The entanglement of two quantum memory systems 12.5 km apart from each other

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Image representing the nodes' layout on a map. Credit: Luo et al.

Quantum computing technology could have notable advantages over classical computing technology, including a faster speed and the ability to tackle more complex problems. In recent years, some researchers have also been exploring the possible establishment of a "quantum internet," a network that would allow quantum devices to exchange information, just like classical computing devices exchange information today.

The quantum internet could open fascinating possibilities for numerous quantum technology applications. For instance, it could enable more secure communications, more precise remote sensing and distributed quantum computing networks.

Researchers at the University of Science and Technology of China and Jinan Institute of Quantum Technology have recently demonstrated quantum entanglement between two memory devices located at 12.5 km apart from each other within an urban environment. Their paper, published in *Physical Review Letters*, could be a further step towards the development of a quantum internet.

"In 2020, we published a paper in which we demonstrate the entanglement of two quantum memories via a fiber link of 50 km," Xiao-Hui Bao, one of the researchers who carried out the study, told Phys.org. "In that experiment, both two memories we used were located within one lab and thus not fully independent. The next step in our research was to make the two memories fully independent, while placing a long distance between them."

In their experiment, Bao and his colleagues introduced two quantum nodes in different locations in an urban environment, placing them at a 12.5 km distance from one another. In the first node, dubbed node A, they entangled their first quantum memory with a single photon. This single photon was then sent to node B and stored within the second quantum memory.

"In this way we entangle the two remote quantum memories," Bao explained. "Since the photon emitted from our memory is near infrared (795 nm), being not suitable for low-loss transmission in fiber, we make use of the quantum frequency conversion technique to shift the photon's wavelength to 1342 nm instead, which improves the overall transmission efficiency significantly."

While some previous studies had demonstrated quantum connections over long distances, they primarily involved the transfer of entangled photons. On the other hand, Bao and his colleagues established entanglement between two atom-based quantum memory devices.

This could enable connectivity between several different nodes, which is a key requirement for establishing reliable quantum computing networks.

"The main achievement of our recent work is that we realized the longest distance of entanglement distribution with quantum memories," Bao said. "Such entanglement is the fundamental resource to build quantum network and quantum repeaters."

The recent work by Bao and his colleagues is a notable contribution to the area of research focusing on the establishment of a quantum internet. Their demonstration of entanglement between two quantum memory systems at 12.5 km could be an important step towards enabling secure quantum communications over long distances.

"In the current experiment, the remote entanglement generated is not heralded yet, limiting its further applications," Bao added. "In the near future, we plan to implement a heralded version, meanwhile we plan to extend number of nodes as well."

More information: Xi-Yu Luo et al, Postselected Entanglement between Two Atomic Ensembles Separated by 12.5 km, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.129.050503

Yong Yu et al, Entanglement of two quantum memories via fibres over dozens of kilometres, *Nature* (2020). DOI: 10.1038/s41586-020-1976-7