Multiplexed Single-Photon Sources Based on Spatial Multiplexers with Optimized Structure

A Kaszás[1,2], M Mechler[2], and P Ádám[3]

[1] *University of Pécs, 7624, Boszorkány út 2., Pécs, Hungary. Contact Phone: +36 72 503 650*
[2] *Institute of Physics, University of Pécs, 7624, Ifjúság útja 6, Pécs, Hungary.*
Contact Phone: +36-72-503-600/24399
Contact Email: kaszas.andras@mik.pte.hu

Single-photon sources still play an essential role in several experiments aiming at realizing or verifying theoretically established concepts in the fields of quantum information processing and photonic quantum technology. A possible realization of a single-photon source involves some kind of multiplexing of heralded single-photon sources where the multiphoton contribution in the individual heralded sources is suppressed by decreasing the input photon number, and the resulting increased zero-photon probability is reduced by the parallel use of several sources. Several theoretical and experimental studies have discussed the possible means to increase the single-photon probability of spatially, temporally or spectrally multiplexed sources [1, 2]. Using the statistical theory of these sources, it becomes possible to optimize multiplexed single-photon sources, that is, to maximize the output single-photon probability by determining the optimal system size, in other words, the number of multiplexed units, and the mean number of photon pairs generated in the multiplexed units for a given set of loss parameters [3–6]. Recently, in order to increase the single-photon probability of spatially multiplexed single-photon sources, the idea of optimizing the structure of the multiplexer has been raised. In Ref. [7] a method for the stepwise optimization of the structure of binary-tree multiplexers was developed. Then a method for finding the multiplexer with the optimal structure out of all possible structures formed by a given number of photon routers was proposed and analyzed for suboptimal numbers of the multiplexed units up to $N = 11$ [8]. This method basically scales with the factorial of the number of the constituent photon routers, hence finding the optimal number of the multiplexed units for a given set of the loss parameters is an intriguing issue.

In this talk, we present a method which combines the stepwise and the overall structure optimization for obtaining the optimal multiplexer structure. This method can be applied for any numbers of multiplexed units. We accomplish the full optimization problem for several sets of realistic loss parameters, hence we determine the optimal input mean photon number, the optimal number of multiplexed units, and the optimal structure of the spatial multiplexer for which the single-photon probability of a spatially multiplexed single-photon source is maximal.

References

[1] E Meyer-Scott, C Silberhorn and A Migdall, Rev. Sci. Instrum. **91**, 041101 (2020)

[2] P Adam and M Mechler, Appl. Sci. **14**, 11249 (2024)

[3] F Bodog, M Mechler, M Koniorczyk and P Adam, Phys. Rev. A **102** 013513 (2020)

[4] P Adam, F Bodog and M Mechler, Opt. Express **30** 6999 (2022)

[5] P Adam, F Bodog, M Koniorczyk and M Mechler, Phys. Rev. A **105** 063721 (2022)

[6] P Adam and M Mechler, Opt. Express **31**, 30194 (2023)

[7] P Adam and M Mechler, Opt. Express **32**, 17173 (2024)

[8] M Mechler and P Adam, arXiv:2407.17370 (2024)