Dynamic polarization control for free-space continuous-variable quantum key distribution

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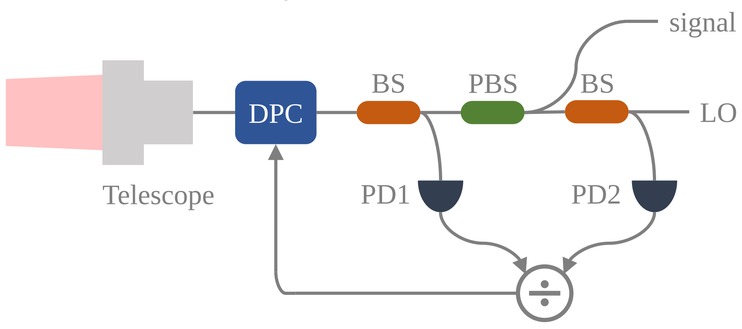
Motivation

- Local oscillators and weak quantum signals are co-transmitted.
- Free-space channels are fading channels, i.e., channel losses are time-varying. This causes difficulties in dynamic polarization control for continuous-variable quantum key distribution.

Scheme

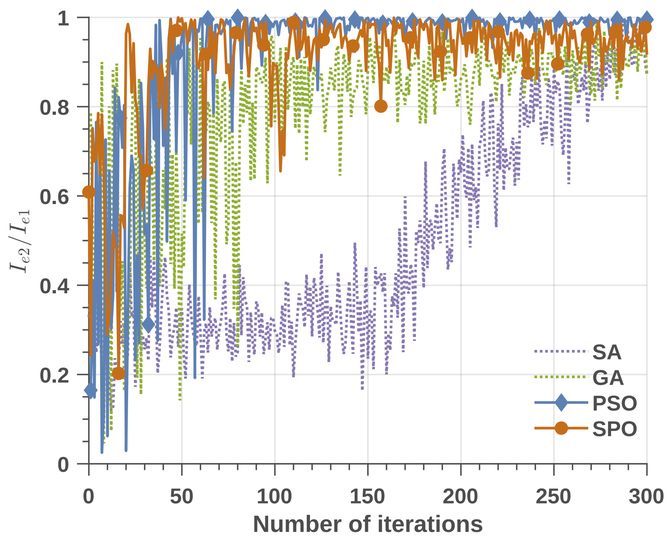
A dynamic polarization control scheme is proposed for free-space continuous-variable quantum key distribution.



At a receiving terminal, the outputs of the PD1 and the PD2 are divided and used as feedback signals for the DPC. Selecting an optimization algorithm according practical environments and optimizing the feedback.

Numeric Simulations

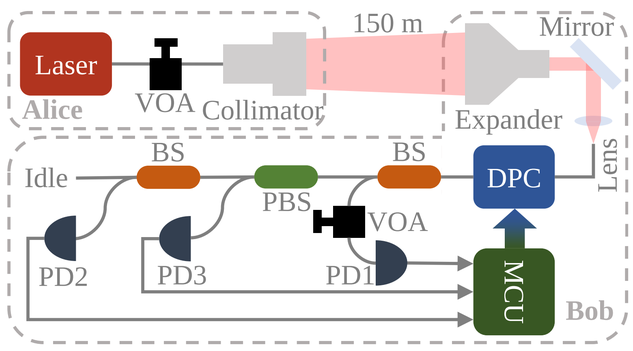
Several optimization algorithms are used to simulate and demonstrate the polarization control process.



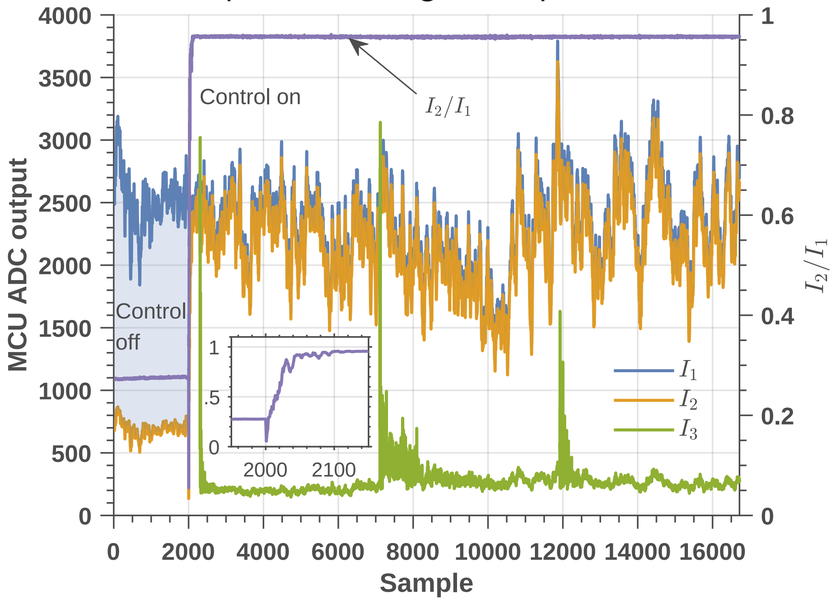
Different algorithms may have different performance in different environments. Most importantly, a suitable algorithm should have fast and nice convergence.

Experimental Verification 1

- A proof-of-principle experiment is performed over a 150-m free-space fading channel.



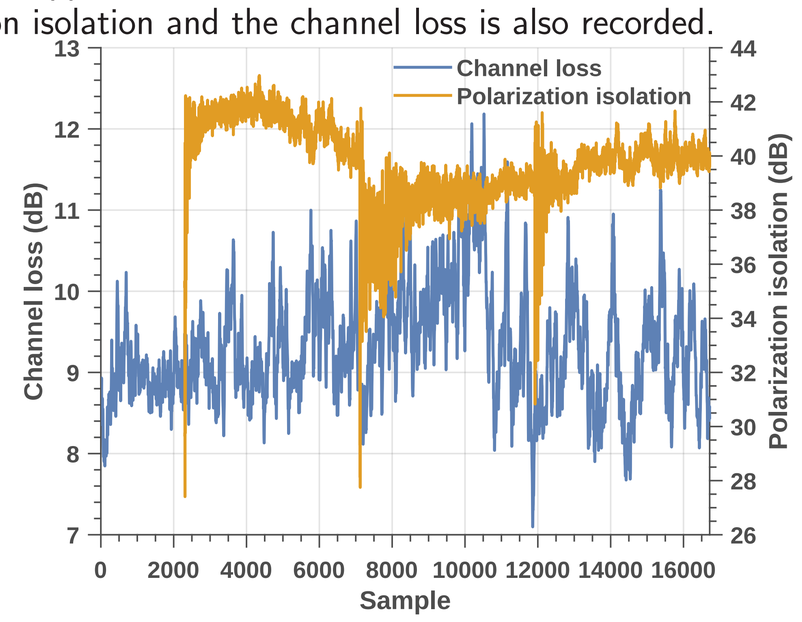
- The polarization control process during the experiment is recorded.



Experimental Verification 2

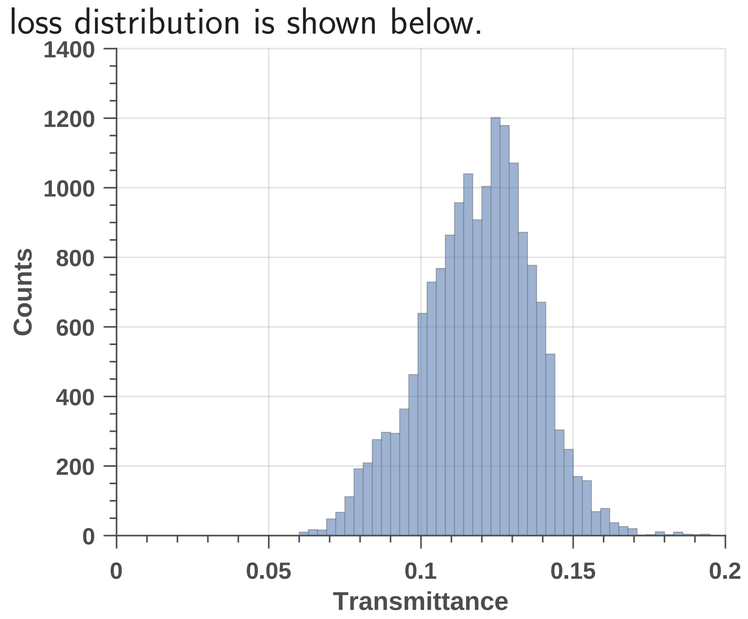
The control system is rebooted for three times to demonstrate the control process. A rapid increase in I_2 (and I_2/I_1) can be clearly observed when turning on the dynamic polarization control system. The light leakage is effectively suppressed.

- Polarization isolation and the channel loss is also recorded.



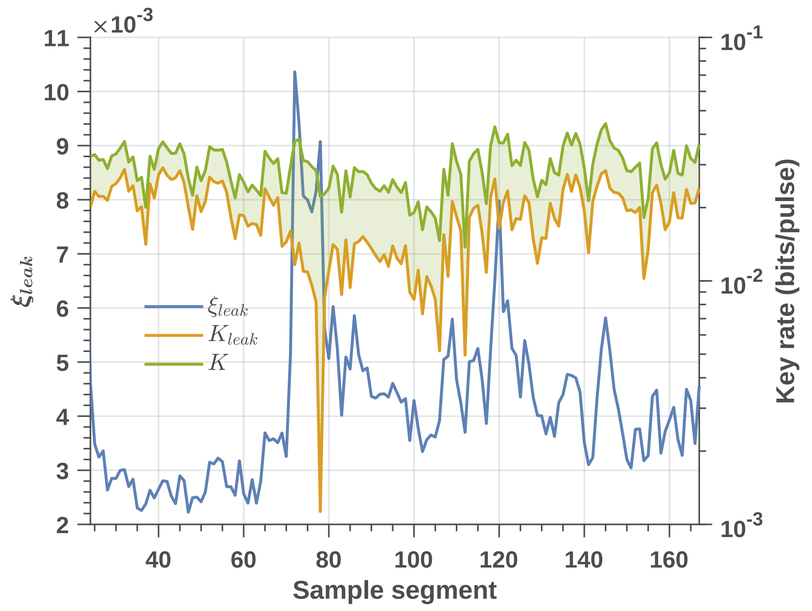
Polarization isolation can be maintained at a high level in spite of channel loss fluctuations.

- The channel loss distribution is shown below.



Key Rate Reduction

Note it is not possible to build up a perfect dynamic polarization control system, so light leakage to the signal path always exists and could induce excess noise.



Smaller excess noise can be achieved when the polarization isolation is relatively high; of course, it would usually corresponds to a smaller reduction in final secret key rates.

Conclusion

- Proposed a dynamic polarization control scheme for free-space continuous-variable quantum key distribution.
- Numeric simulations are performed.
- A proof-of-principle experiment is performed to demonstrate the scheme.
- Secret key rates are analyzed.