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Reading data stored in antiferromagnets for better RAM

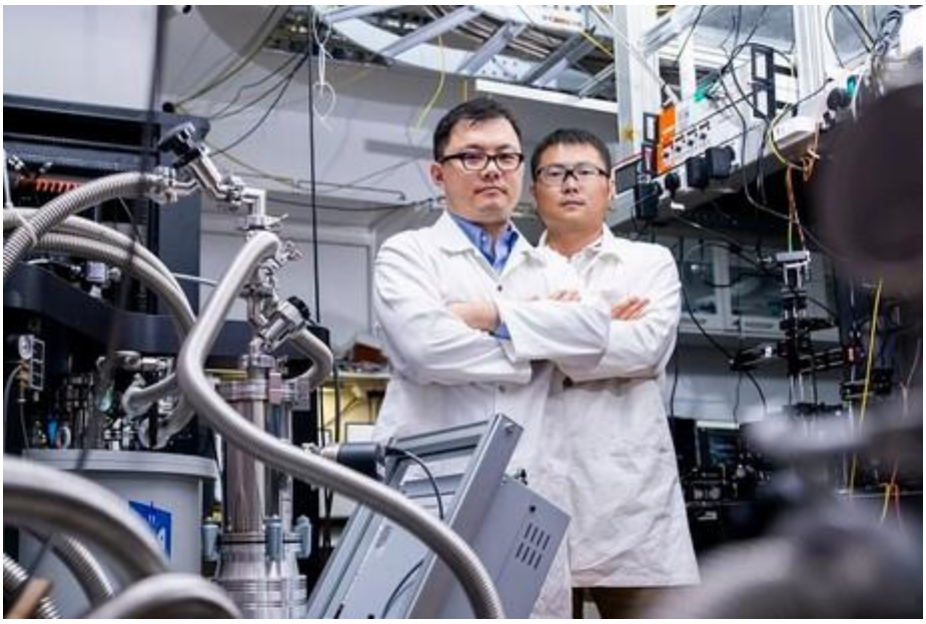

Image caption: Research fellow Dr Wang Naizhou (left) and Assoc Prof Gao Weibo from Nanyang Technological University, Singapore with the cryogenic superconducting magnet used to conduct their experiments on antiferromagnets. Image credit: Nanyang Technological University, Singapore.

Scientists from Nanyang Technological University, Singapore (NTU Singapore) have made an advancement in developing alternate materials for the high-speed memory chips that let computers access information quickly and that bypass the limitations of existing materials. The scientists have discovered a way that allows them to make sense of previously hard-to-read data stored in these alternative materials, known as antiferromagnets.

Antiferromagnets are considered to be attractive materials for making computer memory chips because they could be more energy efficient than traditional ones made from silicon. Memory chips made of antiferromagnets are not subject to the size and speed constraints nor corruption issues that are inherent to chips made with other magnetic materials.

Computer data is stored as code comprising a string of 1s and 0s. Methods exist to 'write' data onto antiferromagnets, by configuring them so that they can represent either the number 1 or 0. However, there are currently no practical methods to 'read' this data from antiferromagnets. Now, scientists led by Associate Professor Gao Weibo from NTU have found a solution.

Results from experiments, published in the scientific journal *Nature*, showed that at ultra-low temperatures close to the coldness of outer space, if they passed a current through antiferromagnets, a unique voltage was measured across them. Depending on whether this voltage was positive or negative, the scientists could figure out if the antiferromagnets were coded as 1 or 0. This then allowed the data stored in the materials to be read.

“Our discovery provides a straightforward way to read data stored in antiferromagnets by being able to distinguish the two states the materials can take. The findings advance research in using antiferromagnets for computer memory in the future,” Gao said.

Chips for computer memory, also called random-access memory (RAM), are used to quickly access data, such as for opening software and editing documents in computers. Memory chips made with antiferromagnets could store and change data faster than those made from magnetic materials called ferromagnets because they can change between the 1 and 0 states about 100 times faster. This is useful for resource-intensive computing tasks.

Computer memory traditionally comprises silicon microchips, but in the past few decades, researchers have looked at using ferromagnets, made from alloys of cobalt and iron, from memory chips, and that are now used in artificial intelligence and space applications. This is partly because ferromagnetic chips are more energy efficient than silicon ones. Memory chips use the internal properties of ferromagnets to store data. However, if ferromagnetic chips are exposed to magnetic chips, such as those from power lines or industrial equipment with electromagnets, these properties can get disturbed, thus corrupting or destroying the data that is stored. Ferromagnets also produce magnetic fields themselves that can disrupt the internal properties of other nearby ferromagnets.

Antiferromagnets can overcome these issues as they do not produce magnetic fields because their internal properties are different from those of ferromagnets. This means they will not become disturbed in the presence of other magnets, and more antiferromagnets can be packed in the same amount of space than ferromagnets, thus increasing memory capacity. Despite finding ways to configure antiferromagnets to encode data as 1s and 0s, reading this information is difficult, because there are no practical methods that can distinguish what state the materials are in.

The researchers found a solution to this problem while studying the physical properties of a new antiferromagnetic material called manganese bismuth telluride. The researchers passed an alternating current through a tiny device consisting of manganese bismuth telluride crystal flakes at low temperatures of around 5 Kelvins or -268°C. The researchers found a unique voltage signal across the crystals with a frequency double that of the alternating current. They also found that depending on how the antiferromagnetic manganese bismuth telluride was configured, the sign of the voltage would change.

If the voltage was positive, it meant the antiferromagnet was in a state representing 0. If the voltage was negative, the material was in a state representing 1. This solved the problem of not being able to read information stored in antiferromagnets.

The scientists believe that other antiferromagnets will display a similar behaviour and their next step will be to test such materials that can encode data at room temperature.

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