Multiplexed continuous-variable quantum communication in the presence of inter-mode cross talk

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Multiplexing of quantum signals can be a feasible and efficient way for improving performance of quantum communication. However, the method can be limited by the presence of inter-mode cross talk, leading to noise from adjacent quantum modes. We consider the effect of linear cross talk in continuous-variable quantum entanglement and key distribution and show that it imposes restrictions on the initial entangled resource to be shared or, equivalently, on the modulation depth of quantum key distribution. Furthermore, the protocols become more sensitive to channel noise if the cross talk between the signals is present. The necessity in optimization of the initial resource is clearly seen in Fig. 1, where distributed entanglement and tolerable channel noise are given with respect to the state variance at different levels of cross talk.
We also propose the method of cross talk compensation by optimized coupling of the multiplexed modes prior to their detection or use of entanglement, as shown in Fig. 2. Such method allows full or partial reconstruction of the entangled resource or efficiency of quantum communication. We show that it is no less efficient than the optimal feed-back control, while preserving the mode structure [1]. Importantly, the method can be equivalently realized on data in the post-processing stage [2], enabling drastic improvement to performance of multiplexed quantum communication.

References

[1] O. Kovalenko, V.C. Usenko, and R. Filip, Optics Express, **29** (2021) 24083

[2] O. Kovalenko, Y.S. Ra, Y. Cai, V.C. Usenko, C. Fabre, N. Treps, and R. Filip, Photonics Research, **9** (2021) 2351

Figures

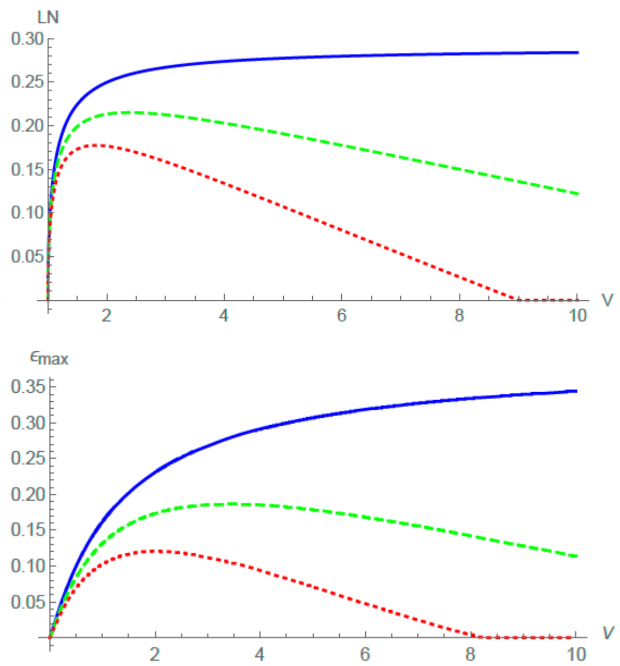

Figure 1: Logarithmic negativity (upper plot) and maximum tolerable channel noise (lower plot) in multimode quantum communication with respect to the variance of the initial entangled state (in case of entanglement distribution) or modulated signal (in quantum key distribution) in the presence of linear cross-talk coupling of 0.9 (green dashed lines), 0.8 (red dotted lines), compared to the absence of cross talk (blue solid lines).

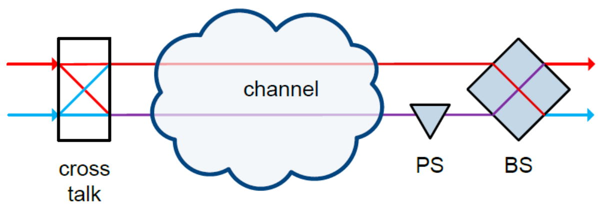

Figure 2: Compensation scheme for linear cross talk between two modes, based on a variable phase-shift (PS) and a beamsplitter (BS). Decoupled modes are then available for use in the entanglement-based schemes or for measurement in the prepare-and-measure quantum communication.