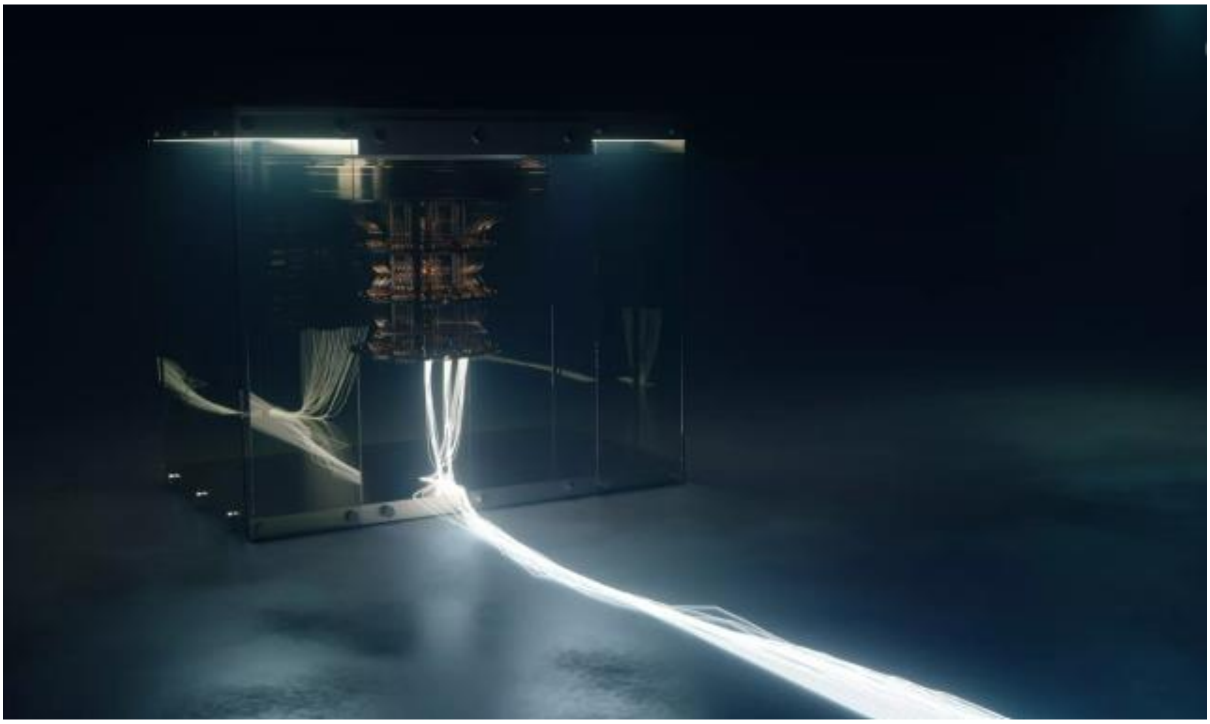
Read01 (China)

Scientists in Singapore: Liquid Electrons May Support Quantum Computing

English translation

2022/10/29

It could be an exciting day as Singapore scientists make new progress in quantum computing

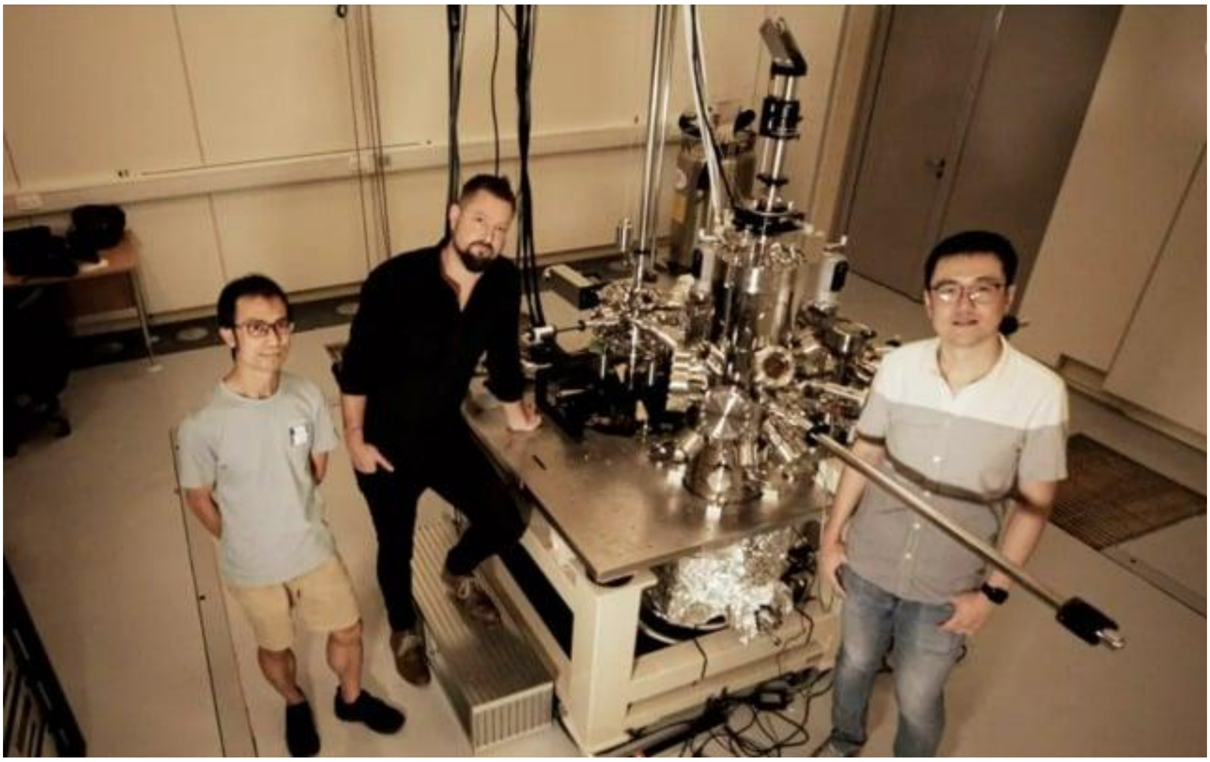


The field of quantum computing may have just received a boost in coherence and error-proofing in the form of parafermions: In a special state of matter, groups of electrons behave like a liquid. Based on the results of experiments done by scientists at Nanyang Technological University in Singapore, parafermions are expected to form when electrons are kept at temperatures close to absolute zero (-273 degrees Celsius). The research is a breakthrough because it demonstrates that electrons can interact strongly under certain conditions – this was only theorised by scientists previously.

The ordered movement of electrons produces what we know as electricity. However, even if the electrons move in this "ordered" pattern, they are not in actuality. This is because electrons are negatively charged and repel one another, so they tend to move in different directions individually and haphazardly (like a gas) rather than as a cohesive whole. They are like impaired drivers: they may encounter some "bumps" on the way to their destination. But when electrons behave like liquids, it’s akin to swapping impaired drivers for orderly ones; drivers know and respect each other’s boundaries, speeds, and directions to reduce conflict so they can better reach their destinations.

Of course, such movements are the subject of a lot of theoretical thinking, but such strong electron interactions have at least been shown to exist through experiments.

When electrons move in so-called "helical Tomonaga-Luttinger liquids," there is less particle interaction and energy exchange between them and the system. This in turn reduces the amount of systemic and environmental disturbances that are often responsible for producing errors and collapsed quantum states in quantum systems. Another important factor is having electrons cooled to near absolute zero, as it allows some materials to reach a state of superconductivity, in which electrons travel across their surface without any resistance, further reducing possible environmental interference elements. The system was cooled to absolute zero (in the experiment, this was down to 4.5 Kelvin or -269 degrees Celsius) forcing the particles to slow down so that they could barely move.



Electrons (and their spin properties) have been used as quantum programmable particles for some time. As a result, improvements in electronic control leads to less disturbance, which means fewer errors and better coherence, which means longer lifetimes for the actual qubits that can store or process information. In fact, some quantum systems (such as IBM's Quantum 1 and Quantum 2) already utilise superconducting qubits.

In this case, the scientists used atomically thick graphene substrates, where atomic-thick crystals of tungsten ditelluride were deposited: an almost two-dimensional material known as a "quantum spin Hall insulator," which insulates gravity on the inside, but has electron features on the outside. After assembling the graphene/tungsten ditelluride substrate and cooling it to absolute zero, the research team placed it under a scanning tunnelling microscope just a nanometre away from its surface: smaller than a DNA strand, and smaller than any currently fabricated transistor (even when looking at the transistors used in the latest and greatest graphics cards).

When placed under a scanning tunnelling microscope and cooled to absolute zero, the researchers noticed that the electrons in the graphene/tungsten substrate increased their repulsive force. Their repulsion is so strong that the electrons are forced to move collectively due to the interaction between each electron's repulsive field. The researchers registered Luttinger parameters in the range of 0.21 to 0.33. This parameter represents the strength of the interaction between particles; when it reaches 1, the interaction is at its weakest state.

When the Luttinger parameter is less than 0.5, the interaction is strong and the electrons are forced to move collectively. This is the area where parafermions are predicted to exist. This is a very significant range of variation, as the Luttinger parameter can only vary between 0 and 1, and involves control at a fairly low value for the Luttinger parameter.

https://read01.com/oENey40.html