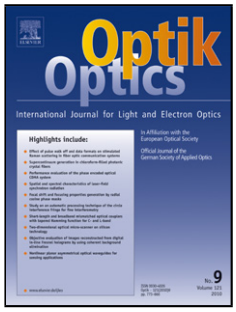

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Entanglement concentration for photon systems assisted with single photons

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Abstract The entanglement concentration protocols (ECPs) are presented for concentrating arbitrary partially entangled Bell-like state, *N*-photon GHZ state and *N*-photon *W* state, respectively, and the corresponding maximally entangled state can be obtained finally with a certain probability. Besides, compared with other ECPs, the accurate coefficients of the initial partially entangled state in this ECP do not need to know in advance. Moreover, current ECPs can be repeated to acquire a higher success probability. The devices used in the schemes are linear which leads to flexible operations and improves the performance greatly in the present experiment and our ECPs may be useful in the long-distance quantum information processing.

Keywords: linear optics; partially entangled state; entanglement concentration; repeating concentration; quantum communication

1. Introduction

Entanglement is an important source in the fields of quantum communication and quantum information, and is widely used in quantum computing [1], quantum key distribution [2-5], quantum teleportation [6-9], quantum dense coding [10,11], quantum secure direct communication [12-15], quantum secret sharing [16-20] and quantum state sharing [21-25] and so on. The maximally entangled states are usually required in above applications as an entanglement channel. The general process is to prepare the maximally entangled states locally and distribute it to distant parties. However, the entanglement degree of the states may be degraded due to the influence of channel noise during the storage and distribution process, and it will transform the maximally entangled states into non-maximally entangled states or mixed states. Hence, it is quite essential to reconstruct the maximally entangled states from the partially entangled states. In order to overcome this difficulty, two concepts, called entanglement purification [26-30] and entanglement concentration [31-44] came into being. When the initial maximally entangled state transforms into a mixed entangled state, at this point, Communication parties can use the entanglement purification to improve the fidelity of the systems. However, if the initial maximally entangled state becomes a partially entangled pure state, one can exploit entanglement concentration to distill the maximally entangled state from the non-maximally entangled pure state to reconstruct a subset of systems in a maximally entangled state. By and large, the entanglement purification is more general but the entanglement concentration is more efficient and most of the existing ECPs