Microscopy with heralded Fock states

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In the presented work [1] a quantum ghost imaging setup is considered, where Spontaneous parametric down-conversion (SPDC) heralded single photons are used to illuminate a sample. The SPDC-generated photon pairs are described by a biphoton wavefunction which is further propagated through a given optical setup (see Fig. 1) and analyzed at different steps of the propagation path. The analysis includes not only the spatial mode profile investigation but also examining its phase. Analytical expressions for the spatial mode tracking together with the widths of the heralded and non-heralded modes are provided. These analytical results are supported through numerical calculations, and a comprehensive discussion considering practical factors like finite-size optics and single-photon detectors. As a result, it is demonstrated that the diffraction limit can be approached while mitigating photon losses, which leads to an enhanced signal-to-noise ratio - a critical factor for the practical use of quantum light. Furthermore, it is shown that spatial resolution manipulation is possible by careful preparation of the amplitude and phase of the spatial mode profile of the single photon at the microscope objective's input. This is proven to be true for both quantum and classical light. Spatial entanglement of the biphoton wavefunction or adaptive optics can be utilized for this purpose. Analytical formulas describing how the parameters of the incident and focused spatial mode profiles are related are provided.

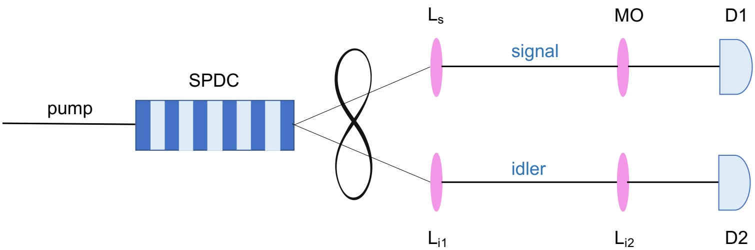

Fig. 1: A scheme of experimental setup concept. L_s, L_{i1}, L_{i2} - lenses, MO - microscope objective, D_1, D_2 - detectors.

References

[1] M. Gieysztor, J. Nepinak, C. J. Pugh, P. Kolenderski, Opt. Express **31** (13), 20629-20640 (2023) .

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