Redefining Measurement

Use Case: QKD Research

A simple polarisation-based QKD system operating over a high-loss fibre channel using the ID281 SNSPD system

Research Field: Quantum Key Distribution	
Country: Italy	

Experimental need	Solution	Results
Four channel high quantum efficiency polarisation insensitive single-photon detectors.	Multiple channel fully automated SNSPD detection system	Polarisation insensitive QKD solution for long-haul telecommunication link compatible with challenging urban fiber networks

"The IDQ SNSPD solution allowed us to quickly get outstanding results which resulted in previously unachieved QKD performance overcoming the challenges of both fibre losses and polarization drifts associated with long-haul fibre optic links."

Paolo Villoresi
Professor of Experimental Physics

Experimental need

On September 27th 2019, the University of Padova published a paper : on Simple Quantum Key Distribution with qubit-based synchronization and a self-compensating polarization encoder. This use case provides a summary of the published results (Source: https://arxiv.org/pdf/1909.12703.pdf)

Researchers from the University of Padova were aiming at developing a telecom-wavelength Quantum Key Distribution system with a novel and simple qubit synchronisation method, combined with a system to implement encoding based on the polarisation states.

The objective was to demonstrate excellent performance in demanding conditions, namely a large optical loss over a 26 km-long fibre-based quantum channel and up to 43 dB link attenuation (the losses were adjusted with a VOA).

Using polarisation qubits over a fibre link inevitably entails polarisation fluctuations in the system, and the researchers worked to demonstrate that this will not impair the stability and performance of their system despite of the fibre lengths and optical losses.

Solution

The team built upon some of their previous work to realise a highly-stable and high-fidelity “POGNAC” polarisation qubit encoder. Photons are launched into a 26 km-long G.655 dispersion-shifted optical fibre channel with 0.35 dB/km loss, followed with a variable optical attenuator to introduce additional losses to simulated connection and installation losses.

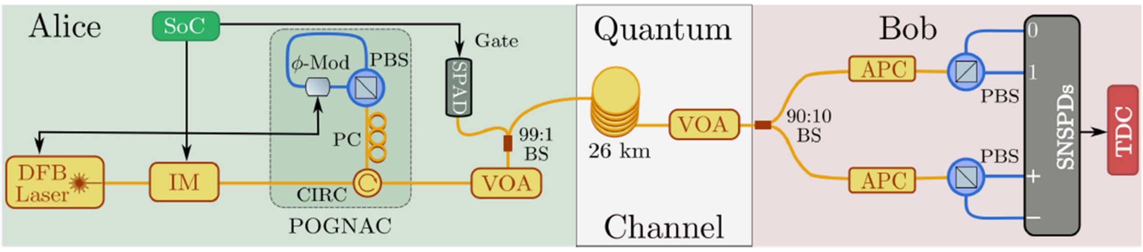

Fig. 1: Experimental Setup. Single Mode fibre are indicated in yellow while Polarization Maintaining fibers in blue.

The photons are detected with a completely passive decoding scheme that uses four superconducting nanowire single-photon detectors, which are part of IDQ’s ID281 system. The system cools down the detectors to 0.8 K using a fully automated high performance cryostat. At this temperature, the detectors offer guaranteed and best-in-class performance. The efficiency of the detectors, measured by IDQ and by the Padova team independently, reaches 85% to 90%.

Results

The combination of the setup’s apparatus, which provides an excellent stability, and of the high-efficiency and low-noise SNSPD detectors, allowed the team to demonstrate an extremely low QBER (<= 0.3%) over 6 hours of acquisition (see Fig. 2 and 3). A positive key rate was obtained with a total cumulated loss as high as 43 dB.

This loss is equivalent to a continuous section of 215 km of SMF-28 optical fibre, which illustrates well the quality of the proposed solution and represents an important step towards technologically mature QKD systems.

The developed simple design reduces the complexity for both the QKD transmitter and receiver to simultaneously achieve three different tasks, i.e. synchronization, polarisation compensation and QKD. The QKD transmitter shows high intrinsic stability and the lowest average QBER ever re-ported for an active polarization source developed using only COTS components, resulting in 80 secure bits per second at 43 dB of total channel losses. The simplicity of the QKD implementation renders it compatible with many different scenarios, ranging from urban QKD fiber links to free-space satellite QKD links via Cube-Sats, where small footprint and low energy consumption are of critical importance.

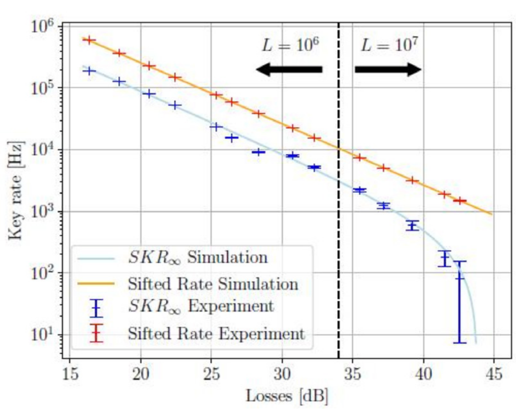

FIG.2

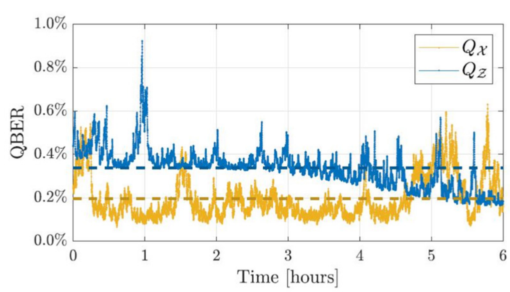

FIG. 3. QBER Measurment for a 6 hour long acquisition along a 26 km optical fiber channel. The average QBER measured for the key-generation basis was $Q_Z = 0.3 \pm 0.1\%$ (dashed blue line) while an average $Q_X = 0.2 \pm 0.1\%$ (dashed yellow line) was measured for the control basis.

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