# Erratum

to the doctoral thesis

*"System Integration of High-Performance Continuous-Variable Quantum Key Distribution"*

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Thesis defended: December 9, 2024
Erratum issued: November 26, 2026

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Upon the last two years, minor mistakes were found by colleagues reading my PhD thesis. I would like to thank Simone Conton, Alexis Rosio and Manon Huguenot for finding some of these errors.

Page and line numbers refer to the printed/submitted version of the thesis. Line numbers are counted from the top of the page unless marked "(from bottom)".

None of the corrections below affect the main conclusions of the thesis.

## List of Corrections

| Page | Location | Original | Corrected |
|---|---|---|---|
| Title page | Line 6 | École Doctorale Informatique, Télécommunications et Électronique (n° 572). | École Doctorale Informatique, Télécommunications et Électronique (n° 130). |
| 9 | Fig .2.1 | "panda" fiber | "panda" fiber |
| 9 | Line 4 | such that the confinement of the light is ensured by $n_2 > n_1$ | such that the confinement of the light is ensured by $n_2 < n_1$ |
| 40 | Line 12 | and $Z$ the overall noise, including the shot noise the electronic noise and the excess noise | and $Z$ the overall noise, including the shot noise, the electronic noise and the excess noise |
| 49 | Eq. (3.43) | $\Gamma_{AB_3FG} = (Y^{BS})^T[\Gamma_{AB_1} \oplus \Gamma_{F_0G}]Y^{BS}$ | $\Gamma_{AB_3FG} = Y^{BS}[\Gamma_{AB_1} \oplus \Gamma_{F_0G}](Y^{BS})^T$ |
| 49 | Eq. (3.45) | $Y^{BS} = \mathbb{I}_A \oplus \begin{bmatrix} \sqrt{\eta}\cdot\mathbb{I}_2 & \sqrt{1-\eta}\cdot\mathbb{I}_2 \\ \sqrt{1-\eta}\cdot\mathbb{I}_2 & \sqrt{\eta}\cdot\mathbb{I}_2 \end{bmatrix} \oplus \mathbb{I}_G$ | $Y^{BS} = \mathbb{I}_A \oplus \begin{bmatrix} \sqrt{\eta}\cdot\mathbb{I}_2 & \sqrt{1-\eta}\cdot\mathbb{I}_2 \\ -\sqrt{1-\eta}\cdot\mathbb{I}_2 & \sqrt{\eta}\cdot\mathbb{I}_2 \end{bmatrix} \oplus \mathbb{I}_G$ |
| 64 | Line 5 (from bottom) | For bandwidth-limited channel | For bandwidth-limited channels |
| 64 | Line 1-2 (from bottom) | the overall temporal response of emitter filter, channel and receiver filter x | the overall temporal response of the emitter filter, channel and receiver filter x |
| 68 | Every mention | $L_{ZC}$ | $N_{ZC}$ |

*continued on next page*

| Page | Location | Original | Corrected |
|---|---|---|---|
| 69 | 7 (from bottom) | Another effect that will have similar effects | Another phenomenon that will have similar effects |
| 71 | 2 (from bottom) | $\beta_{\text{rrc}} = 5$ | $\beta_{\text{RRC}} = 5$ |
| 72 | 4 | $\text{SPS} = \frac{R_s}{R_{\text{DAC}}}$ | $\text{SPS} = \frac{R_{\text{DAC}}}{R_s}$ |
| 160 | Eq. (7.9) | $E_\pi^{\text{receiver}} = \kappa \max\left(1, \eta T \langle n \rangle\right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$ | $E_\pi^{\text{receiver}} = \kappa \max\left(\frac{q}{\eta}, T\langle n \rangle\right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$ |
| 160 | Line 9 (from bottom) | where $\kappa$ is here to ensure the $\gg$ relation ($\kappa = 10$ or 100). | where $q = 1$ or 2 is the number of measured quadratures and $\kappa$ is here to ensure the $\gg$ relation ($\kappa = 10$ or 100). |
| 160 | Eq. (7.10) | $E_\pi = \kappa \left(\langle n \rangle + \max\left(1, \eta T \langle n \rangle\right)\right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$ | $E_\pi = \kappa \left(\langle n \rangle + \max\left(\frac{q}{\eta}, T\langle n \rangle\right)\right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$ |

## Substantive Corrections

1. **Page 160, Equations (7.9) and (7.10)**: an error in the derivation of the energy of the receiver is found, due to the lack on consideration of the efficiency of the detector on the local oscillator. Here we reperform the derivation to report the correct expression.

   One can always consider a lossy balanced detector with efficiency $\eta$ as pure loss with efficiency $\eta$ followed by a perfect detector. The conditions from Ferraro, Olivares and Paris given on page 160 are valid for the perfect detector. Hence, it is required that $|\beta| \gg 1$ where $\beta$ is the *effective* local oscillator amplitude (after losses) and $|\beta|^2 \gg \langle \hat{a}^\dagger \hat{a} \rangle$ where $\hat{a}$ and $\hat{a}^\dagger$ are the annihilation and creation operators after the losses. We consider that the efficiency $\eta$ is the same for the signal and the local oscillator.

   In the case of homodyne detection, these two conditions directly translate to:

   $$\begin{cases} \eta \langle n_{\text{LO}} \rangle \gg 1 \\ \eta \langle n_{\text{LO}} \rangle \gg \eta T \langle n \rangle \end{cases}$$

   where $T$ is the attenuation of the quantum channel and $\langle n \rangle$ the number of photon at Alice's side.

   In this case of the homodyne detection, we have that both the local oscillator and signal undergo an additional 50:50 coupler, giving the conditions:

   $$\begin{cases} \frac{\eta}{2} \langle n_{\text{LO}} \rangle \gg 1 \\ \frac{\eta}{2} \langle n_{\text{LO}} \rangle \gg \frac{\eta}{2} T \langle n \rangle \end{cases}$$

   Only the first condition differ by a constant factor.

   Hence Equation (7.9) should read

   $$E_\pi^{\text{receiver}} = \kappa \max\left(\frac{q}{\eta}, T\langle n \rangle\right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$$

where $q$ is the number of quadratures. Similarly Equation (7.10) should read

$$E_\pi = \kappa \left( \langle n \rangle + \max \left( \frac{q}{\eta}, T\langle n \rangle \right) \right) \frac{hc}{\lambda} \frac{N_{\text{target}}}{K_\pi}$$

The new formula slightly changes Fig. 7.5, without any substantial impact on the findings.

## Bibliography Corrections

None.