A PM-PCF SAGNAC CONFIGURATION FOR HYBRID-WAVELENGTH PHOTON PAIR GENERATION

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Polarization-entangled photon sources are a key enabling technology for future quantum cryptography and secure communication based on Quantum Key Distribution (QKD) protocols [1]. Traditionally, entangled photon pairs are produced via spontaneous parametric down-conversion (SPDC) in periodically poled nonlinear crystals using free-space optical setups [2]. While such sources can exhibit high performance, fiber-based implementations are generally more robust and offer improved compatibility with existing optical fiber infrastructure, motivating the investigation of all-fiber alternatives. In this work, we present a fiber-based source for polarization-entangled photon pair generation based on spontaneous four-wave mixing (SFWM) in polarization-maintaining photonic crystal fiber (PM-PCF) in a Sagnac loop configuration. The Sagnac loop is pumped using 200 ps pulses at 1038 nm, generating nondegenerate photon pairs with signal and idler wavelengths at 831 nm and 1381 nm, respectively. This wavelength combination is particularly attractive for hybrid quantum networks, as it combines low-loss transmission in standard telecom fiber with compatibility with high-efficiency silicon single-photon detectors and quantum memory platforms operating in the near-infrared [3]. Polarization entanglement is produced by coherently superposing photon-pair generation processes from counter-propagating, orthogonally polarized pump pulses in the Sagnac interferometer. The experimental setup employs a fiber-based pump laser, pulse picking and amplification stages, and mutually twisted PM-PCF arms to ensure stable polarization control and phase matching. Signal and idler photons are separated using spectral filtering and detected with avalanche photodiodes, with polarization analysis performed using waveplates and polarizing beam splitters. The demonstrated source provides a compact, stable, and network-compatible platform for polarization-entangled photon generation, potentially suited for future hybrid quantum networking applications.

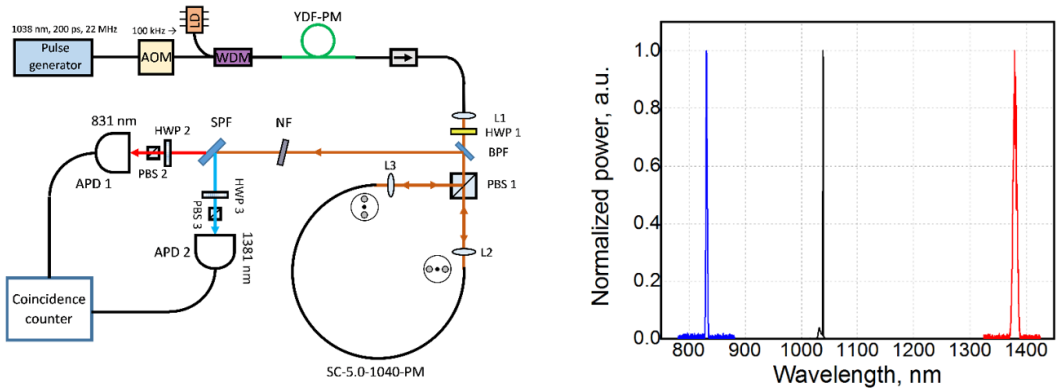

Fig. 1. Polarization-entangled photon pair generation setup (left). Spectra of pump, signal and idler waves generated in the PM-PCF (right).

Acknowledgements

This project has received funding from the Research Council of Lithuania (LMTLT), agreement No. [P-MIP-24-668]

[1] F. Xu, X. Ma, Q. Zhang, H.-K. Lo, and J.-W. Pan, "Secure quantum key distribution with realistic devices," Reviews of Modern Physics, vol. 92, no. 2, May 2020, doi: 10.1103/revmodphys.92.025002.
[2] P. G. Kwiat, K. Mattle, H. Weinfurter, A. Zeilinger, A. V. Sergienko, and Y. Shih, "New High-Intensity Source of Polarization-Entangled photon pairs," Physical Review Letters, vol. 75, no. 24, pp. 4337–4341, Dec. 1995, doi: 10.1103/physrevlett.75.4337.
[3] H. J. Kimble, "The quantum internet," Nature, vol. 453, no. 7198, pp. 1023–1030, Jun. 2008, doi: 10.1038/nature07127.