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Scientists succeed in linking two different quantum systems

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Physicists at the Universities of Bonn and Cambridge have succeeded in linking two completely different quantum systems to one another. In doing so, they have taken an important step forward on the way to a quantum computer. To accomplish their feat the researchers used a method that seems to function as well in the quantum world as it does for us people: teamwork. The results have now been published in the *Physical Review Letters*.

When facing big challenges, it is best to work together. In a team, the individual members can contribute their individual strengths – to the benefit of all those involved. One may be an absent-minded scientist who has brilliant ideas, but quickly forgets them. He needs the help of his conscientious colleague, who writes everything down, in order to remind the scatterbrain about it later. It's very similar in the world of quanta. There the so-called quantum dots (abbreviated: qDots) play the role of the forgetful genius. Quantum dots are unbeatably fast, when it comes to disseminating quantum information. Unfortunately, they forget the result of the calculation just as quickly – too quickly to be of any real use in a quantum computer.

In contrast, charged atoms, called ions, have an excellent memory: They can store quantum information for many minutes. In the quantum world, that is an eternity. They are less well suited for fast calculations, however, because the internal processes are comparatively slow. The physicists from Bonn and Cambridge have therefore obliged both of these components, qDots and ions, to work together as a team. Experts speak of a hybrid system, because it combines two completely different quantum systems with one another.

Absent-minded qDots

qDots are considered the great hopes in the development of quantum computers. In principle, they are extremely miniaturized electron storage units. qDots can be produced using the same techniques as normal computer chips. To do so, it is only necessary to miniaturize the structures on the chips until they hold just one single electron (in a conventional PC it is 10 to 100 electrons).

The electron stored in a qDot can take on states that are predicted by quantum theory. However, they are very short-lived: They decay within a few picoseconds (for illustration: in one picosecond, light travels a distance of just 0.3 millimeters). This decay produces a small flash of light: a photon. Photons are wave packets that vibrate in a specific plane – the direction of polarization. The state of the qDots determines the direction of polarization of the photon. "We used the photon to excite an ion", explains Prof. Dr. Michael Köhl from the Institute of Physics at the University of Bonn. "Then we stored the direction of polarization of the photon".

Conscientious ions

To do so, the researchers connected a thin glass fiber to the qDot. They transported the photon via the fiber to the ion many meters away. The fiberoptic networks used in telecommunications operate very similarly. To make the transfer of information as efficient as possible, they had trapped the ion between two mirrors. The mirrors bounced the photon back and forth like a ping pong ball, until it was absorbed by the ion. "By shooting it with a laser beam, we were able to read out the ion that was excited in this way", explains Prof. Köhl. "In the process, we were able to measure the direction of polarization of the previously absorbed photon". In a sense then, the state of the qDot can be preserved in the ion – theoretically this can be done for many minutes.

This success is an important step on the still long and rocky road to a quantum computer. In the long term, researchers around the world are hoping for true marvels from this new type of computer: Certain tasks, such as the factoring of large numbers, should be child's play for such a computer. In contrast, conventional computers find this a really tough nut to crack. However, a quantum computer displays its talents only for such special tasks: For normal types of basic computations, it is pitifully slow.

More information: Direct photonic coupling of a semiconductor quantum dot and a trapped ion; *Physical Review Letters*; dx.doi.org/10.1103/PhysRevLett.114.123001

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