A QKD-oriented tuning toolbox for photon number statistics with semiconductor quantum dots

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The recent progress made on quantum dot (QD) single-photon sources has opened the possibility of using these devices for various applications such as quantum computing and communications [1]. High brightness and single-photon purity are the key parameters to deploy secure quantum communication like Quantum Key Distribution (QKD). While a clear advantage for high-performance QDs is expected over Poisson-distributed sources [2], **the search for a mid-term advantage of QDs in practical scenarios has been overlooked**. We thus propose a hybrid approach, using both laser and single photons to share a secret key. Driving our QD off-resonantly allows a convenient rejection of the excitation laser with spectral filtering. Furthermore, we can push this feature to **collect a mix of both laser light and single photons** by changing the angles of the bandpass filters. Based on this, we implemented a testbed for the BB84 protocol with polarization control with a modular setup. With this approach, we can access a wide range of single-photon purities, count rates, and Quantum Bit Error Rates (QBER) and this enables us to optimize the Secret Key Rate (SKR) at a given distance. Our work enhances the rate performances one would get by using single photons only but maintains the security advantages offered by a high purity at long distances [3]. This work paves the way for hybrid approaches with a mix of laser and single photons for quantum communications.

References

[1] Maring, N. et al., *Nat. Photon.* **18**, 603-609 (2024)
[2] Bozzio, M. et al., *npj Quantum Inf* **8**, 104 (2022)
[3] Portella, Y. et al., Manuscript in preparation (2025)

Figures

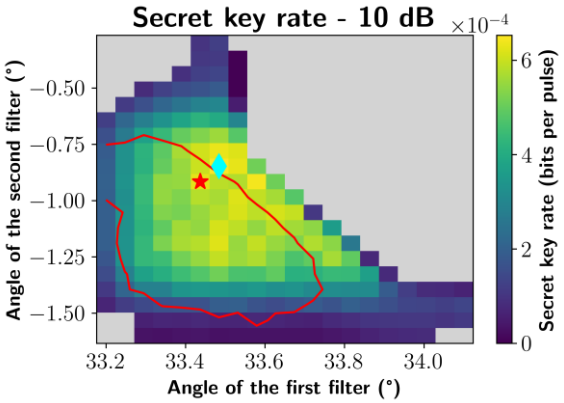

Figure 1: SKR as function of the filters' angle. The red region indicates the area where purity is over 95%. The red star marker (resp. blue diamond) indicates the highest SKR in the red region (resp. global maximum).

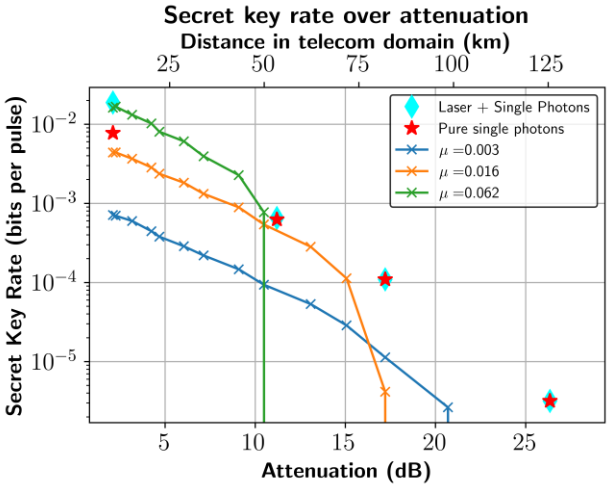

Figure 2: Distance scaling of the SKR. Red stars and blue diamonds are data points taken from the SKR colormaps for various attenuations. The SKR measured when only using laser is plotted in coloured lines.