Single Quadrature Continuous Variable Quantum Key Distribution with a Local Local Oscillator

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We present a continuous variable quantum key distribution scheme based on single quadrature modulation that exploits a local oscillator that is generated at the receiving station. The scheme is able to generate secret keys over at short distance with a very simple setup.

Prepare-and-measure continuous-variable quantum key distribution (CVQKD) systems traditionally use two electro-optical modulators, a phase modulator and an amplitude modulator. However modulating in two conjugate quadratures is not necessary to obtain a secret key. Overlapping coherent states are non-orthogonal and thus, fulfill a necessary condition for quantum key distribution. Those states can also be generated in one quadrature only, so that a single quadrature modulation scheme is sufficient for CVQKD [1, 2]. The modulated quadrature can be addressed by a phase modulator or by directly modulating the pump current of a laser diode. Hence the sender can be implemented without a complex amplitude modulator which is usually implemented by a Mach-Zehnder interferometer whose bias point has to be actively stabilized or by using no modulator at all, reducing the cost of the system immensely.

A further complication in CVQKD systems is the need of a local oscillator that traditionally is transmitted through the quantum channel along with the weak signal pulses. This is often done through time multiplexing to avoid scattering of photons from the bright local oscillator pulses into the weak signal pulses. Experimentally, this requires a time multiplexing and a time demultiplexing stage at the transmitter and receiver station, respectively, thus leading to an increased experimental complexity of the setup. Moreover, since the quantum channel is potentially controlled by an eavesdropper the transmission of the local oscillator opens up potential side-channel attacks like intensity attacks. It is possible to reduce the experimental complexity (in terms of number of components) and eliminate local oscillator attacks by generating the local oscillator at the receiver station, that is, using a local Local Oscillator [3–5].

Here, we present an experimental implementation of CVQKD where the single quadrature CVQKD scheme of [2] is combined with a local local oscillator approach. In addition to the experimental demonstration we also present theoretical results on the maximum secret key rate for different levels of eavesdropping attacks including local preparation noise. Our demonstration and analysis show that an extremely simple setup with a low degree of complexity can be used to generate secret keys over a short (intra-city) distance.

[1] V. Usenko and F. Grosshans, Phys. Rev. A 92, 062337 (2015)
[2] T. Gehring, C.S. Jacobsen and U.L. Andersen, Arxiv: 1507.01003 (2015) To appear in Quantum Information and Computation (2016)
[3] D. Huang et al, Opt. Lett. **40**, 3695 (2015)
[4] B. Qi et al, Phys. Rev. X **5**, 041009 (2015)
[5] D. Soh et al, Phys. Rev. X **5**, 041009 (2015)