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Raman Effect and E-Commerce

The Raman effect may help quantum communication become a reality, says S.Ananthanarayanan.

E-commerce, which transacts business deals over the Internet, needs a way to be sure whether or not a sensitive message has been read by a snooper on the way. The use of single photons to carry the information is seen as a way to do it. But a practical way to actually implement a ‘photon stream’ did not seem within reach. Scientists in Georgia, Harvard and California reported in the journal, ***Nature*** early this month that they may have worked it out.

Medium is message

The classic way to keep things secret was to use codes and hide the message. But the problem was safeguarding the code itself. If the code were sent by telephone, cable or wireless, there is no guarantee that nobody was listening in. What is worse, there is no way to know whether or not there had been an eavesdropper. But if the code word or number were conveyed through a stream of single photons, it turns out that any ‘listening in’ would leave a mark on the message itself.

Photons have a property called ‘polarisation’, which is related to the way their electrical part changes as the photons speeds forward. By coding polarisation ‘up’ to mean ‘1’ and ‘down’ to mean ‘0’, a stream of photons can carry a message in the binary language of computers.

In sending a secret message, like a code, a complex series of ‘1’s and ‘0’s are sent through photons oriented in a complex pattern of directions. The receiver uses a fixed series of filters (in different orientations) to read the message. She then talks to the sender, over a public telephone, to say what filters she used. The sender tells her which filters were valid. The ‘1’s or ‘0’s for which the filters were valid are then taken as the valid entries. But this exchange would not reveal whether which values were ‘1’ or ‘0’ and the code remains secret.

Enter quantum mechanics

The difference that QM makes is that the polarization state of a photon is not just one value but is in fact all possible polarizations at the same time, with different likelihood of the various states to be found, if there was a measurement. But once measured and found to be in some state, the photon is fixed in that state. And this final state depends not on the original state, but on the orientation of the detector!

This quantum mechanical property becomes useful to detect whether a message has been read, which is the same as ‘measured’, before being received. Along with the list of filters used, to make out the ‘valid’ photons, the actual values conveyed by some of them are also exchanged. If there had been any listening in, then, some of the values would have changed and the whistle would be blown.

Practical problem

The difficulty is that streams of photons, or even the laser light in optical fibre cables, gets rapidly weakened with distance. In fact, the signal falls to half in about 15 kilometres. In ordinary optical communication, the signal is ‘boosted’ every time it falls too low and the message is maintained. But with single photons carrying information in their polarisation state, such a ‘boosting’ procedure would destroy the delicate ‘many states at once’ condition and result in all photons being ‘measured’ even without a real snooper being around.

This is where the discovery of the US scientists amounts to a breakthrough. They have used ensembles of specially prepared rubidium atoms. The specific isotope that is used has a structure and energy levels that enable close *tuning* of weak laser light that makes it possible to exactly absorb or release energy when scattering photons.

Raman effect

The Raman effect is scattering where light changes frequency when it gets scattered. This takes place when the a bit of the incident photons’ energy is held back by the scattering atom, or some energy added by the atom, to the scattered photon Now, the US scientists’ arrangement was that weak laser light was used to excite an ensemble of Rb atoms so that just *one* photon, of a particular frequency, corresponding to the difference of 2 energy states of the Rb is absorbed. This event was signalled by the scattered light, which can be detected.

Now this absorbed photon, for a fleeting instant, is the shared or coherent property of all the Rb atoms at once and so long as it lasts, another tuned laser pulse can induce the ensemble to emit a photon of the same character. If this emitted photon is directed to another ensemble of Rb atoms, they can then absorb the photon, rather than scatter it, and then release it when induced by a tuned laser, with the original polarization intact.

The arrangement has been verified to work, with the quantum nature of the photon being preserved, and holds out promise of improvement.