continuous variables quantum correlation transferring with classical independent intensity beams

Jiangrui Gao, Hongxin Zou, Suqin Zhai, Juan Guo, Rongguo Yang, Junxiang Zhang

State Key Laboratory of Quantum Optics and Quantum Optics Devices, Institute of Opto-Electronics

Shanxi University, Taiyuan 030006, People's Republic of China

E-mail address: jrgao@sxu.edu.cn

Abstract: We report the first realization of quantum correlation transferring. The initial two correlated twin beams are generated from two separated OPO and laser. The transferred intensity quantum correlation degree of 1dB below SNL is measured.

OCIS codes: 270.2500; 999.9999 quantum information

The quantum property transfer between different systems or different places is a fundamental interest for quantum physics and quantum information. There are many exciting report on the field. for example, discrete variable teleportation[1] and continuous variable teleportation[2], transferring a unknown quantum state with the assistance of the entanglement, transferring a atom property to another atom by cavity QED[3]. Quantum entanglement swapping, which means to entangle two quantum systems that have never directly interacted with each other[4], have been also experimentally realized[5,6]. It is very important for quantum net and quantum computation[7,8,9]. correlation transferring is experimentally demonstrated with two quantum correlated twin beams. Intensity quantum correlated twin beams is a kind of easily used nonclassical beams, since it first time experimentally demonstrated[10], the generation and application have been widely studied extensively[11]. Some protocols of quantum key distribution(QKD) for continuous variables (CVs) quantum correlated twin beams were theoretically proposed[12,13], and the experimental demonstration was also realized recently[14]. The intensity quantum correlation transfer may have remarkable application potential in quantum communication.

A conditional protocol of transferring quantum-correlation in continuous variable regime experimentally demonstration is reported recent. A post selection, originally proposed for use in a discrete-variable system was used. To the best of our knowledge, the unconditional intensity quantum correlation transfer of CVs has not been experimentally accomplished so far. Thus it still is a real challenge to realize unconditional quantum correlation transfer without post-selection. In this report, we will present the first experimental realization of intensity quantum correlation transfer.

Figure 1 is the schematic of the experimental setup. The lasers are two homemade continuous wave intracavity frequency-doubled and frequency stabilized ring laser. One is Nd-doped $YAlO_3$ perovskite (Nd:YAP)/KTP laser, another one is Nd-doped $NYVO_4$/KTP. The second harmonic waves output at 540 nm and 532nm from the laser source are used for the pump fields of two nondegenerate optical parametric oscillators (NOPOs), respectively. The two independent quantum correlated twin beams (B1, B2) and (B3, B4) are generated from separated NOPO1 and NOPO2. The quantum correlation transfer is achieved by using measured B1-B3 signal to transform B4, and B4 will present the quantum property of B1 and correlated with B2. The quantum correlation of two independent beams B2

1-55752-813-6/06/$25.00 ©2006 IEEE

and B4, which come from NOPO1 and NOPO2 respectively, is show in Figure 2. The trace a is the measured correlation noise powers of beams B2 and B4, it is below the corresponding shot noise limit(SNL) (trace c). The trace b is correlation noise powers of beams B2 and B4 when B1 and B2, B3 and B4 without quantum correlation, as same as 4 general coherent beams (by mixing beam B1 and B2, B3 and B4 together with half wave plates HW1 and HW2 in fig1), it is 3dB larger than SNL. The experimental result consists well with theory.

The quantum correlation degrees of 1 dB below the shot noise limit from the quantum correlation transfer is measured straightly.

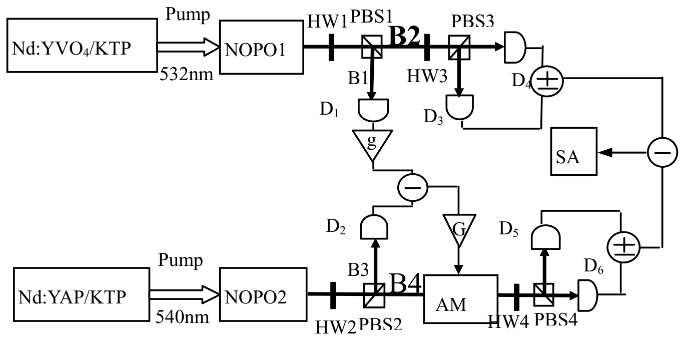

FIG. 1. Schematic of experimental setup. Nd:YAP /KTP and Nd:YVO_4/KTP: laser source; HW1~HW4: half-wave plates; PBS1~PBS4: polarizing beam splitters; $D_{1\text{-}4}$: photodiode detector; B1~B4: beam1~beam4; AM: amplitude modulator; SA: spectrum analyzer.

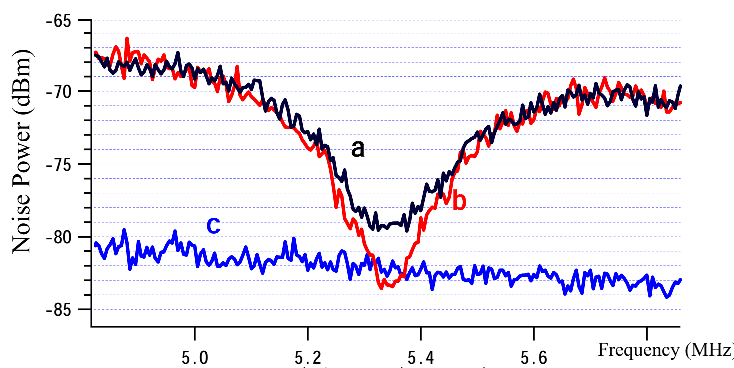

Fig.2. experiment results

[1] Bouwmeester. D. et al., “Experimental quantum teleportation,” Nature 390, 575–579 (1997)

[2] A. Furusawa, et al., “Unconditional quantum teleportation,”Science 282,706 (1998); T. C. Zhang et al., “Quantum teleportation of light beams,” Phys. Rev. A 67, 033802 (2003); W. P. Bowen et al. “Experimental investigation of continuous-variable quantum teleportation,” Phys. Rev. A 67, 032302 (2003).

[3] A. S. Parkins and H. J. Kimble, “Quantum state transfer between motion and light,” J. of Opt. B 1, 496 (1999)

[4] R. E. S. Polkinghorne and T. C. Ralph, “Continuous variable Entanglement Swapping,” Phys. Rev. Lett. 83, 2095 (1999)

[5] Jian-Wei Pan, et al., “Experimental entanglement swapping: entangling photons that never interacted,” Phys. Rev. Lett. 80, 3891 (1998)

[6] Xiaojun Jia, et al. “Experimental demonstration of unconditional entanglement swapping for CVs,” Phys. Rev. Lett. 93, 250503(2004

[7] P. van Loock et al., “Multipartite entanglement for continuous variables: a quantum teleportation network,” Phys. Rev. Lett. 84, 3482 (2000)

[8] Mauro Paternostro, W. Son etal, “Dynamical entanglement transfer for quantum-information networks,” Phys. Rev. A 70,022320 (2004)

[9] Hidehiro Yonezawa, et al., “Demonstration of a quantum teleportation network for continuous variables,” Nature 431,430(2004)

[10] A. Heidmann, et al., “Observation of quantum noise reduction on twin laser beams,” Phys. Rev. Lett. 59, 2555 (1987)