Absolute self-calibration of single-photon and multiplexed photon-number-resolving detectors

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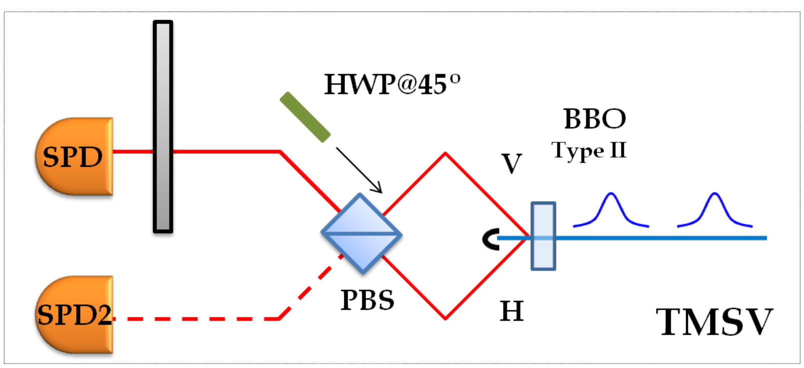
We introduce a method to calibrate a single-photon detector (SPD) without requiring a reference detector. Our method is valid for SPDs as well as multiplexed detectors, which are known to be photon number resolving (PNR). This method can be a good solution for measuring the efficiency within a photonic circuit, containing only one detector.

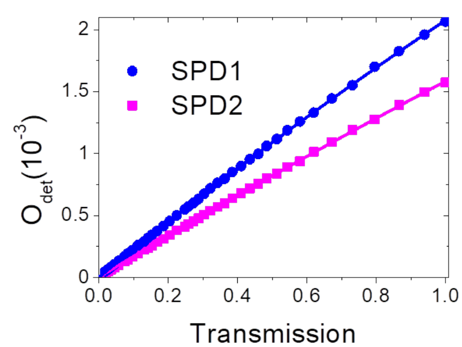
An SPD is calibrated by determining its detection efficiency. The standard method to calibrate SPDs is to use correlated photon pairs from a twin-beam state[1]. Two detectors are required for this calibration method as the coincidence rate must be known. We develop a model to characterize a multiplexing PNR detector taking into account several distorting effects; Finite detection efficiency, finite number of SPD elements, dark counts, and cross-talks. The analysis is used for experimentally calibrating a single SPD[2].

The experimental setup is given in Fig. 1(a). A pulsed two mode squeezed vacuum (TMSV) state is generated and spatially overlapped by a polarizing beam splitter (PBS). The light is attenuated by a variable neutral density filter (NDF) and directed into a single SPD. SPD2 is used for comparison to the standard procedure.

The experimental results are shown in Fig. 1(b). The odds, the probability for detection divided by the probability for no detection is plotted as a function of the NDF transmission, for two SPDs. The data are fitted to a second order polynomial (solid lines) and the efficiency is extracted from the fit. Table 1 shows good agreement between the two methods.



(a)



(b)

Figure 1: (a) Experimental setup (b) Results

Table 1: The efficiencies measured by the single detector method (η_1) and the coincidence method (η_2).

SPD #	η_1	η_2
1	$17.4 \pm 1.0\%$	$17.3 \pm 0.8\%$
2	$12.7 \pm 0.9\%$	$11.7 \pm 0.8\%$

References

[1] D. N. Klyshko, Sov. J. Quantum Electron. 7, 591 (1977).

[2] L. Cohen, Y. Pilnyak, D. Istrati, N. M. Studer, J. P. Dowling, and H. S. Eisenberg, arXiv:1711.03594.