# New technology breakthroughs enabling global ultra-secure Quantum networks for financial, government and Military

Quantum key distribution (QKD), establishes highly secure keys between distant parties by using single photons to transmit each bit of the key. A unique aspect of quantum cryptography is that Heisenberg's uncertainty principle ensures that any attempts to intercept and measure quantum transmissions, will introduce an anomalously high error rate in the transmissions between Alice and Bob, allowing them to detect the attempted eavesdropping. QKD is suitable for use in any key distribution application that has high security requirements including financial transactions, electoral communications, law enforcement, government, and military applications.

Currently Most Quantum Communication links are direct point-to-point links through telecom optical fibers and, ultimately limited to about 300-500 km due to losses in the fiber. Long distance fibre optic communications exploit the low loss of silica fibres in the 1.3 µm and 1.55 µm wavelength bands. In optical fibers, the wavelength of 1550 nm is very convenient, as it experiences the lowest absorption losses of the whole spectrum, and can be detected with Indium-Gallium-Arsenide avalanche photodiodes (InGaAs APD) in the single photon counting regime.

The next important milestone, is development of large scale

QKD network to extend QKD from point-to-point configuration to multi-user and large-scale scenario. China has also operationalised the 2,000-km quantum communication main network between Beijing and Shanghai using quantum repeaters.

Another way to overcome distance limitation is by bringing quantum communication into space. An international team led by the Austrian physicist Anton Zeilinger has successfully transmitted quantum states between the two Canary Islands of La Palma and Tenerife, over a distance of 143 km.

Free space QKD channels based on Free space laser communication and have several advantages over the optical fiber. Firstly, the atmosphere is an almost non birefringent medium which guarantees the preservation of photon polarization. Secondly, there is a relatively low absorption loss in the atmosphere for certain wavelengths. This fact enables us to achieve a longer communication range. For free-space quantum channels, the transmission wavelength is usually chosen around 780 nm, which corresponds to the quantum efficiency peak of Silicon Avalanche Photodiodes (Si APD).

Recently, China launched a quantum science satellite and performing many quantum experiments with optical links between space and ground. In one of the experiment the Micius' satellite used quantum key distribution for secure video chat between one ground station near Vienna, with one near Beijing.

However, establishing global QKD networks would require combining satellite networks with fiber optic links and free space links all dissimilar in wavelength.

"Interfacing fundamentally different quantum systems is key to building future hybrid quantum networks. Such heterogeneous networks offer capabilities superior to those of their homogeneous counterparts, as they merge the individual advantages of disparate quantum nodes in a single network architecture. However, few investigations of optical hybrid interconnections have been carried out, owing to fundamental and technological challenges such as wavelength and bandwidth matching of the interfacing photons," write authors in nature.

The ICFO researchers have developed a solution and solved the challenge of a reliable transfer of quantum states between different quantum nodes via single photons. A single photon needs to interact strongly and in a noise-free environment with the heterogeneous nodes or matter systems, which generally function at different wavelengths and bandwidths. As Nicolas Maring states "it's like having nodes speaking in two different languages. In order for them to communicate, it is necessary to convert the single photon's properties so it can efficiently transfer all the information between these different nodes."

## Quantum internet goes hybrid

In a recent study published in Nature, ICFO researchers led by ICREA Prof. Hugues de Riedmatten report an elementary "hybrid" quantum network link and demonstrate photonic quantum communication between two distinct quantum nodes placed in different laboratories, using a single photon as information carrier.

In their study, the ICFO researchers used two very distinct quantum nodes: the emitting node was a laser-cooled cloud of Rubidium atoms and the receiving node a crystal doped with Praseodymium ions. From the cold gas, they generated a quantum bit (qubit) encoded in a single photon with a very-narrow bandwidth and a wavelength of 780 nm. They then converted the photon to the wavelength of 1552 nm to demonstrate that this network could be completely compatible with the current telecom C-band range.

Subsequently, they sent it through an optical fiber from one lab to the other. Once in the second lab, the photon’s wavelength was converted to 606 nm in order to interact correctly and transfer the quantum state to the receiving doped crystal node. Upon interaction with the crystal, the photonic qubit was stored in the crystal for approximately 2.5 microseconds and retrieved with very high fidelity.

For this experiment the researchers used a photon encoding technique called time-bin encoding, which is very well suited to communicating qubits and preventing interference. Our results open up the prospect of optically connecting quantum nodes with different capabilities and represent an important step towards the realization of large-scale hybrid quantum networks.

## References and Resources also include:


https://phys.org/news/2017-11-quantum-internet-hybrid.html#jCp

https://www.sciencealert.com/scientists-just-transferred-quantum-information-from-a-gas-to-a-crystal-for-the-first-time