Quantum scientists break aluminium 'monopoly' (Update)

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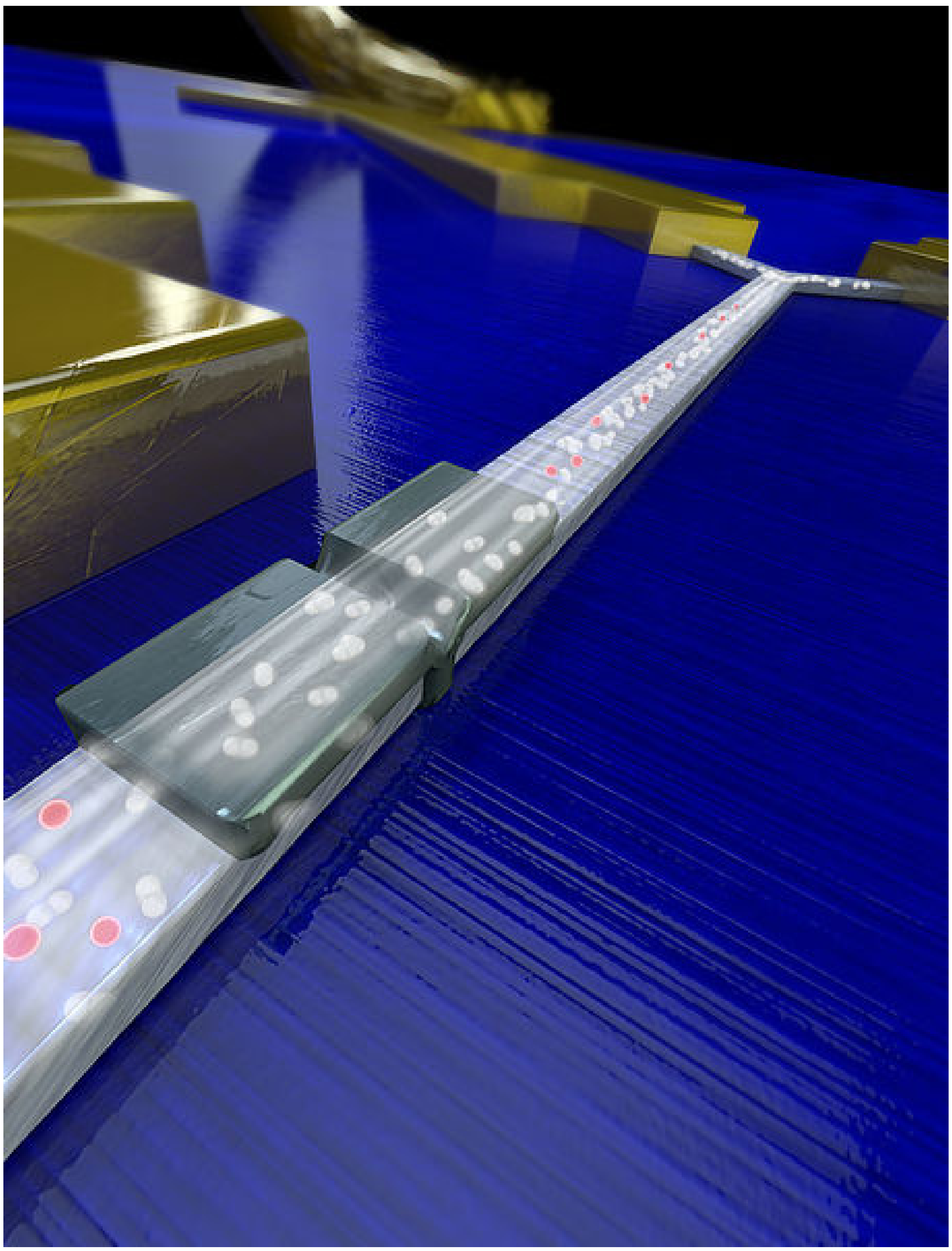

Credit: TUDelft/Tremani

A Majorana fermion, or a Majorana particle, is a fermion that is its own antiparticle. Discovering the Majorana was the first step, but utilizing it as a quantum bit (qubit) still remains a major challenge. An important step towards this goal has just been taken by researchers from TU Delft in today's issue of *Nature Physics*. It is a nearly thirty-year-old scientific problem that has just been resolved: demonstrating the difference between the even and odd occupation of a superconductor in high magnetic fields. Thus far, this was only possible in aluminium, which is incompatible with Majoranas. This result enables the read out and manipulation of quantum states encoded in prospective Majorana qubits.

Qubit

Qubits store information similarly to normal (digital) bits. While a bit represents either 0 or 1, a qubit utilizes the laws of quantum mechanics, making it possible to be in a superstate of 0 and 1 simultaneously. This enables solving several mathematical problems much faster than the most capable supercomputers ever built. Several research groups and companies around the globe are pursuing the development and prototyping of such a powerful quantum computer, including QuTech at the Delft University of Technology in The Netherlands.

Majoranas

A qubit encoded by Majorana's is a promising building block for a practical quantum computer. Until now, it was a major challenge to read out such a Majorana qubit. In order to do so, one needs to determine whether the number of the electrons is even or odd, or, in other words, what the parity state is. The measurement of the parity of superconductors has been performed for the last thirty years, however, successful experiments were exclusively done on aluminium while all attempts addressing different superconducting materials, such as vanadium or niobium, have failed. This is a major issue for Majorana research as superconductivity is required to survive in high magnetic fields, at which aluminium ceases to be a superconductor.

An alternative to aluminium

The research group at TU Delft has succeeded in determining the parity in a different superconductor, niobium titanium nitride (NbTiN). Most importantly, this material remains superconducting in high magnetic fields, which is an essential property to create Majoranas. "The most beautiful outcome is that not only can we distinguish between the even and odd number of electrons, but a prepared, say, even state remains the same for more than one minute," says David van Woerkom from QuTech. "Since we typically work with timescales of micro- or even nanoseconds, one minute is essentially an eternity."

Quasiparticles

Majoranas are a special kind of quasi-particle: All measurable properties of Majoranas are zero, meaning that this particle is its own antiparticle. A pair of Majoranas are insensitive to local perturbations, making the Majorana a very promising candidate for quantum computation. Majoranas were first postulated in the 1930s by the young Italian scientist Ettore Majorana, who disappeared under mysterious circumstances not more than one year after his groundbreaking work. The first experimental evidence of the Majorana particle was reported in 2012 by the group of Leo Kouwenhoven in Delft.

More information: One minute parity lifetime of a NbTiN Cooper-pair transistor, *Nature Physics* (2015) DOI: 10.1038/nphys3342

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