Spatial reshaping of a squeezed state of light

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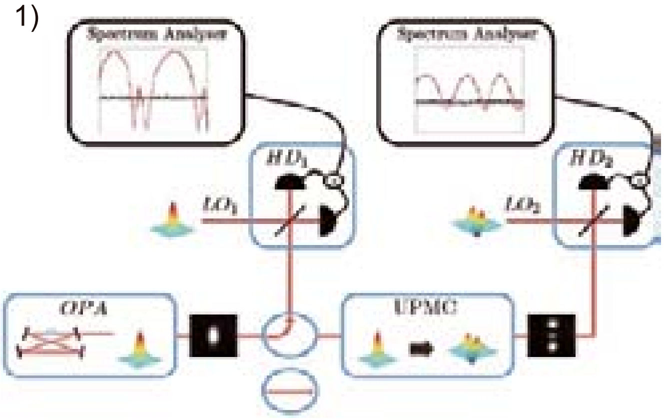
Reshaping the spatial profile, or mode, of a quantum state of light is one of the challenges in many quantum optics applications. We test the noise properties of a universal programmable mode converter (UPMC) [1] and demonstrate that it can reshape the spatial mode of a beam while retaining its quantum properties. No detectable amount of noise is added to the light and only the standard transmission losses through conventional optical elements are found to affect the non-classical nature of the transformed light.

Our results confirm that the UPMC can transform the spatial profile of the light while retaining its quantum properties, excluding passive losses introduced by its optical components [2]. Convincingly, the UPMC does not add noise, and allows for high quality mode matching. It must be noted here that our device is a proof of principle UPMC. A lossless transform is indeed possible given access to higher quality optical components; there is nothing fundamental in the UPMCs design that destroys the quantum state of the light. To that extent, the UPMC is a useful link between the quantum resource and its manipulation. Moreover, the programmable nature of the UPMC makes it a flexible device, allowing for example the same OPA and optical set-up to be used for a wide range quantum enhanced detections.

1)



2)

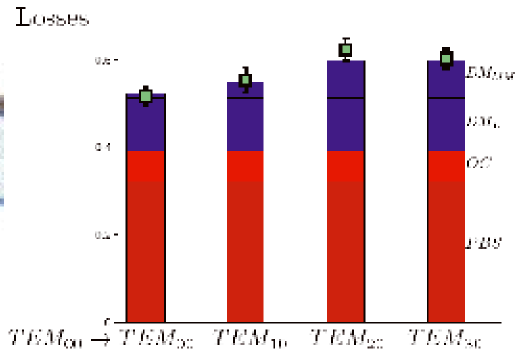


Fig. 1: General schematic of the experiment. The output of the optical parametric amplifier (OPA), a squeezed state in the TEM_{00} mode, is either sent directly to be measured on the first homodyne detection HD_1 using a local oscillator in the TEM_{00} mode or sent through the UPMC. The UPMC changes the spatial profile of the light, in this specific example to a TEM_{20}. The squeezing levels in the TEM_{20} output mode are then measured using HD_2.
Fig. 2: Comparison between the losses calculated from the quantum variance measurements and the losses in power, for different transformations of the spatial profile. PBS shows the losses from the polarizing beamsplitters and OC the losses from the other optical components. DM_L shows the losses from the reflections on the DM and DM_{MM} represents the loss due to the spatial profile mismatch. Finally, the squares represent the losses calculated from the quantum variance measurements.

References

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