Experimental open air quantum cryptography with single photons

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Abstract: We report the full implementation of the BB84 quantum cryptography protocol, using a true single photon source, operating at night in open air between two buildings, and we show its superiority over faint pulses schemes.

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Single photon sources are at the heart of the quantum cryptography protocol known as BB84 [1]. This protocol allows two remote protagonists, usually called Alice and Bob, to securely build an identical secret key using two communication channels: one quantum communication channel over which single polarized photons are sent from Alice to Bob, and a classical channel that they use to communicate publicly. First realizations of this protocol[2] have been using faint laser pulses to simulate single photons, although optimal efficiency requires a single photon source. Since then, continuous progress have been made in this field, including commercial developments[3]. Nevertheless the first demonstration of BB84 with single photon has only been realized in 2002, in our group [4], shortly followed by similar results obtained by another team[5].

Since this first demonstration, we built a realistic prototype allowing the distribution of a secret key between two buildings of the Institut d'Optique, in Orsay. This prototype successfully operates at night, in presence of city lights, by sending single polarized photons through open air (quantum channel) and using the internet network (classical channel). The single photon source, based on colored center of diamond nanocrystals under pulsed excitation[6], operates at room temperature and emits in the 700-900 nm range.

We have been able to increase the secret key distribution rate by a factor of 2 since our first experiments, reaching a rate of about 15 kbits/s. The quantum bit error rate, characterizing polarization encoding and detection quality, was lower than 2%. We also showed a clear advantage of single photon sources over attenuated pulsed lasers when the communication distance becomes significant. The main effect of an increase of the distance between Alice and Bob is an increase of the losses on the quantum channel that result in the decrease of the key distribution rate. We measured the effect of losses by adding optical attenuating filters on the quantum channel. The results obtained (Fig. 1) show that our device is still able to produce a secure key in presence of a 12 dB attenuation while a device based on faint pulses operated under the same conditions has already reached its limit. Further developments of such single photon source in the 700-900 nm range allows to envision a vertical transmission between a satellite and the Earth.

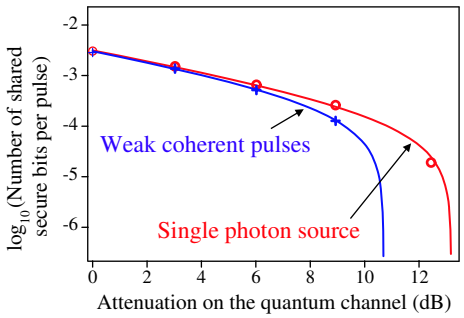

Fig. 1. Measured performance of our single photon source device compared with the maximum performance of a device using faint pulses.

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