Development of a Three-Node Entangled Quantum Networks

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The emergence of single-and entangled-photon generation and detection technologies has driven major breakthroughs across a wide range of quantum information processing applications. Building on this progress, quantum metrology—the science of measurement that leverages non-classical correlations of light or matter—offers substantial improvements in precision beyond classical limits, with far-reaching implications for applications such as clock synchronization [1], baseline interferometry [2], quantum sensor networks [3], and secure communication [4]. The National Research Council (NRC) Canada is currently developing a three-node quantum network testbed using time-bin entangled photons at telecommunication wavelengths and photon-number-resolving detectors, in which the quantum links between distant nodes are actively stabilized to the picosecond level and polarization drift is suppressed. This work advances quantum measurement and secure data transfer capabilities while also supporting in-situ calibration of single-photon sources, detectors, and processors, thereby contributing to the development of future standards in quantum photonics.

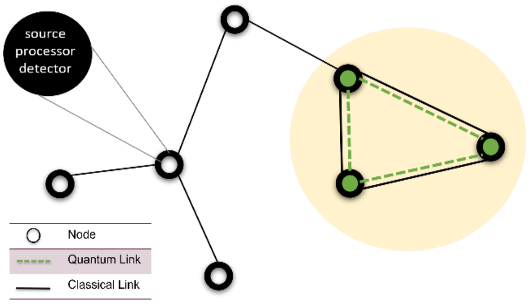

Figure 1. Schematic of the three-node photonic quantum network testbed (highlighted in yellow circle) under development at NRC.

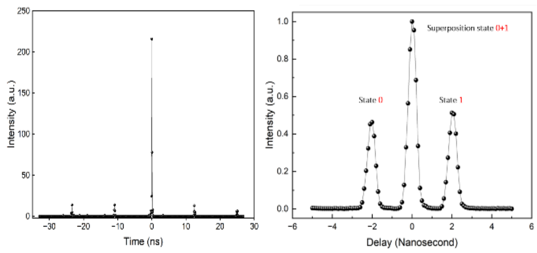

Figure 2. Characterization of quantum correlations and time-bin states. (a) Histogram of photon-pair coincidence counts (b) Measurement of time-bin states.

Entangled photons are generated through spontaneous parametric down-conversion and analyzed using optical interferometers followed by multipixel superconducting nanowire single-photon detectors operated at 0.8 K. An optical pulse used for channel stabilization co-propagates with quantum signals on orthogonal fiber polarization, while temporal and spectral multiplexing minimizes noise such as Raman scattering. Arrival times of stabilization signals from different nodes are compared in real time to stabilize the channel length with picosecond-level precision and compensate polarization drift. This quantum network testbed enables multipartite entanglement distribution for connecting distant quantum sensors or clocks and provides a shared platform for validating quantum hardware and protocols.

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