Photon sources and detectors for advanced quantum networking in real-world environments

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The realization of quantum optical networks requires distribution, manipulation, and verification of entanglement across geographically separated nodes under nonideal operating conditions. We report progress in developing quantum network technology that supports entanglement distribution, quantum teleportation, and entanglement swapping [1-4], including over deployed optical fibers that simultaneously carry classical Internet traffic and synchronization systems. We develop wavelength-division multiplexed (WDM) sources of entangled photons and leverage high-resolution superconducting nanowire single-photon detectors to enable multi-channel operation and source repetition rates up to 10 GHz.

We investigate design methods for maximizing the performance of teleportation-based quantum network applications in noisy environments, including integration with classical internet traffic [4]. We thoroughly study the impact of filtering broadband background noise photon sources on multiphoton applications and develop informed strategies for designing the joint spectrum of entangled photon sources relative to spectral filtering strategies [3]. Quantum teleportation of polarization qubits is demonstrated over 30 km of standard spooled fiber co-propagating with 400 Gbps of classical data using wavelength-optimized source design, coincidence filtering, and spectrotemporal filtering [4]. Multi-channel WDM entanglement distribution technology [1] is demonstrated alongside high-capacity classical data transmission (4.7 THz) over a 24-km fiber installed underground in the Chicago, USA metropolitan area [2]. We then show time-bin entanglement swapping over a 40 km repeater-like configuration comprising four 10-km fiber segments populated by 10-Gbps classical data channels.

These results establish a pathway toward scalable quantum networks in real-world infrastructure by combining high-rate entangled-photon sources, low-jitter single-photon detectors, and multiplexing technologies to deploy advanced teleportation and entanglement-swapping systems. Crucially, they demonstrate that quantum networks can coexist with high-bandwidth classical data transmission and synchronization signals, providing a foundation for integrated quantum–classical networks and future distributed quantum information systems.

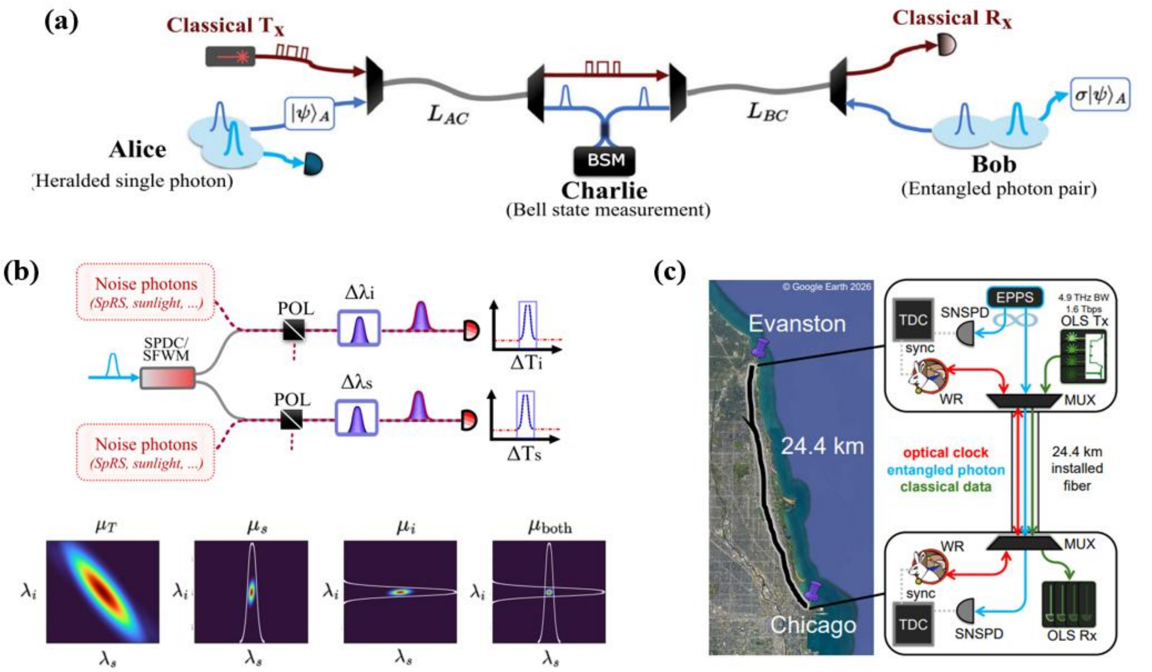

Fig. 1: *(a) Quantum teleportation over optical fiber networks carrying classical communication signals generating background noise photons [4]. (b) Optimization of filtering methods for improving both noise resilience and spectral purity [3]. (c) Deployed entanglement-based network with entangled photons propagating through a 24-km fiber with coexisting with 1.6 terabits/s of classical communications [2].*

References

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