14 quantum bits: Physicists go beyond the limits of what is currently possible in quantum computation

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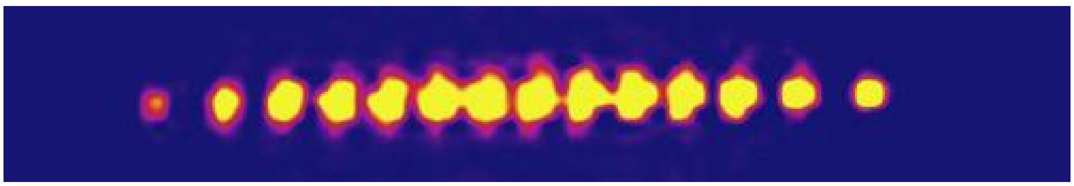

Up to 14 quantum bits were entangled in an ion trap.

(PhysOrg.com) -- Quantum physicists from the University of Innsbruck (Austria) have set another world record: They have achieved controlled entanglement of 14 quantum bits (qubits) and, thus, realized the largest quantum register that has ever been produced. With this experiment the scientists have not only come closer to the realization of a quantum computer but they also show surprising results for the quantum mechanical phenomenon of entanglement.

The term entanglement was introduced by the Austrian Nobel laureate Erwin Schrödinger in 1935, and it describes a quantum mechanical phenomenon that while it can clearly be demonstrated experimentally, is not understood completely. Entangled particles cannot be defined as single particles with defined states but rather as a whole system. By entangling single quantum bits, a quantum computer will solve problems considerably faster than conventional computers. "It becomes even more difficult to understand entanglement when there are more than two particles involved," says Thomas Monz, junior scientist in the research group led by Rainer Blatt at the Institute for Experimental Physics at the University of Innsbruck. "And now our experiment with many particles provides us with new insights into this phenomenon," adds Blatt.

World record: 14 quantum bits

Since 2005 the research team of Rainer Blatt has held the record for the number of entangled quantum bits realized experimentally. To date, nobody else has been able to achieve controlled entanglement of eight particles, which represents one quantum byte. Now the Innsbruck scientists have almost doubled this record. They confined 14 calcium atoms in an ion trap, which, similar to a quantum computer, they then manipulated with laser light. The internal states of each atom formed single qubits and a quantum register of 14 qubits was produced. This register represents the core of a future quantum computer. In addition, the physicists of the University of Innsbruck have found out that the decay rate of the atoms is not linear, as usually expected, but is proportional to the square of the number of the qubits. When several particles are entangled, the sensitivity of the system increases significantly. "This process is known as superdecoherence and has rarely been observed in quantum processing," explains Thomas Monz. It is not only of importance for building quantum computers but also for the construction of precise atomic clocks or carrying out quantum simulations.

Increasing the number of entangled particles

By now the Innsbruck experimental physicists have succeeded in confining up to 64 particles in an ion trap. "We are not able to entangle this high number of ions yet," says Thomas Monz. “However, our current findings provide us with a better understanding about the behavior of many entangled particles." And this knowledge may soon enable them to entangle even more atoms.

Some weeks ago Rainer Blatt's research group reported on another important finding in this context in the scientific journal *Nature*: They showed that ions might be entangled by electromagnetic coupling. This enables the scientists to link many little quantum registers efficiently on a micro chip. "All these findings are important steps to make quantum technologies suitable for practical information processing," Rainer Blatt is convinced.

The results of this work are published in the scientific journal *Physical Review Letters*.

More information: 14-Qubit Entanglement: Creation and Coherence. Thomas Monz, Philipp Schindler, Julio T. Barreiro, Michael Chwalla, Daniel Nigg, William A. Coish, Maximilian Harlander, Wolfgang Hänsel, Markus Hennrich, Rainer Blatt. *Phys. Rev. Lett.* 106, 130506 (2011) DOI:10.1103/PhysRevLett.106.130506

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