Metropolitan quantum network

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Quantum network testbeds are rapidly advancing, with several metropolitan-scale efforts already underway in major cities, including DC-QNet in the Washington, D.C. area. Distributing entanglement over tens of kilometers is challenging, especially when the fiber is partially aerial. Key difficulties include node-synchronization, maintaining polarization stability, loss, and quantum–classical coexistence. Here, we present our progress in developing a metropolitan-scale quantum-network testbed addressing these challenges. This includes entanglement distribution over 62 km of real-world, partially aerial deployed fiber between NIST and the University of Maryland (UMD), using commercial tools focused on polarization stabilization. We also perform local entanglement distribution measurements using fiber spools exceeding 100 km, employing home-built tools to address synchronization and quantum–classical coexistence with a commercial White Rabbit system.

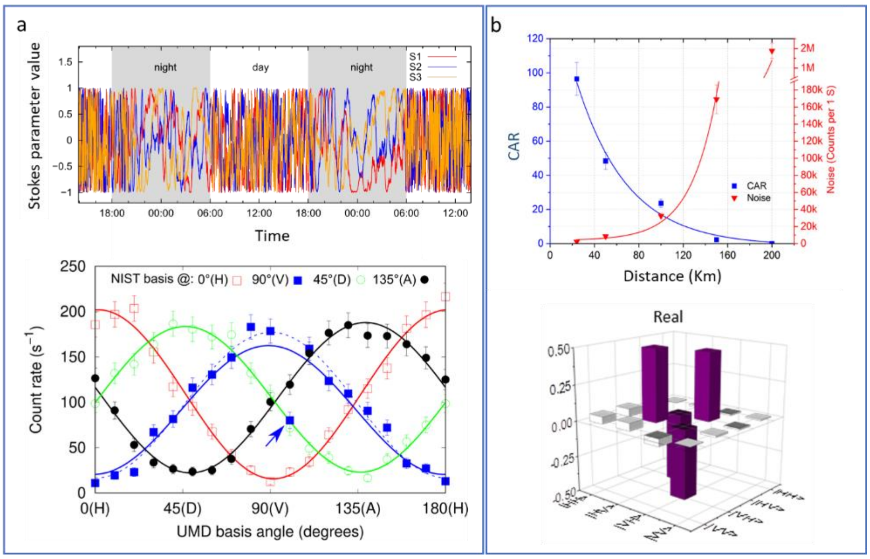

Figure 1: a) Entanglement distribution over a 62-km partially aerial fiber link. Top: polarization drift over 48 hours without stabilization. Bottom: polarization-correlation fringes after stabilization. b) Local entanglement distribution using fiber spools. Top: CAR versus fiber length. Bottom: quantum-state tomography over 100 km.

As shown in Fig. 1(a), we successfully distributed entanglement between NIST and UMD over 62 km of partially aerial fiber. Despite the severe polarization drift characteristic of aerial links, polarization stabilization enabled good visibilities with a CHSH parameter of S=2.34±0.37. Synchronization was avoided by sending SNSPD-triggered optical pulses through a parallel fiber in the same TX/RX pair and time-stamping them at UMD, ensuring a stable signal–idler delay. Synchronization was then addressed separately in a local experiment using fiber spools and a commercial White Rabbit switch, allowing classical synchronization signals to coexist with quantum signals in the same fiber. In this configuration, we achieved entanglement distribution over more than 100 km with visibilities exceeding 80% and a CHSH parameter of S= 2.30±0.04.

As a next step, we plan to implement entanglement distribution over metropolitan deployed link with integrated polarization stabilization, quantum-node synchronization, and coexistence-based fiber-drift compensation in a unified field-ready system.

References

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[2] Rahmouni, Anouar, et al. *Journal of Optical Communications and Networking* 16.8 (2024): 781-787.