentially transformative device that could make quantum computing robust against the errors that currently restrict what it can achieve. "If the claim stands, it would be a scientific milestone for the field of topological quantum computing and physics beyond," says Scott Aaronson, a computer scientist at the University of Texas at Austin.

However, the claim is controversial because the evidence supporting it has not yet been presented in a peer-reviewed paper. It is made in a press release from Microsoft accompanying a paper in *Nature* that has been written by more than 160 researchers from the company's Azure Quantum team [**1**]. The paper stops short of claiming a topological qubit but instead reports some of the key device characterization underpinning it.



Majorana 1. Microsoft has unveiled a quantum processor with a "topological core."
Credit: J. Brecher/Microsoft

Writing in a peer-review file accompanying the paper, the *Nature* editorial team says that it sought additional input from two of the article's reviewers to "establish its technical correctness," concluding that "the results in this manuscript do not represent evidence for the presence of Majorana zero modes [MZMs] in the reported devices." An MZM is a quasiparticle (a particle-like collective electronic state) that can act as a topological qubit.

"That's a Big No-No"

"The peer-reviewed publication is quite clear [that it contains] no proof for topological qubits," says Winfried Hensinger, a physicist at the University of Sussex, UK, who works on quantum computing using trapped ions. "But the press release speaks differently. In academia that's a big no-no: You shouldn't make claims that are not supported by a peer-reviewed publication"–or that have at least been presented in a preprint.

Chetan Nayak, leader of Microsoft Azure Quantum, which is based in Redmond, Washington, says that the evidence for a topological qubit was obtained in the period between submission of the paper in March 2024 and its publication. He will present those results at a talk at the Global Physics Summit of the American Physical Society in Anaheim, California, in March.

But Hensinger is concerned that “the press release doesn’t make it clear what the paper does and doesn’t contain.” He worries that some might conclude that the strong claim of having made a topological qubit is now supported by a paper in *Nature*. “We don’t need to make these claims–that is just unhealthy and will really hurt the field,” he says, because it could lead to unrealistic expectations about what quantum computers can do.

As with the qubits used in current quantum computers, such as superconducting components or trapped ions, MZMs would be able to encode superpositions of the two readout states (representing a 1 or 0). By quantum entangling such qubits, information could be manipulated in ways not possible for classical computers, greatly speeding up certain kinds of computation. In MZMs the two states are distinguished by “parity”: whether the quasiparticles contain even or odd numbers of electrons.

Built-In Error Protection

As MZMs are “topological” states, their settings cannot easily be flipped by random fluctuations to introduce errors into the calculation. Rather, the states are like a twist in a buckled belt that cannot be smoothed out unless the buckle is undone. Topological qubits would therefore suffer far less from the errors that afflict current quantum computers, and which limit the scale of the computations they can support. Because quantum error correction is one of the most challenging issues for scaling up quantum computers, “we want some built-in level of error protection,” explains Nayak.

It has long been thought that MZMs might be produced at the ends of nanoscale wires made of a superconducting material. Indeed, Microsoft researchers have been trying for several years to fabricate such structures and look for the characteristic signature of MZMs at their tips. But it can be hard to distinguish this signature from those of other electronic states that can form in these structures.

In 2018 researchers at labs in the US and the Netherlands (including the Delft University of Technology and Microsoft), **claimed to have evidence of an MZM** in such devices. However, they then had to retract the work after others raised problems with the data. “That history is making some experts cautious about the new claim,” says Aaronson.

Now, though, it seems that Nayak and colleagues have cracked the technical challenges. In the *Nature* paper, they report measurements in a nanowire heterostructure made of superconducting aluminum and semiconducting indium arsenide that are consistent with, but not definitive proof of, MZMs forming at the two ends. The crucial advance is an ability to accurately measure the parity of the electronic states. “The paper shows that we can do these measurements fast and accurately,” says Nayak.

“The device is a remarkable achievement from the materials science and fabrication standpoint,” says Ivar Martin, a materials scientist at Argonne National Laboratory in Illinois. “They have been working hard on these problems, and seems like they are nearing getting the complexities under control.” In the press release, the Microsoft team claims now to have put eight MZM topological qubits on a chip called Majorana 1, which is designed to house a million of them.

Even if the Microsoft claim stands up, a lot will still need to be done to get from a single MZM to a quantum computer, says Hensinger. Topological quantum computing is “probably 20–30 years behind the other platforms,” he says. Martin agrees. “Even if everything checks out and what they have realized are MZMs, cleaning them up to take full advantage of topological protection will still require significant effort,” he says.

Regardless of the debate about the results and how they have been announced, researchers are supportive of the efforts at Microsoft to produce a topological quantum computer. “As a scientist who likes to see things tried, I’m grateful that at least one player stuck with the topological approach even when it ended up being a long, painful slog,” says Aaronson.

“Most governments won’t fund such work, because it’s way too risky and expensive,” adds Hensinger. “So it’s very nice to see that Microsoft is stepping in there.”

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Philip Ball is a freelance science writer in London. His latest book is ***How Life Works*** (Picador, 2024).

REFERENCES

1. Microsoft Azure Quantum *et al.*, “Interferometric single-shot parity measurement in InAs–Al hybrid devices,” **Nature 638, 651 (2025).**