CACNews.ca (Canada)
1 Dec 2024

English translation

Scientists find way to shrink quantum computer components 1,000 times

Source: cnBeta

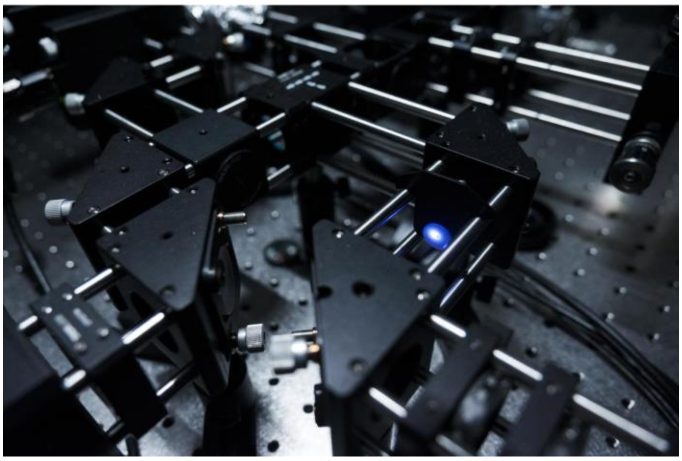
Researchers have developed a revolutionary method to dramatically reduce the size of quantum computing components by using thinner materials to generate entangled pairs of photons. The breakthrough enables simpler, more compact setups for quantum technology, with the potential to transform fields from climate science to pharmaceuticals.

Leevi Kallioniemi, a PhD student from the School of Physical and Mathematical Sciences at Nanyang Technological University, Singapore, uses a blue laser device to generate entangled photon pairs. Image credit: Nanyang Technological University, Singapore

The discovery by the researchers could make quantum computing much more compact, potentially shrinking basic components by a factor of 1,000 while requiring less equipment.

One class of quantum computers currently under development relies on pairs of light particles, or photons, that are linked to each other and, in quantum physics parlance, are "entangled." One way to generate these photons is to shine lasers through millimeter-thick crystals and use optical devices to ensure that the photons are linked to each other. The downside to this approach is that it is too bulky to be integrated into a computer chip.

Now, scientists at Nanyang Technological University, Singapore (NTU Singapore) have found a way around this problem by using thinner materials (only 1.2 microns thick, about 80 times thinner than a human hair) to produce connected pairs of photons. Moreover, they do not need additional optical equipment to maintain the connection between the photon pairs, making the entire device simpler.

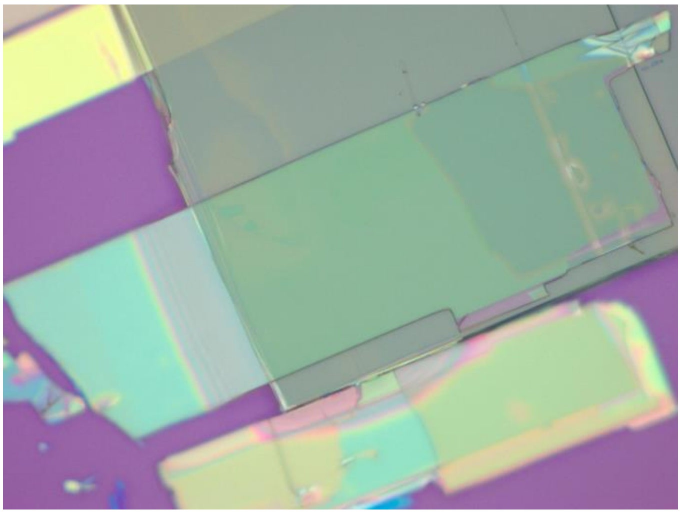


A blue laser device used to generate entangled photon pairs in an experiment at Nanyang Technological University, Singapore. Credit: Nanyang Technological University, Singapore

"Our new method for creating entangled photon pairs paves the way for the miniaturization of quantum optical entanglement sources, which is crucial for applications in quantum information and photon quantum computing ." He added that this method could reduce the size of devices for quantum applications, as many current quantum application devices require large, bulky optical devices that need to be aligned before they can work, which is very troublesome.

Quantum computers are expected to revolutionize the way we tackle many challenges, from helping us better understand climate change to finding new medicines faster by completing complex calculations and quickly finding patterns in large data sets. For example, a quantum computer could perform calculations that would take today's supercomputers millions of years to complete in minutes.

This is possible because quantum computers can perform multiple calculations simultaneously, rather than one at a time like standard computers.

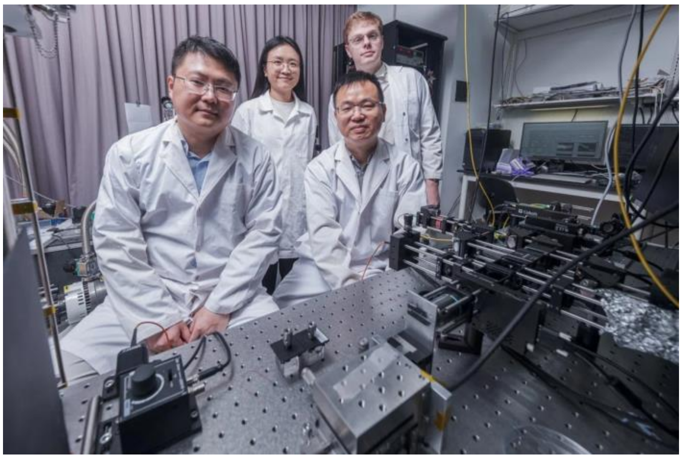


Two thin sheets of niobium oxychloride stacked together and photographed under an optical microscope. The grains of one sheet (grey) are perpendicular to the grains of the other sheet (green). Source: Nanyang Technological University, Singapore

Quantum computers can do this because they perform calculations using tiny switches called quantum bits, or qubits, that can be both on and off at the same time. It's like flipping a coin in the air and spinning it between heads and tails. In contrast, standard computers use switches that can be either on or off at any time, but not both at the same time.

Photons can be used as qubits in quantum computers to perform faster calculations because they can be both on and off at the same time. However, they can only be in both states at the same time if the photons are produced in pairs, with one photon linked to, or entangled with, the other. An important condition for entanglement is that the paired photons need to vibrate in sync.

One advantage of using photons as qubits is that they can be created and entangled at room temperature, so relying on photons can be easier, cheaper and more practical than using other particles, such as electrons, which require ultra-cold temperatures approaching those of outer space for quantum computing.



(From left) Professor Gao Weibo, Dr Lyu Xiaodan, Professor Liu Zheng and PhD student Leevi Kallioniemi are part of the NTU Singapore team that discovered a new way to generate entangled photon pairs using extremely thin materials. Source: Nanyang Technological University, Singapore

Researchers have been working to find thinner materials that can generate connected pairs of photons for use in computer chips. However, one challenge is that when materials become thinner, the rate at which they generate photons slows down dramatically, making it impractical for computing.

Recent advances have shown that a new crystalline material called niobium oxychloride is promising, with unique optical and electronic properties that allow it to efficiently generate photon pairs despite being very thin. But these photon pairs are useless for quantum computers because they are not entangled when they are generated.

Professor Gao from NTU's School of Electrical and Electronic Engineering and School of Physical and Mathematical Sciences, in collaboration with Professor Liu Zheng from the School of Materials Science and Engineering, found a solution.

Professor Gao's solution was inspired by a well-established method for making entangled photon pairs using thicker, larger crystalline materials, published in 1999. It involves stacking two sheets of thick crystal together and positioning the grains of each crystal perpendicular to each other.

However, due to the different ways in which the photon pairs propagate through the thick crystal after they are generated, the vibrations produced by the photon pairs may still be out of sync. Therefore, additional optical equipment is needed to synchronize the photon pairs to maintain the connection between the light particles.

Professor Gao speculated that a similar twin-crystal setup could be used to generate linked photons using two thin wafers of niobium oxychloride (1.2 microns thick in total), without the need for additional optics. He expected this to happen because the wafers used were much thinner than the bulk crystals used in earlier studies. As a result, the generated photon pairs would have to travel a smaller distance in the niobium oxychloride wafers, so the light particles would stay in sync with each other. The NUS team's experiments proved that his hunch was correct.

Professor Sun Zhipei of Aalto University in Finland specializes in photonics and was not involved in the NTU study. He said entangled photons are like synchronized clocks that show the same time no matter how far apart they are, thus enabling instant communication, and the research team's method of generating quantum entangled photons "is a major advance that has the potential to enable the miniaturization and integration of quantum technology."

Professor Sun, co-lead researcher at the Research Council of Finland's Centre of Excellence in Quantum Technologies, said: "This research achievement is expected to advance the development of quantum computing and secure communications as it can enable more compact, scalable and efficient quantum systems."

The research team plans to further optimize the design of their device to produce even more linked photon pairs than is currently possible.

Some of the ideas include exploring whether introducing tiny patterns and bangs on the surface of niobium oxychloride flakes can increase the number of photon pairs produced. Another idea is to study whether stacking niobium oxychloride flakes with other materials can improve photon production.

Compiled from/ScitechDaily

https://cacnews.ca/163080.html