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Institute for Solid State Physics and Optics
Quantum Optics and Quantum Information Dept.
Quantum Information National Laboratory
Work Package 5

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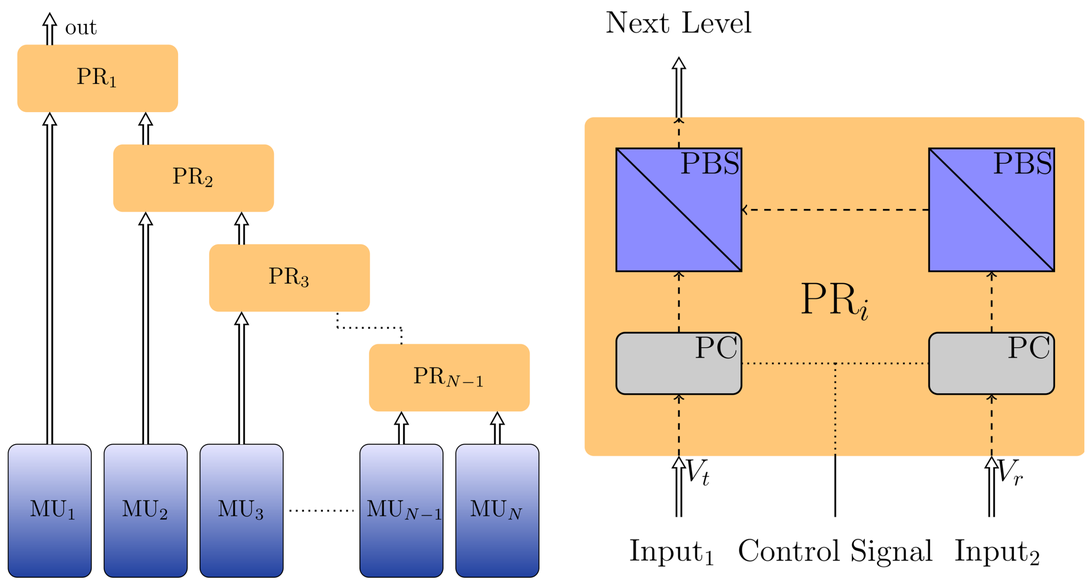
Introduction

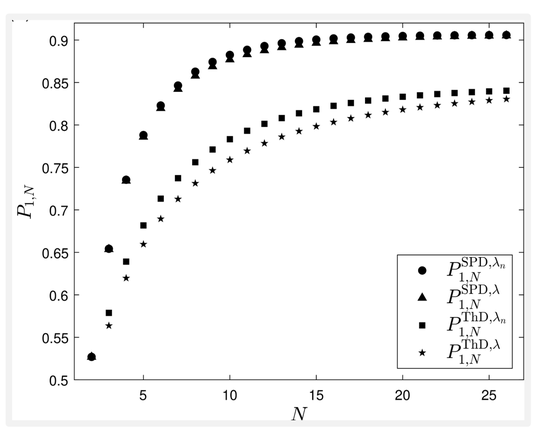
One task of Work Package 5 of the QNL is the development of multiplexed single-photon sources. We have developed a statistical theory describing the operation of multiplexed single-photon sources equipped with photon-number-resolving detectors that includes the potential use of different input mean photon numbers in each of the multiplexed units. We have proposed two novel types of spatially multiplexed single-photon sources based on incomplete binary-tree multiplexers. The application of the incomplete binary-tree approach can significantly improve the performance of the multiplexed single-photon sources for suboptimal system sizes that is a typical situation in current experiments. We have proposed and analyzed novel types of spatially multiplexed single-photon sources based on output-extended incomplete binary-tree multiplexers where the construction of the multiplexers takes into account the total transmission efficiencies of the multiplexer arms at which a novel router can be added to the system.

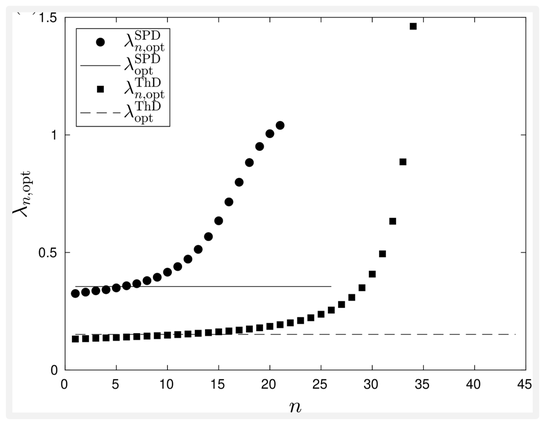
Research Highlights

Single-photon sources based on asymmetric spatial multiplexing with optimized inputs



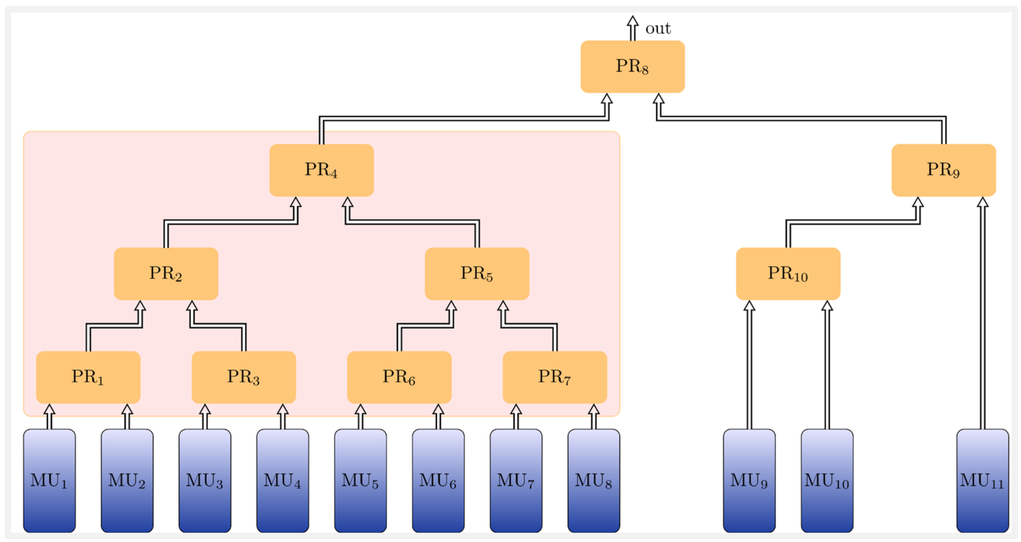
$$P_i^{(S)} = \prod_{k=1}^{N}\left(1-\sum_{j\in S}P_k^{(D)}(j)\right)\delta_{i,0} + \sum_{n=1}^{N}\left[\prod_{k=1}^{n-1}\left(1-\sum_{j\in S}P_k^{(D)}(j)\right)^{(1-\delta_{1,n})}\sum_{l=i}^{\infty}\sum_{j\in S}P^{(D)}(j|l)P_n^{(\lambda_n)}(l)V_n(i|l)\right]$$

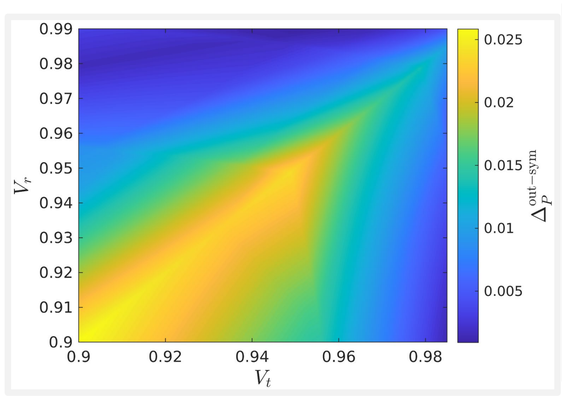


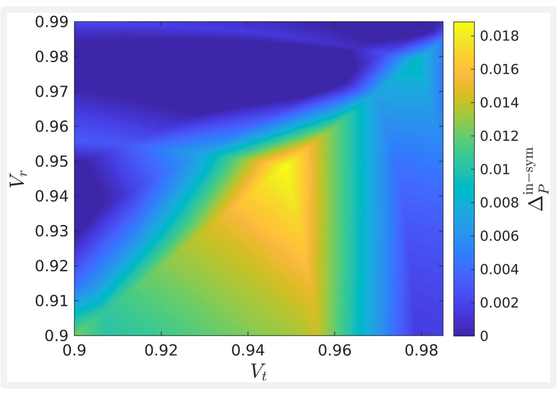


The highest single-photon probability is 0.935 that can be achieved in single-photon sources based on asymmetric spatial multiplexing using state-of-the-art bulk-optical devices.

Spatially multiplexed single-photon sources based on incomplete binary-tree multiplexers

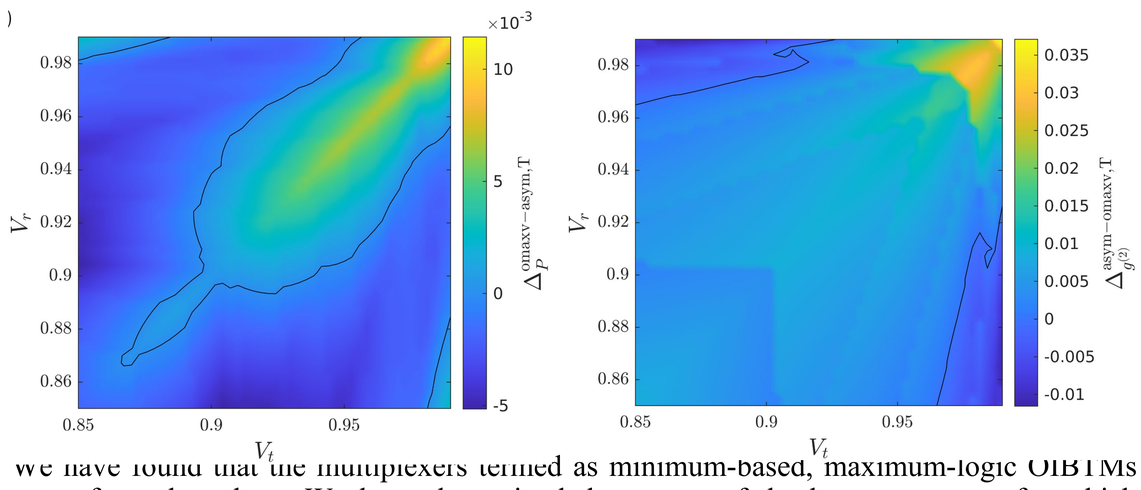






A special advantage of using the proposed multiplexer schemes is that high single-photon probabilities can be achieved at a reduced number of the required component sources compared to complete binary-tree multiplexers with similar performance.

Single-photon sources based on incomplete binary-tree multiplexers with optimal structure



We have found that the multiplexers termed as minimum-based, maximum-logic OIBTMs outperform the others. We have determined the ranges of the loss parameters for which single-photon sources based on such systems yield higher single-photon probabilities and lower values of the second-order autocorrelation function than that can be achieved by using asymmetric multiplexers.

Publications

[1] P. Adam, F. Bodog, and M. Mechler, Opt. Express **30**, 6999 (2022).
[2] P. Adam, F. Bodog, M. Koniorczyk, and M. Mechler, Phys. Rev. A **105,** 063721 (2022).
[3] P. Adam, M. Mechler, Optics Express **31**, 30194 (2023).

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