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A new way to control qubits

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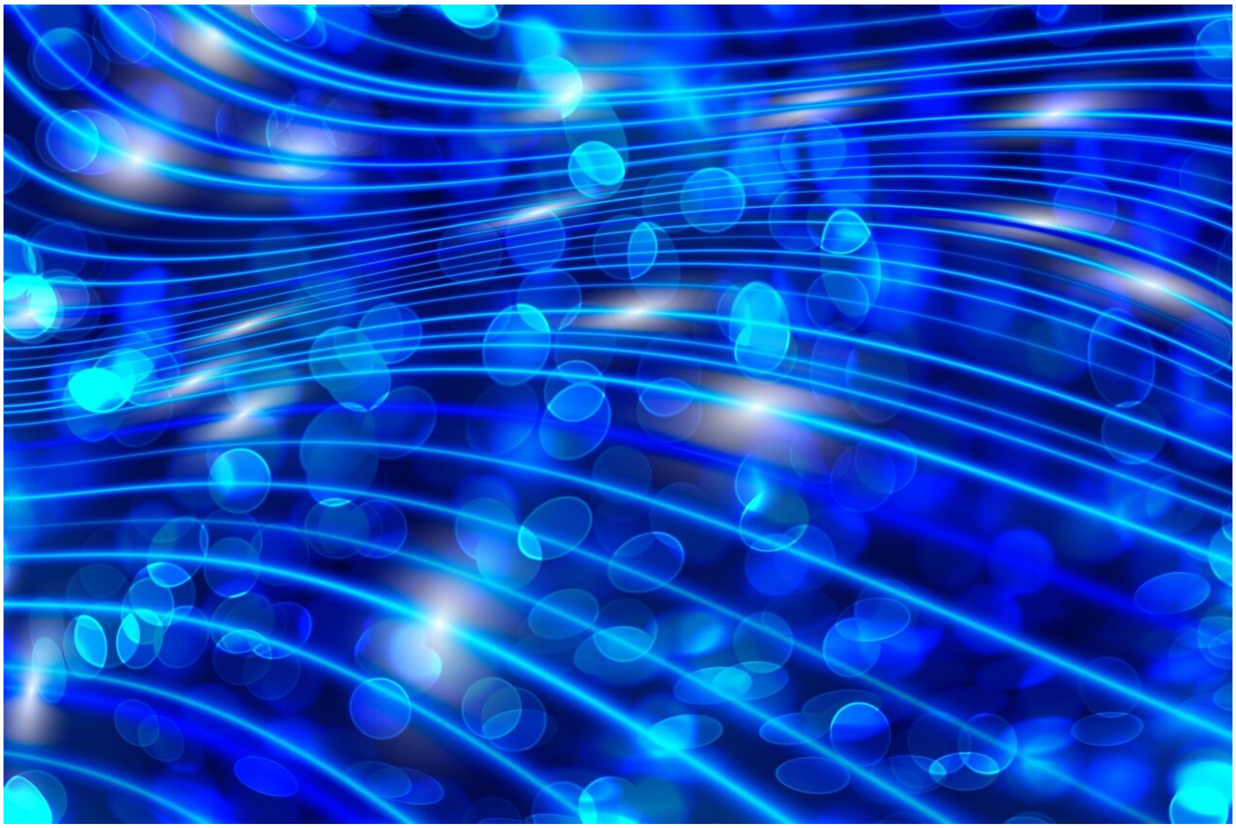

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A research team that includes two UO physicists have outlined new techniques for controlling the building blocks of quantum computing, a potentially significant step toward making such computers more accurate and useful.

Physicists David Allcock and David Wineland are founders of the new Oregon Ions Laboratory, which was recently set up in the basement of Willamette Hall. They are among 12 authors of a new paper, which is based on an experiment at the National Institute for Standards and Technology in Boulder, Colorado. Both scientists previously worked at the Colorado lab and continued to collaborate on the project after coming to the UO in 2018.

The techniques, described in the journal *Nature*, involve the use of trapped-ion quantum bits, or qubits, in quantum computing and simulations. They could lead to improvements in the operation of quantum computers, which still make too many computation errors to be effective tools, the physicists said.

The problem with quantum computers is that their logic gates—the tools used to perform basic logic functions in computing—"are really bad," Allcock said.

"They fail about 1 percent of the time," he said. "You can do about 100 (operations), then you get garbage out."

Wineland added, "The whole field is in a stage now, because of errors that exist, that we can't do lengthy calculations or simulations of practical value on our machines."

The goal is to get to 10,000 operations without error and then add layers of checks to fix the errors as they happen, he said.

"We want to get to that point," Allcock said. "Then you can use quantum computers for something useful. Right now they're just toys."

Wineland said trapped ions are like a bowl of marbles that have certain magnetic properties. Physicists can apply forces to the ions with different methods, including lasers, Allcock said. But lasers are expensive and complex machines, whereas making logic gates using magnetic forces is cheaper and more practical because they can be generated directly with integrated circuits, he said.

"What we did here is show these techniques work as well as anyone has done logic gates before," he said.

Google and IBM are among the commercial enterprises that have armies of engineers working on such problems, while academic physicists are trying to show there are better, more basic techniques for solving them.

"We've shown you can do it in a technically simpler way," he said.

If physicists and engineers can make quantum computers reliable and able to operate with large enough capacity, they could simulate other systems, Wineland said. For example, a quantum computer could simulate the action of a molecule used in drug therapy without having to synthesize it in a lab.

"There are some very practical, useful outcomes," Wineland said. "We're just scratching the surface."

More information: Srinivas, R. et al. High-fidelity laser-free universal control of trapped ion qubits. *Nature* (2021).
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