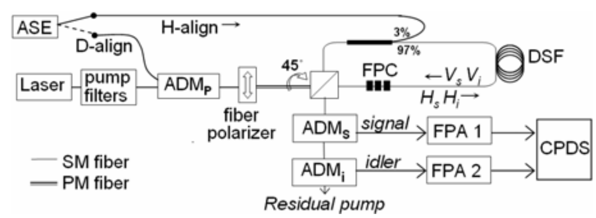
POLARIZATION ENTANGLED PHOTON SOURCE WITH AUTOMATED ALIGNMENT AND MEASUREMENT SYSTEMS

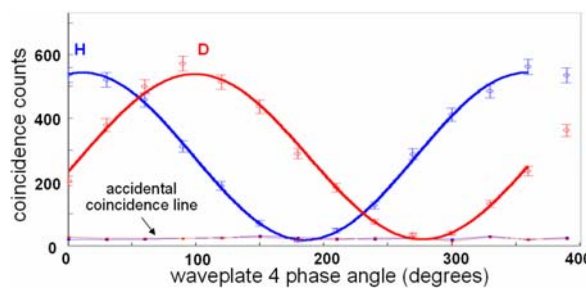
Shawn X. Wang, P. Moraw, C. Chan, and Gregory S. Kanter
NuCrypt, LLC, 1840 Oak Ave, Suite 212-S, Evanston, IL 60201

Introduction: Most sources of entangled light are used primarily in laboratory environments and require considerable manual effort to operate and maintain. For the entangled photon source (EPS) to be viable for quantum communication and other purposes outside of laboratory environments, physical robustness and ease of use are important factors [1]. We describe an all-fiber source of polarization entangled photons which is designed to interoperate with electronically controlled polarization analyzers and a correlated single photon detection system (CPDS) such that both the alignment of the measurement bases and subsequent measurements can be automated. A dedicated alignment source allows for proper bases alignment using only classical light. High quality entangled light is generated near 1550nm and two photon interference (TPI) fringes in two non-orthogonal bases can be measured on timescales of ten seconds using 50MHz gated single photon counters. The system is constructed with commercially available off-the-shelf fiber-coupled components and has the potential for one-touch operation of the entire process of generating and measuring polarization entangled light.

Experiment: The polarization EPS is shown in Fig. 1(a) and is similar to [2]. A 50MHz modelocked laser is used for pumping 100 m of dispersion shifted fiber to create correlated photon-pairs via four-wave mixing, and a polarization Sagnac loop is used to generate entanglement from the correlated pairs. The major improvement of the source reported here is an additional alignment signal injection port, such that the improved design has one alignment signal for the horizontal (0˚ respect to the polarization beam cube) polarization state $|H\rangle$ and another alignment signal for the diagonal (45˚) polarization state $|D\rangle$. This allows complete alignment using only singles counts, which eliminates the previous need for coincidence counts; resulting in a more efficient and accurate alignment procedure due to the much higher rate of singles counts. The two predetermined non-orthogonal polarization bases states completely describe the polarization frame of reference, allowing the source and analyzers frames to be matched. The alignment signal injected into the photon source is the broadband amplified spontaneous emission (ASE) of an erbium doped fiber amplifier. The ASE is polarized by either the fiber polarizer before the Sagnac loop or the fiber polarization beam splitter of the loop, depending on whether aligning to the $|D\rangle$ or $|H\rangle$ states respectively. The fiber polarizer has a polarization maintaining fiber output which is attached to the input of the loop at a fixed 45˚ angle with respect to the axis of the beam splitter. Add-drop multiplexers are used for injecting the $|D\rangle$ alignment source as well as dropping out signal and idler photons as the output of the source. Two calibrated electronically controlled fiber-coupled polarization controllers (FPC) followed by polarizers are used as fiber polarization analyzers (FPA) for projecting the entangled light onto a specified measurement basis. During the computer controlled alignment procedure, each FPA sequentially uses the two alignment sources to align the polarization frame of reference of itself to that of the source. The FPAs and the CPDS (NuCrypt CPDS-2) are computer controlled to automatically step through the alignment and measurement procedures in both bases. Fig. 1(b) shows representative ~30 second TPI results of two non-orthogonal polarization bases, successfully yielding better than 90% raw fringe visibility.



(a)



(b)

Fig. 1. (a) Experimental setup of the entangled photon source, polarization analyzer, and photon detection system. (b) 30 second fringe measurement of H and D bases.

Conclusion: We have demonstrated a robust and easy to use system of generating and measuring polarization entangled photons. A dedicated alignment source and fast detection speed enable quick evaluation of the quality of entanglement . This work was supported in part by the Army Research Office although the content does not necessarily reflect the position of the government and no endorsement should be inferred.

REFERENCES

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[2] S. X. Wang and G. S. Kanter, IEEE Selected Topics in Quantum Electronics, **15**, pp1733-1740 (2009).