Quantum calibration paves way for super-secure communication

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(PhysOrg.com) -- A new approach to calibrating quantum mechanical measurement has been developed with particular applications in optics and super-secure quantum communication.

Scientists have used the approach to directly calibrate a detector that can sense the presence of multiple individual photons, it is revealed in research published yesterday(16 November) in *Nature Physics.*

Being able to sense the presence of individual photons is an important requirement for the development of future long-distance quantum communication devices and networks. One of the potential applications of this new detector is in devices for secret communications, which could allow information to be exchanged in total security guaranteed by the laws of physics, with no possibility of interception, or eavesdropping.

Photons are miniscule 'packets' of light energy. Visible daylight is made of billions upon billions of photons which enter your eye every second. The photon detector described in today's Nature Physics paper is unique because, unlike previous detectors which could only tell scientists whether any photons were present or not, this machine can count and record the precise number of up to eight individual photons at any one time, making it one of the most accurate light-detecting machines in the world.

This means that devices which rely on information being transmitted in the form of light energy – such as fibre optic technologies used in everyday communications - could detect the safe arrival of that light energy with an unprecedented level of accuracy.

Professor Martin Plenio from Imperial College London's Institute for Mathematical Sciences and Department of Physics, one of the team behind the research on this new device reported in today's publication, explains how this development could lead to ultra-secure communications technologies in the future:

"If you can detect the presence of light at the individual photon level you make it impossible for any information being transmitted as light energy to go astray, unnoticed, en route from transmitter to detector. An exciting development in the future could be to use this fundamental science to ensure that information and messages are transported across long distances with absolute security, and reach their destination without being tampered with."

This single photon detector technology also has potential applications in precision measurement and in manipulating the behaviour of small numbers of photons.

"Measurement is still a very enigmatic part of quantum mechanics," said Professor Ian Walmsley of Oxford University, co-author of the paper. "This approach enables us to say what a measurement is doing without having to build a model of it. This could lead to us being able to properly calibrate many types of quantum devices with photon detectors being just one application."

Long distance quantum communication technologies and other quantum devices in the future will rely on scientists harnessing quantum behaviour to create systems that can far exceed the processing capabilities of current silicon- based devices. The term 'quantum behaviour' is used to describe a system which is governed by the laws of quantum mechanics, as opposed to being governed by the classical laws of physics such as mechanics, gravity and Einstein's general theory of relativity. Quantum mechanics comes into play when systems are the size of atoms or smaller and when they exhibit particle and wave properties at the same time, which means the conventional laws of mechanics no longer apply.

Professor Plenio and his colleagues at Imperial together with Professor Ian Walmsley and his team at the University of Oxford will now use this novel type of detector to carry out an experiment in which they aim to enhance quantum correlations in light that has been transmitted through an optical fibre. This will form the basic building block for a repeater station for photons and is essential for the creation of future long distance quantum communication networks.

The photon counter described in today's Nature Physics paper was first developed by the research team of Professor Walmsley with Dr Konrad Banaszek and Dr Christine Silberhorn in 2003. The results out today show conclusively for the first time that the counter works as predicted.

Citation: 'Tomography of quantum detectors', *Nature Physics*, advanced online publication, 16 November 2008.

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