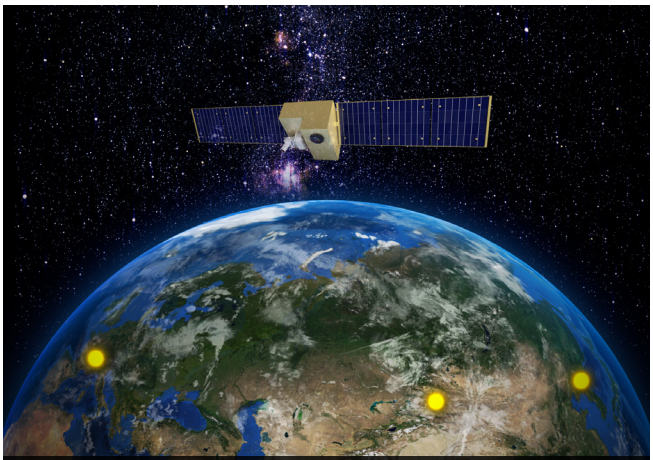
Making light work of quantum breakthroughs

Jian-Wei Pan's team has used the quantum mechanics of photons to create A RECORD-BREAKING COMPUTER and an unprecedented satellite-based network for SECURE INTERNATIONAL COMMUNICATION.



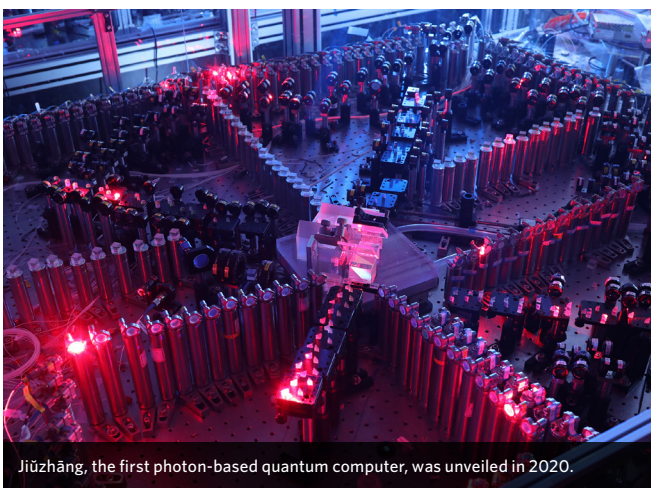
The first highly secure ground-to-space quantum network was revealed in 2021.

When Jian-Wei Pan looks up at the night sky, he pictures a 'quantum satellite constellation', a global network of communications satellites relaying light particles, or photons, that have been encrypted to provide new levels of data security.

This, he imagines, might one-day provide the basis for an un-hackable 'quantum internet'. On the ground, will be quantum computers that speed through tasks that are currently impossible.

In the past year, Pan and his colleagues reported two milestones towards this vision: the first ground-to-space quantum network spanning more than 4,600 kilometres, which was detailed in *Nature* in 2021; and the first photon-based quantum computer that dramatically outperforms today's best machines, reported in *Science* in 2020.

Quantum cryptography exploits the laws of the microrealm, quantum mechanics, to prevent hacking – and is already used in a number of industries in China and elsewhere. If you encode your messages using a secure key made of quantum bits, or qubits, any attempt to eavesdrop will raise an alarm.



Jiŭzhāng, the first photon-based quantum computer, was unveiled in 2020.

The challenge is to create a long-distance network because optical fibres attenuate light exponentially with distance. The solution; to bounce signals around the globe with satellites, since photons can zoom through the vacuum of space, with little obstruction.

In 2017, Pan and his colleagues used China's low-orbit Micius satellite to break the record for quantum teleportation, transmitting the quantum state of a photon on Earth 1,400 kilometres to a photon in orbit, and later that year securely linking Beijing to Vienna for video communicating by this method.

In 2021, the group achieved the fastest ever secure communication key distribution rate at 47.8 kilobytes per second between the satellite and ground – 40 times higher than the previous record.

"We are planning to launch a high-orbit satellite in a few years and build a quantum satellite constellation," says Pan.

But for a comprehensive quantum internet, a constellation needs to hook up quantum computers.

In 2019, Google reported their quantum computer Sycamore had performed a task that was beyond the reach of any classical supercomputer. Sycamore's 53 qubits were made from tiny superconducting loops.

In 2020, Pan's team followed up by demonstrating that their quantum computer, Jiŭzhāng, built with 76 photon qubits, could perform a certain task 10^{14} times faster than a classical supercomputer.

Jiŭzhāng's feat "is an early and important milestone of quantum computing," says Pan, but he also urges caution. Quantum computers are still in their infancy, and a sense of inertia driven by unrealized hype could spell a 'quantum winter' for funding and interest. "We need to be optimistic, but realistic," he says. ■

Phone: +86-551-63600455
Email: hfnl@ustc.edu.cn
Website: en.hfnl.ustc.edu.cn