Speeding-up quantum computing using giant atomic ions

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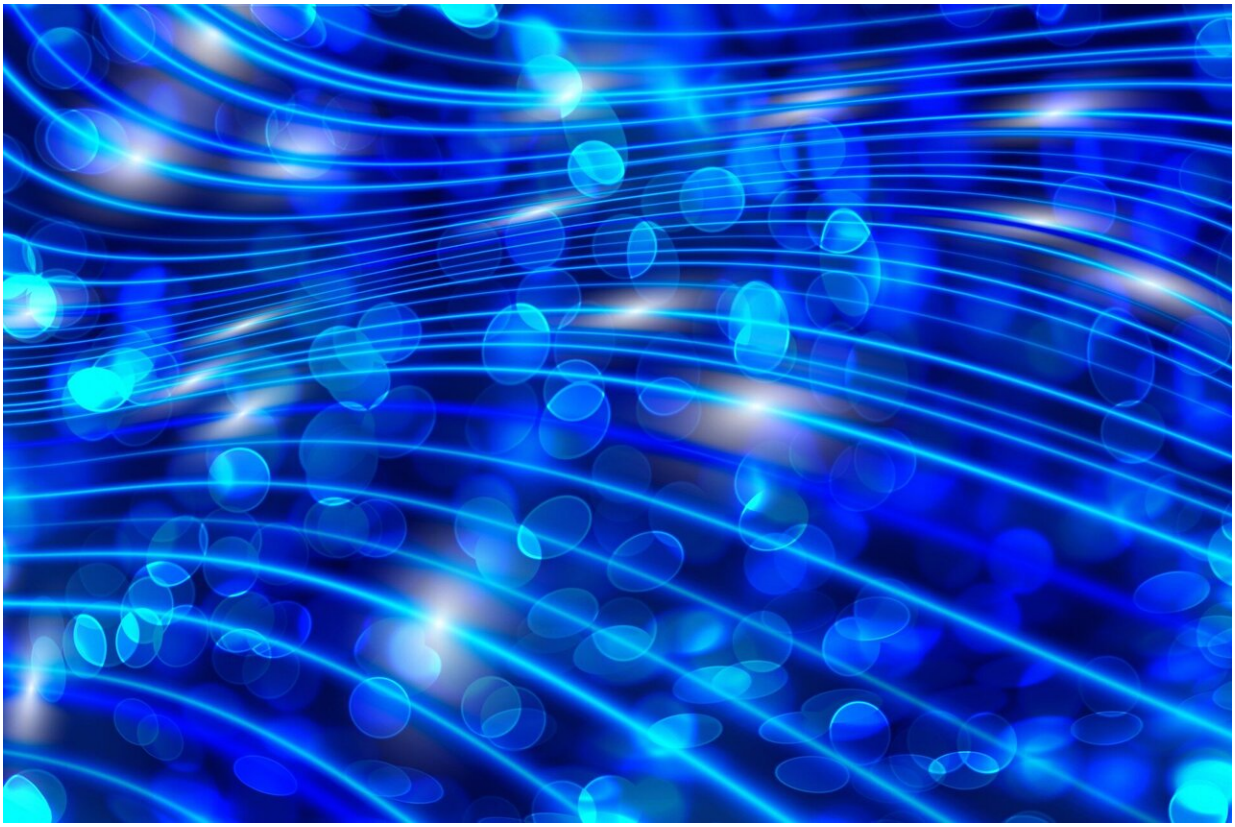

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Trapped Rydberg ions may be the next step towards scaling up quantum computers to sizes where they can be practically usable, a new study in *Nature* shows.

Different physical systems can be used to make a quantum computer. Trapped ions that form a crystal have led the research field for years, but when the system is scaled up to large ion crystals this method gets very slow. Complex arithmetic operations cannot be performed fast enough before the stored quantum information decays.

A Stockholm University research group may have solved this problem by using giant Rydberg ions, 100 million times larger than normal atoms or ions. These huge ions are highly interactive and, therefore, can exchange quantum information in less than a microsecond.

"In a sense, Rydberg ions form small antennas for exchanging quantum information and thus make it possible to realize particularly fast quantum gates, which are the 'basic building blocks' of a quantum computer," explains Markus Hennrich, Department of Physics, Stockholm University, and group leader from the Stockholm University team. "The interaction between Rydberg ions is not based on crystal vibrations, as with ions trapped in crystal form, but on the exchange of photons. The fast interaction between the Rydberg ions can be used to create quantum entanglement."

"We used this interaction to carry out a quantum computing operation (an entangling gate) that is around 100 times faster than is typical in trapped ion systems," explains Chi Zhang, researcher at the Department of Physics, Stockholm University.

Theoretical calculations supporting the experiment have been conducted by Igor Lesanovsky and Weibin Li at University of Nottingham, UK and University of Tübingen, Germany.

"Our theoretical work confirmed that there is indeed no slowdown expected once the ion crystals become larger, highlighting the prospect of a scalable quantum computer," says Igor Lesanovsky from University

of Tübingen.

Quantum computers are regarded as one of the key technologies of the 21st century. While conventional computers function according to the laws of classical physics, quantum computers work according to the rules of quantum mechanics. The ability of entangled quanta to exchange information without time delay makes them very fast and powerful. In the future, quantum computers could be used wherever complex calculations need to be solved, for example in the design of new medications or in artificial intelligence.

More information: Zhang, C., Pokorny, F., Li, W. et al. Submicrosecond entangling gate between trapped ions via Rydberg interaction. *Nature* 580, 345–349 (2020). doi.org/10.1038/s41586-020-2152-9 , nature.com/articles/s41586-020-2152-9

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