Polarization entangled-photon pair source ready for full automation

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In this work we show polarization-entangled photon source that is consisted of two PPLN nonlinear crystals, mounted in the aluminum block, sandwiched between a pair of birefringent crystals [1]. Each PPLN crystal generate pair of infrared photons in specified polarization state, orthogonal to each other. Namely, one crystal produces a pair with vertical $|\updownarrow_1\updownarrow_2\rangle$, the other in horizontal $|\leftrightarrow_1\leftrightarrow_2\rangle$ polarization. That allows to obtain polarization-entangled state $|\leftrightarrow_1\leftrightarrow_2\rangle + |\updownarrow_1\updownarrow_2\rangle$.

The experimental setup of the source is presented in Figure 1. It enables characterization of a source, such as quantum-state tomography measurements, by collecting single counts (SC) and coincidence counts (CC) between detectors (D1, D2) for different sets of motorized quater-wave plates (QWP) and half-wave plates (HWP). The result of such measurement is presented in Figure 2. Figure 3 shows the electronic system that enables to automatically adjust the position of the opto-mechanical elements to the optimal position, thanks to which it is possible to maximize the achieved Bell parameter and state fidelity – measures of quantum entanglement quality. Due to the use of motorized components, the setup of such source is self-alining. All components used are commercially available.

References

[1] R. Horn, T. Jennewein, *Opt. Express,* **27** (2019) 17369

Figures

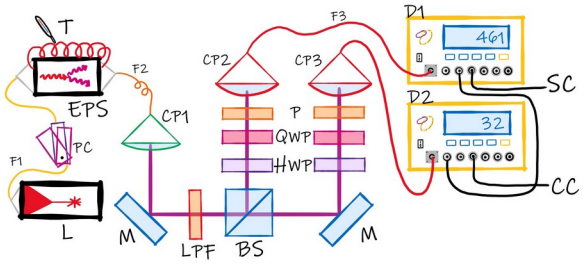

Figure 1: Experimental setup. Photon source(EPS) generates entangled states, which are characterized by coincidence measurements with InGaAs detectors (D1,D2), on different settings of motorized quater-wave plates (QWP) and half-wave plates (HWP).

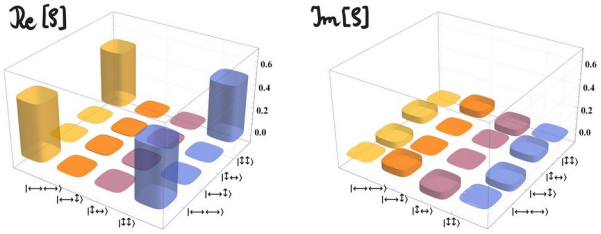

Figure 2: Real and imaginary part of the density matrix representing the entangled state produced by the source.

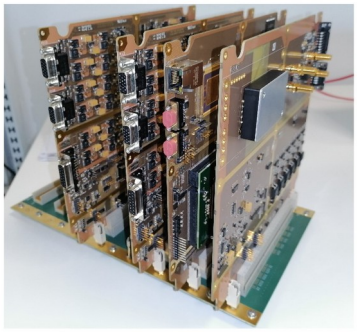

Figure 3: SECSQES electronics, responsible for controlling instruments within experiment, consisting of 6 modules: Power supply Unit, Control Unit (LEON3 space grade processor and FPGA chip, containing artificial Intelligence and steering algorithms), two Stepper Motor Units, Piezo Actuator Unit, Auxiliary Unit/Detector Interface Module (50ps resolution for input signals, automatic phase comparator and pulse generator for FPGA chip, laser current driver, laser temperature controller and PPLN crystal temperature controller.