New Material May Lead To Advances In Quantum Computing

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Scientists at Florida State University's National High Magnetic Field Laboratory and the university's Department of Chemistry and Biochemistry have introduced a new material that could be to computers of the future what silicon is to the computers of today.

The material -- a compound made from the elements potassium, niobium and oxygen, along with chromium ions -- could provide a technological breakthrough that leads to the development of new quantum computing technologies. Quantum computers would harness the power of atoms and molecules to perform memory and processing tasks on a scale far beyond those of current computers. The research was recently published in *Physical Review Letters*.

"The field of quantum information technology is in its infancy, and our work is another step forward in this fascinating field," said Saritha Nellutla, a postdoctoral associate at the magnet lab and lead author of the paper.

Semiconductor technology is close to reaching its performance limit. Over the years, processors have shrunk to their current size, with the components of a computer chip more than 1,000 times smaller than the thickness of a human hair. At those very small scales, quantum effects -- behaviors in matter that occur at the atomic and subatomic levels -- can start playing a role. By exploiting those behaviors, scientists hope to take computing to the next level.

In current computers, the basic unit of information is the “bit,” which can have a value of 0 or 1. In so-called quantum computers, which currently exist only in theory, the basic unit is the “qubit” (short for quantum bit). A qubit can have not only a value of 0 or 1, but also all kinds of combinations of 0 and 1 -- including 0 and 1 at the same time -- meaning quantum computers could perform certain kinds of calculations much more effectively than current ones.

How scientists realize the promise of the theoretical qubit is not clear. Various designs and paths have been proposed, and one very promising idea is to use tiny magnetic fields, called “spins.” Spins are associated with electrons and various atomic nuclei.

Magnet lab scientists used high magnetic fields and microwave radiation to “operate” on the spins in the new material they developed to get an indication of how long the spin could be controlled. Based on their experiments, the material could enable 500 operations in 10 microseconds before losing its ability to retain information, making it a good candidate for a qubit.

Putting this spin to work would usher in a technological revolution, because the spin state of an electron, in addition to its charge, could be used to carry, manipulate and store information.

“This material is very promising,” said Naresh Dalal, a professor of chemistry and biochemistry at FSU and one of the paper’s authors. “But additional synthetic and magnetic characterization work is needed before it could be made suitable for use in a device.”

Dalal also serves as an adviser to FSU chemistry graduate student Mekhala Pati, who created the material.

Source: FSU