Unconventional superconductor may be used to create quantum computers of the future

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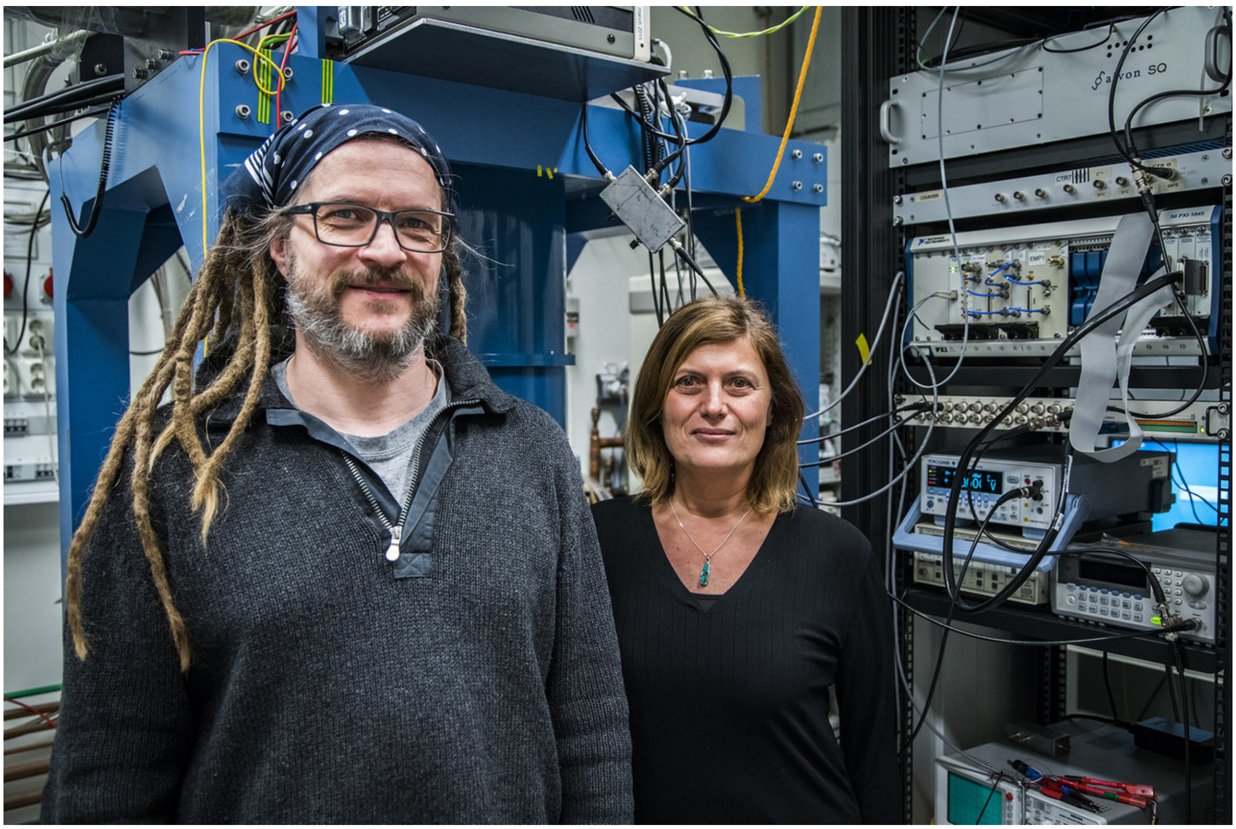

After an intensive period of analyses the research team led by Professor Floriana Lombardi, Chalmers University of Technology, was able to establish that they had probably succeeded in creating a topological superconductor. Credit: Johan Bodell/Chalmers University of Technology

With their insensitivity to decoherence, Majorana particles could become stable building blocks of quantum computers. The problem is that they only occur under very special circumstances. Now, researchers at Chalmers University of Technology have succeeded in manufacturing a component that is able to host the sought-after particles.

Researchers throughout the world are struggling to build quantum computers. One of the great challenges is to overcome the sensitivity of quantum systems to decoherence, the collapse of superpositions. One track within quantum computer research is therefore to make use of Majorana particles, which are also called Majorana fermions. Microsoft, among other organizations, is exploring this type of quantum computer.

Majorana fermions are highly original particles, quite unlike those that make up the materials around us. In highly simplified terms, they can be seen as half-electron. In a quantum computer, the idea is to encode information in a pair of Majorana fermions separated in the material, which should, in principle, make the calculations immune to decoherence.

So where do you find Majorana fermions? In solid state materials, they only appear to occur in what are known as topological superconductors. But a research team at Chalmers University of Technology is now among the first in the world to report that they have actually manufactured a topological superconductor.

"Our experimental results are consistent with topological superconductivity," says Floriana Lombardi, professor at the Quantum Device Physics Laboratory at Chalmers.

To create their unconventional superconductor, they started with what is called a topological insulator made of bismuth telluride, Bi_2Te_3. A topological insulator conducts current in a very special way on the surface. The researchers placed a layer of aluminum, a conventional superconductor, on top, which conducts current entirely without resistance at low temperatures.

"The superconducting pair of electrons then leak into the topological insulator, which also becomes superconducting," explains Thilo Bauch, associate professor in quantum device physics.

However, the initial measurements all indicated that they only had standard superconductivity induced in the Bi_2Te_3 topological insulator. But when they cooled the component down again later, to routinely repeat some measurements, the situation suddenly changed—the characteristics of the superconducting pairs of electrons varied in different directions.

"And that isn't compatible at all with conventional superconductivity. Unexpected and exciting things occurred," says Lombardi.

Unlike other research teams, Lombardi's team used platinum to assemble the topological insulator with the aluminum. Repeated cooling cycles gave rise to stresses in the material, which caused the superconductivity to change its properties. After an intensive period of analyses, the researchers established that they had probably succeeded in creating a topological superconductor.

"For practical applications, the material is mainly of interest to those attempting to build a topological quantum computer. We want to explore the new physics hidden in topological superconductors—this is a new chapter in physics," Lombardi says.

The results were recently published in *Nature Communications* in a study titled "Induced unconventional superconductivity on the surface states of Bi_2Te_3 topological insulator."

More information: Sophie Charpentier et al, Induced unconventional superconductivity on the surface states of Bi2Te3 topological insulator, *Nature Communications* (2017). [DOI: 10.1038/s41467-017-02069-z](https://doi.org/10.1038/s41467-017-02069-z)

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