Quantum information processing with continuous variables over optical fiber

Kuanshou Zhang [1,2], Jinxia Feng [1,2], Yuanji Li [1,2]

[1] State Key Laboratory of Quantum Optics and Quantum Optics Devices, institute of Opto-Electronics, Shanxi University, Taiyuan, Shanxi, 030006, People's Republic of China

[2] Collaborative Innovation Center of Extreme Optics, Shanxi University, Taiyuan, Shanxi, 030006, People's Republic of China

E-mail: kuanshou@sxu.edu.cn

Metropolitan fiber quantum communication network is the key step to construct quantum communication network. Owing to continuous variable (CV) quantum entangled states of optical field can be generated unconditionally and deterministically, high-performance quantum information processing with continuous variables based on quantum states of optical field can be achieved. However, quantum information processing with continuous variable over optical fiber is a great challenge.

The entanglement robustness of EPR entangled state distributed over the single-channel and dual-channel optical fiber channel was investigated. It is found that in order to maintain the entanglement robustness of the EPR entangled state in lossy optical fiber channels, the dual-channel scheme has more stringent requirements on the correlation quadrature symmetry and purity of the initial entangled state than the single-channel scheme. In the single-channel scheme, the maximum transmission distance and robustness of the EPR entangled states with asymmetric modes is not sensitive to the asymmetry between modes. The change of asymmetry between modes does not lead to disentanglement. The maximum transmission distance does also not change. Distribution of CV entanglement at a telecommunication wavelength of 1550 nm over single mode fibers are realized experimentally. Entangled beams with quantum entanglement of 8.3 dB is generated using a single nondegenerate optical parametric amplifier based on a type-II periodically poled $KTiOPO_4$ crystal. When one beam of the generated EPR-entangled beams is distributed over 20 km of single mode fiber, 1.02 dB quantum entanglement can still be measured.

A real time deterministic quantum teleportation over a single fiber channel were presented. The effects of the transmission distance, the extra noise in the optical fiber, and the transmission efficiency of the lossy channel on the fidelity of deterministic quantum teleportation over a single optical fiber channel are theoretically analyzed. The real time deterministic quantum teleportation over a single fiber channel by exploiting the generated 1.5 μm EPR entanglement is experimentally implemented. The maximum transmission distance of the deterministic quantum teleportation is 10 km with the fidelity of 0.51 ± 0.01, which is higher than the classical teleportation limit of 1/2.