Quantum correlation plenoptic imaging

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Abstract: We experimentally demonstrate the refocusing capability and the optical performance of a correlation plenoptic imaging (CPI) architecture exploiting intensity correlations between entangled beams produced by a spontaneous parametric down conversion (SPDC) source.

Correlation plenoptic imaging (CPI) is a light-field imaging technique combining large depth of field and 3D imaging capability with high resolution [1-3]. As any light-field imaging technique, CPI relies on retrieving plenoptic information of a three-dimensional sample, namely, the joint information about its spatial distribution and the direction of propagation of light rays [2]. This quantity is encoded in the second order correlation function evaluated from the intensity distributions collected by two disjoint and synchronized high resolution detectors and requires the detected light to be characterized by spatio-temporal correlations between the measured intensity fluctuations: both chaotic light and entangled photons/beams can thus be employed [1,2].

The light-field information enables enlarging the natural depth of field defined by the optical system, refocusing out-of-focus planes and reconstructing 3D images; interestingly, the achieved depth of field is independent of the numerical aperture, as inherited by the properties of spatial coherence of light [4], and its increase does not imply sacrificing diffraction limited resolution [2,5].

All these features are particularly interesting in the microscopy scenario in which correlation plenoptic microscopy based on chaotic light has been experimentally implemented and employed for imaging both 2D and 3D test targets and 3D biomedical phantoms [2].

Here, we shall present the work carried out within NQSTI (spokes 7 and 2), where correlation plenoptic microscopy is being implemented by using entangled photons produced from spontaneous parametric down conversion (SPDC); the goal of the experiment is to exploit quantum correlations in space, time and photon number/intensity, to explore the possibility of achieving sub-shot noise CPI. Entanglement-based CPI would play a major role in enabling imaging low-absorption samples with high signal-to-noise ratio (SNR).

We will present the employed optical architecture as well as the analysis of the resolution limits and optical performance. We shall also present the analysis tools employed to improve the SNR of the refocused images and demonstrate the capability of CPI to significantly improve the quality and the SNR of ghost imaging, as shown in Fig. 1. The experimental refocusing of an out-of-focus bi-dimensional test target will also be presented, while emphasizing the advantages offered by the chosen working regime (many photons per pixel per frame regime) as opposed to the more typical 2-photon regime.

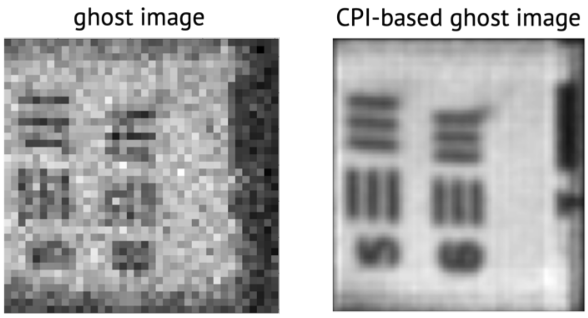

Fig. 1 Comparison between a ghost image and a CPI-based ghost image of a test target.

References

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