Generation of pulsed polarization entangled photon pair using a Sagnac interferometer

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Sources creating the entangled photon pairs are an essential tool for a variety of fundamental quantum mechanical and quantum information experiments. Since the 1990s type-II SPDC has been used extensively as a source of two-photon entangled states for space-time, polarization, and space-time---polarization double entanglement. [1] However, type-II SPDC has its limitation for ultrashort applications due to the very different behavior of two-photon wavepacket. [2] So, how to generate a good pulsed two-photon entangled pair is a very important subject. Here we report a very simple method based on the Sagnac interferometer. As a demonstration of its workability, Experimentally we get two-photon quantum interference for the polarization variable. The main advantages of this scheme is quite good stability, even the interferometer is exposed to the relative environment.

Sagnac interferometer consists of a round loop and a 50/50 beamsplitter (BS) When one light beam arrives at the BS, it will be divided into two equal parts, one part travels through round loop clockwisly, and the other part counter-clockwisly. If the Sagnac interferometer is not very large or the change of the interaction with the time between it and the environment is not very fast, then the influences introduced by the environment to two parts are the same, that means the clockwise and counter-clockwise paths are automatically compensated to be of equal length, so the phase difference between clockwise and counter-clockwise loop can be hold stably.

The Fig. 1 is the figure of the experimental setup. The 400-nm ultrashort pump laser is input to a Sagnac interferometer. We put a 1-mm BBO crystal collinearly created at type I phase matching for SPDC and a half waveplate at 45^{0} for 800nm light inside Sganac interferometer. Besides, there is a quartz plate inside for time compensation. One output of beamsplitter BS1 is input to another 50/50 beamsplitter BS2. We insert a 10-nm interference filter in front of BS2. At each output port of the BS2, a detector package consisting of a Glan-Thompson analyzer A_1 or A_2 and a single-photon detector (PerkinElmer SPCM-AQR-14-FC) is placed.

The outputs of detectors are sent to coincidence circuit for coincidence counting. The coincidence circuit consists of a time-to-amplitude converter and single-channel analyzer (TAC/SCA, ORTEC 567) and a counter (SR400, Standford research systems). The time window of coincidence counting is 2ns. The polarization entanglement can be manifested as the variation in the coincidence rate as a function of the relative angles between the polarization analyzers. This is typically observed in the following way: One of the polarization analyzer is fixed in a particular angle and the coincidence rate is measured as the other analyzer is rotated. The visibility is smallest when the fixed polarizer is set to $\frac{\pi}{4}$, which represents the most exacting test of polarization entanglement. In our experiment, firstly, we fix the polarizer A_2 at 90^0, then fix it at 45^0. We fix the polarizer A_1 and rotate the angle of HWP2 with each step 5^0, which equals to the rotation of the polarizer A_1 with each step 10^0. The experimental data are shown in Fig. 3. All solid lines are least square fits. The visibilities are 93% for $\Theta_2 = 90^0$ and 71% for $\Theta_2 = 45^0$.

We thank Professor H. Imai for his support. We thank K. Usami, Dr. S. Kono and Dr. Y. Nambu for valuable discussion and technical support.

References

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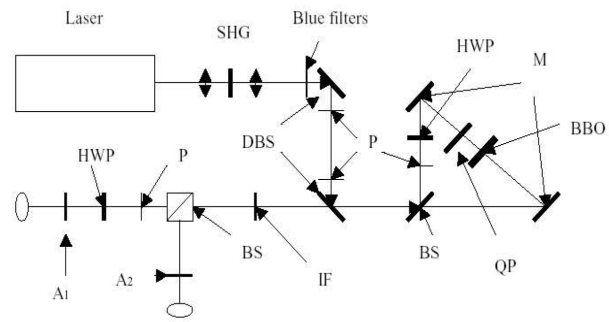

Fig. 1. Experimental setup. DBS: dichronic mirror which transmits 800nmlight and reflects 400nm light; BS: 50/50 beamsplitter; HWP: half waveplate; P: pinhole; IF: interference filter;: $A_{1(2)}$: polarizer; M: mirror; QP: quartz plate.

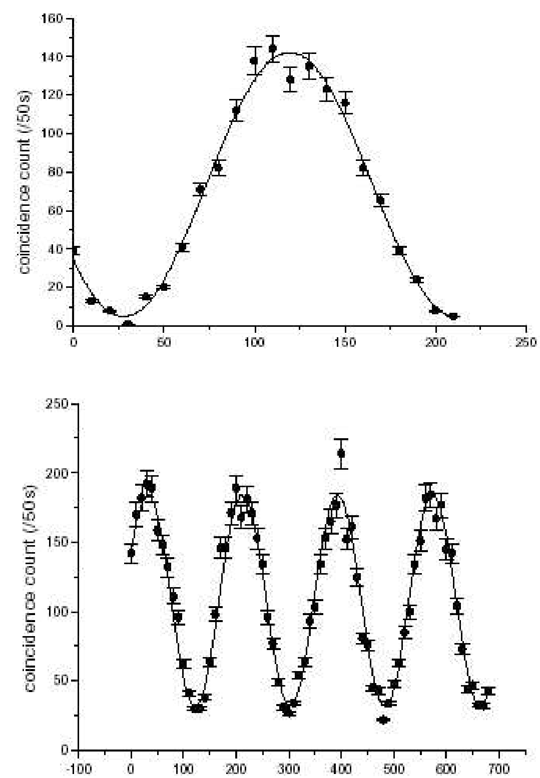

Fig. 2. Experimental results. Dots are experimental data and solid lines are least-squares fits to the data. (a) The angle of polarizer $\Theta_2 = 90^0$. The visibility is about 93%. (b) The angle of polarizer $\Theta_2 = 45^0$ The visibility is about 71%.