Scientists discover new state of matter

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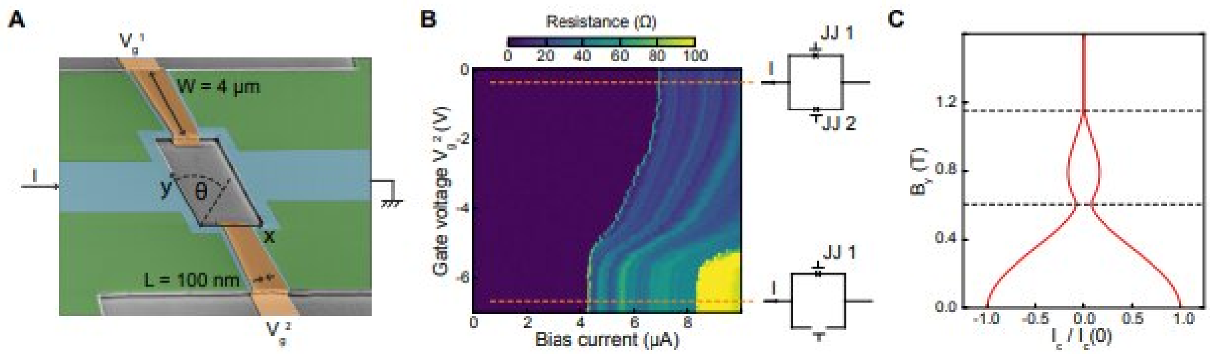

Fig. 1: **Physical system** (A) SEM image (colorized) of a SQUID similar to the one presented. The device is composed of two 4 μm wide JJ with a gap of 100 nm. The central area is about 25 μm^2 and each junction is independently gateable. The x direction is taken colinear to the current flow in the junctions. (B) Measurement of the junction resistance at zero flux as a function of the gate voltage applied on JJ2. At $V_g^2 = 0$ V both junctions can carry a supercurrent, below $V_g^2 < -5.5$ V, JJ2 behaves like an open circuit. (C) Predicted critical current of a junction in the presence of an in-plane field along y. Above the first dashed line, the superconducting state goes from s to p-type and goes back to s-type above the second dashed line.

A team of physicists has uncovered a new state of matter—a breakthrough that offers promise for increasing storage capabilities in electronic devices and enhancing quantum computing.

"Our research has succeeded in revealing experimental evidence for a new state of matter—topological superconductivity," says Javad Shabani, an assistant professor of physics at New York University. "This new topological state can be manipulated in ways that could both speed calculation in quantum computing and boost storage."

The discovery, reported in a paper on arXiv, was conducted with Igor Zutic at the University of Buffalo and Alex Matos-Abiague at Wayne State University.

The work centers on quantum computing—a method that can make calculations at significantly faster rates than can conventional computing. This is because conventional computers process digital bits in the form of 0s and 1s while quantum computers deploy quantum bits (qubits) to tabulate any value between 0 and 1, exponentially lifting the capacity and speed of data processing.

In their research, Shabani and his colleagues analyzed a transition of quantum state from its conventional state to a new topological state, measuring the energy barrier between these states. They supplemented this by directly measuring signature characteristics of this transition in the order parameter that governs the new topological superconductivity phase.

Here, they focused the inquiry on Majorana particles, which are their own antiparticles—substances with the same mass, but with the opposite physical charge. Scientists see value in Majorana particles because of their potential to store quantum information in a special computation space where quantum information is protected from the environment noise. However, there is no natural host material for these particles, also known as Majorana fermions. As a result, researchers have sought to engineer platforms—i.e., new forms of matter—on which these calculations could be conducted.

"The new discovery of topological superconductivity in a two-dimensional platform paves the way for building scalable topological qubits to not only store quantum information, but also to manipulate the quantum states that are free of error," observes Shabani.

More information: William Mayer et al. "Phase signature of topological transition in Josephson Junctions," arXiv:1906.01179v1 [cond-mat.mes-hall] 2019. arxiv.org/pdf/1906.01179.pdf

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