A Source of Separable Photon Pairs for Passive Photon Precertification

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Photon precertification has been proposed as a method to mitigate the effects of transmission losses in photonic quantum communication by verifying the presence of a qubit without disturbing its quantum state [1]. In this approach, an incoming photon is probabilistically split into two photons, where the detection of one photon certifies the presence of the other while preserving the encoded quantum information. This technique has been identified as a promising path toward closing the detection loophole in device-independent quantum communication protocols, but previous implementations required active feed-forward to remove the entanglement of the photon pair and thus produce the correct quantum state, significantly complicating the implementation [2].

Here we present the experimental demonstration of a photon-pair source specifically designed to passively generate *separable* photon pairs, which are suitable for photon precertification without active feed-forward. As shown in Fig. 1, the source relies on spontaneous parametric downconversion in a nonlinear crystal to map the arbitrary polarisation state of a pump laser, $\alpha|H\rangle_p + \beta|V\rangle_p$, onto a two-photon output state $|H\rangle_1(\alpha|H\rangle_2 + \beta|V\rangle_2)$, where one photon acts as a certification signal while the other carries the qubit.

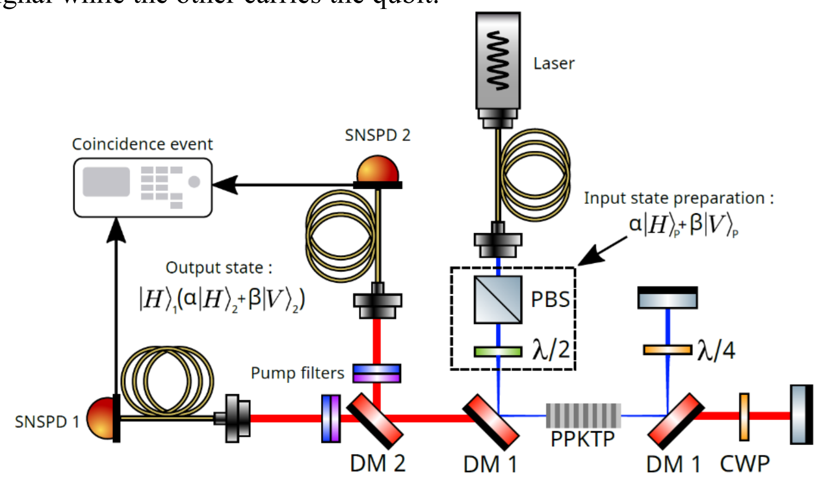

Fig. 1: *Separable photon-pair source. Using a bidirectional configuration and a custom waveplate (CWP), the pump polarisation is transferred to photon 2 while photon 1 remains separable and can be used as a certification signal.*

Quantum state tomography confirms the generation of the targeted separable state with good fidelity, indicating that this configuration represents a promising approach for passive photon precertification, eliminating the need for fast feed-forward or active switching. With further optimization of interference visibility and operation at the single photon level, this approach could enable practical precertification modules for long-distance photonic quantum communication and device-independent quantum protocols.

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