PHYS.ORG

'Spooky action at a distance' aboard the ISS

April 9 2013

International Space Station. Credits: ESA

(Phys.org) —Albert Einstein famously described quantum entanglement as "spooky action at distance"; however, up until now experiments that examine this peculiar aspect of physics have been limited to relatively small distances on Earth.

In a new study published today, 9 April, in the Institute of Physics and German Physical Society's *New Journal of Physics*, researchers have proposed using the International Space Station (ISS) to test the limits of this "spooky action" and potentially help to develop the first global quantum communication network.

Their plans include a so-called Bell experiment which tests the theoretical contradiction between the predictions of quantum mechanics and classical physics, and a quantum key distribution experiment which will use the ISS as a relay point to send a secret encryption key across much larger distances than have already been achieved using optical fibres on Earth.

Their calculations show that "major experimental goals" could already be achieved with only a few overhead passes of the ISS, with each of the experiments lasting less than 70 seconds on each pass.

"During a few months a year, the ISS passes five to six times in a row in the correct orientation for us to do our experiments. We envision setting up the experiment for a whole week and therefore having more than enough links to the ISS available," said co-author of the study Professor Rupert Ursin from the Austrian Academy of Sciences.

Furthermore, the only equipment needed aboard the ISS would be a photon detection module which could be sent to the ISS and attached to an already existing motorised commercial photographer's lens (Nikon 400 mm), which sits, always facing the ground, in a 70 cm window in the Cupola Module.

For the Bell experiment, a pair of entangled photons would be generated on the ground; one would be sent from the ground station to the modified camera aboard the ISS, while the other would be measured locally on the ground for later comparison.

Entangled photons have an intimate connection with each other, even when separated over large distances, which defies the laws of classical physics. A measurement on one of the entangled photons in a pair will determine the outcome of the same measurement on the second photon, no matter how far apart they are.

"According to quantum physics, entanglement is independent of distance. Our proposed Bell-type experiment will show that particles are entangled, over large distances—around 500 km—for the very first time in an experiment," continued Professor Ursin.

"Our experiments will also enable us to test potential effects gravity may have on quantum entanglement."

The researchers also propose a quantum key distribution experiment, where a secret cryptographic key is generated using a stream of photons and shared between two parties safe in the knowledge that if an eavesdropper intercepts it, this would be noticed.

Up until now, the furthest a secret key has been sent is just a few hundred kilometres, which would realistically enable communication between just one or two cities.

Research teams from around the world are looking to build quantum satellites that will act as a relay between the two parties, significantly increasing the distance that a secret key could be passed; however, the new research shows that this may be possible by implementing an optical uplink towards the ISS and making a very minor alteration to the camera already on-board.

More information: Quantum optics experiments to the International Space Station ISS: a proposal" T Scheidl et al 2013 *New J. Phys.* 15 043008. iopscience.iop.org/1367-2630/15/4/043008/article

Provided by Institute of Physics