Towards Quantum Networks: Raman Noise analysis in C-Band over the UNINA Metropolitan Fiber Network

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Optical photons are widely recognized as optimal entanglement carriers for quantum communications, since they offer several advantages: weak interaction with the environment, low-loss transmission, precise control using well-established optical components. These properties make them as the most suitable technology for entanglement distribution between distant nodes in a quantum network. [1]. While preliminary experiments of entanglement distribution have relied on dedicated infrastructures, the practical deployment of urban quantum networks requires leveraging existing telecommunication fiber systems. A major challenge is the coexistence of quantum signals with high-power classical traffic in the same fiber, which introduces significant noise, primarily due to Raman scattering within the quantum channel band. In this study, we focus on transmitting quantum signals in the C-band, which benefits from minimal attenuation (~0.2 dB/km) in standard single-mode fibers, making it ideal for long-distance quantum communication [2]. We experimentally investigate Raman scattering in the C-band induced by classical signals propagating in the O-band, typical of classical infrastructures. The experiment, conducted over the metropolitan fiber network of the University of Naples Federico II, transmitting a classical signal on 3.5 km fiber loop from the Quantum Internet Testbed [3] at Monte Sant'Angelo campus to the Via Claudio campus and back, as showed in Fig.1.

The study was conducted without relying on narrow-linewidth lasers operating at their nominal frequencies, which are commonly used in similar experiments. Instead, we employ commercial SFP exhibiting spectral characteristics that are more complex than those of even highly sophisticated experimental lasers. To mitigate and control these effects, we used a set of optical components - dwmd and filters- to properly manage the spectral properties of the generated signals under investigations. The C-band photons generated by Raman scattering from the O-band are filtered using a high-resolution narrowband filter with a 100 pm bandwidth, ensuring that only the desired spectral components are selected, and are then measured using Superconducting Nanowire Single-Photon Detectors (SNSPDs). The high performance of the setup exploited allows for a comprehensive investigation of the Raman spectra, enabling the identification of even subtle variations in the noise generated across the different wavelength channels. Therefore, it becomes possible to analyze in detail how Raman scattering affects the spectral region of interest. The study provides a cleare picture of which channels in the C-band are the most suitable for quantum signal transmission, highlighting those that are less impacted by Raman noise.

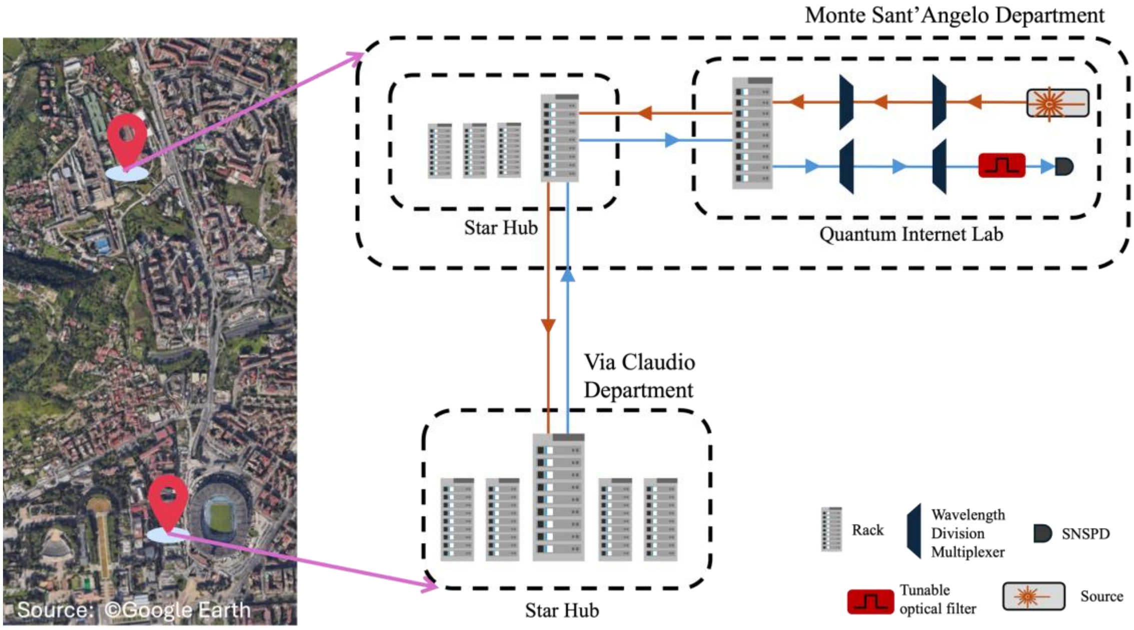

Fig. 1: *Quantum Internet Testbed loop*

References

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