Dominant Noise Source in DWDM Scheme of 1550nm Continuous-variable Quantum Key Distribution

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Although the optical networks which cover multiple cities have been constructed, most of practical quantum key distribution (QKD) systems are based on dedicated network (dark fiber). In order to enlarge the application range of the QKD and avoid the high expense of dedicated network in the city, multiplexing QKD with classical communication signal by wavelength division multiplexing may be an appropriate way. Since current commercial networks always have at least tens of dense wavelength division multiplexed (DWDM) channels in the low-loss 1550 nm transmission window, the power of various background noise and crosstalk generated by nonlinearity are mostly higher than quantum signal. In the previous studies on the multiplexing of discrete-variable QKD (DV-QKD) by using C-band DWDM, it is not achievable to transmit the quantum signal and the conventional classical signal with 0 dBm power in one optical fiber simultaneously [1, 2].

In recent research, it has been demonstrated that continuous-variable quantum key distribution (CV-QKD) is more feasible than DV-QKD to multiplex with classical communication by using DWDM scheme [3]. CV-QKD with a homodyne or heterodyne detection which is regarded as an equivalent filter could efficiently suppress the out-of-band noise [3]. Most of noises which are introduced from high-power classical channel such as imperfect isolation of demultiplex are neglected. Thus, CV-QKD is able to coexist with the standard classical channel even over 75km [4]. In these papers [3,4], spontaneous Raman scattering has been proven to be the dominant source of noise in the specific situation. But in different DWDM schemes, classical channels produce a variety of non-linear noise with different power.

Here, we demonstrate the leading excess noise source where CV-QKD is transmitted simultaneously with high power classical channels multiplexed by DWDM in one optical fiber. We have conducted a series of simulations and experiments to demonstrate the dominant noise mechanism with different classical channel parameters. The results show that the dominant noise mechanism arises from either four-wave mixing or spontaneous Raman scattering, depending on the optical path characteristics as well as the classical channel parameters. By exploring the quantum channel impairments generated from classical channels, theoretical calculations and experimental results enable us to design more reasonable DWDM scheme where these two impairments reduce system performance slightly and channel resources are used more efficiently at the same time.

References

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