Quantum computing takes a step forward with parafermions
Tom’s Hardware Italia

English translation

By Antonello Buzzi
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Scientists at the Nanyang Technological University in Singapore have conducted some experiments on parafermions, or grouped electrons that behave like liquids in a special state of matter (with temperatures close to absolute zero, ie -273 ° C), which could give a big boost to quantum computing.

In fact, the movement of electrons, commonly known as "electricity", although considered "orderly", is not really like that at all. The particles, being negatively charged, repel each other, tending to move singularly and disorderly in different directions and not as a single cohesive whole.

However, when electrons act in what is known as the "Tomonaga-Luttinger helical liquid," there are fewer interactions between the particles and energy exchanges between them and the system. This, in turn, reduces the amount of systemic and environmental interference, often causing errors and collapse of quantum states in quantum systems. The fact that electrons have previously been cooled near absolute zero is also an essential element, as it allows some materials to reach the superconducting state, in which electrons pass through the surface without any electrical resistance, further reducing possible elements of environmental interference.

The system cooled to absolute zero (in the experiment, up to 4.5 degrees Kelvin or -269°C) forces the particles to slow down to almost motionless. Improvements in electron control that lead to reduced noise mean fewer errors and greater consistency, which translates into longer lifespan of actual qubits that can store or process information. In fact, some quantum systems, such as IBM's Quantum One and Quantum Two, already make use of superconducting qubits.

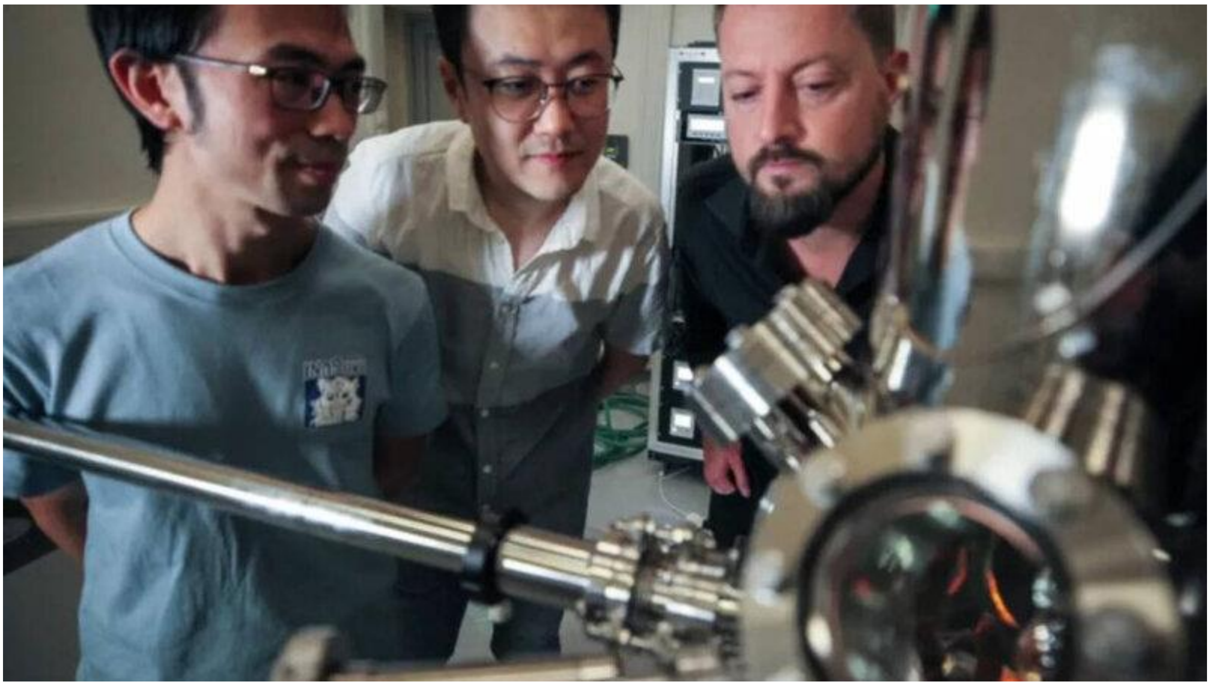

Photo Credit: SPMS/NTU Singapore

In this case, the scientists used an atomic-thick graphene substrate on which they deposited atomic-thick tungsten ditelluride crystals: a nearly two-dimensional material known as a "spin Hall quantum insulator," which isolates gravity inside but has electrons outside. After assembling the graphene and tungsten ditelluride substrate and cooling it to absolute zero, the research team subjected it to a scanning tunnel microscope that was just one nanometer from its surface: smaller than a strand of DNA and smaller than any transistor ever produced.

When they were placed under the scanning tunnel microscope and cooled to absolute zero, the researchers noticed that the electrons in the graphene/tungsten substrate increased their repulsion, which was so strong that the electrons were forced to move collectively due to the interaction between the repulsion fields of each electron. The researchers recorded a Luttinger parameter, which represents the strength of the interactions between electrons, in a range between 0.21 and 0.33 (when it reaches 1, the interactions are at the height of their weakness).

Assistant Professor Weber said:

“When the Luttinger parameter is less than 0.5, interactions are strong and electrons are forced to move collectively. This is the realm in which parafermions are predicted to exist. This is a very remarkable range of variation, since the Luttinger parameter can only vary between 0 and 1. The control of the Luttinger parameter at such low values has never been observed before in any Tomonaga-Luttinger helical liquid.”

The team is now planning to further reduce temperatures by taking advantage of NTU Singapore's new Ultra-Low Vibration Laboratory, built earlier this year, which will allow experiments to be carried out at even lower temperatures of 150 millikelvin (mK) – even closer to absolute zero.

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