Space race under way to create quantum satellite

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In this month's special edition of *Physics World*, focusing on quantum physics, Thomas Jennewein and Brendon Higgins from the Institute for Quantum Computing at the University of Waterloo, Canada, describe how a quantum space race is under way to create the world's first global quantum-communication network.

The field of quantum communication – the science of transmitting quantum states from one place to another – has received significant attention in the last few years owing to the discovery of quantum cryptography.

Quantum cryptography exploits a unique property of single particles, such as photons: they can exist in two separate states – such as vertically polarized or horizontally polarized – or something in-between, known as a quantum superposition. Upon measuring the state of a particle you instantly change this state, meaning an encryption key made of photons can be passed between two parties safe in the knowledge that if an eavesdropper intercepts it, this would be noticed.

Quantum cryptography has been described as a way of creating "unbreakable" messages and has attracted the attention of major technology companies, governments, banks and other security-focused clients.

The transmission of encryption keys over long distances still remains a significant challenge for scientists, however, as the intensity of signals tends to weaken as they travel further because photons get absorbed or scattered off molecules.

Up until now, the furthest that quantum-communication signals have been sent is a few hundred kilometres, which would realistically enable communication between just one or two cities.

There is one place, however, where scattering doesn't appear to happen – empty space. Jennewein and Higgins lead just one of several teams around the world looking to take advantage of this by pursuing the concept of a quantum satellite.

A signal travelling from a ground station on Earth to a satellite would spend most of its time in the empty vacuum of space – rather than in Earth's atmosphere, which is crowded with gas molecules – so the signal would travel a lot further without weakening.

A satellite orbiting at around 32,000 km above Earth would act as a kind of relay between two ground stations in a way that allows them to establish a secure link by sharing an encryption key made of photons.

In addition to the basic mass and power of the satellite itself, the team led by Jennewein and Higgins has been studying the overall design features of the satellite and ground stations and has emphasized the need for them both to be precisely aligned so they can be certain that what they are measuring correctly corresponds to the photons that are prepared.

"With the prospect of global-scale quantum communications and fundamental quantum science within new, unexplored regimes, the next few years are sure to be exciting," Jennewein and Higgins write.

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