Correlations with on-chip detection for continuous-variable QKD

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Despite the great progress in quantum key distribution (QKD) implementations in the recent years, QKD remains a technically demanding and costly technology, which hinders its widespread use for high-security applications. To this end, the photonic integration of QKD devices can play a crucial role by reducing size and cost by several orders of magnitude. Recent efforts in this direction include the development of chip-based devices using various integrated technologies for QKD protocols relying on single-photon detection [1].

Here we report on the on-chip demonstration of the main functionalities of continuous variable (CV) QKD, which requires standard telecommunication technology and in particular no photon counting [2]. Our demonstration is based on silicon chips, which comprise all the components of a CV-QKD system, including attenuators, amplitude and phase modulators, and homodyne detectors. Silicon photonics [3] allows for CMOS compatible technology and wide scale production of the developed devices, and has been used extensively in classical optical communications. Device requirements, however, differ significantly for CV-QKD operation, where for instance high extinction ratio and low loss modulators are necessary. In addition, homodyne detectors based on Si-integrated Ge photodiodes must be optimized to reach shot noise limited performance, which is more challenging than for the InGaAs photodiodes typically used in bulk systems [2].

Two different chips of roughly 0.7 x 0.5 mm^2 each are used for the preparation of states (Alice) and the measurement (Bob). The performance of the homodyne detection at Bob's side has been evaluated using an Alice made of bulk components. In particular, the linearity of the homodyne detector as a function of the local oscillator power has been verified in the shot noise limited regime (SNL). The clearance of the expected photon noise with respect to the electronic noise is between 10 and 20 dB depending on the chip. The excess noise ξ of the setup has been estimated to be below 10%. This is a pessimistic value since the coupling is not yet optimized and it is expected to be drastically improved increasing the achievable secret key rate and distance.

Our results were obtained under typical CV-QKD system operation conditions (100 ns pulses at 1550 nm and 0.5 MHz repetition rate [2]) and are compatible with the generation of secret keys; hence, they illustrate the potential of Si-integrated CV-QKD for the widespread use of this technology in communication networks.

References

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