New Perspectives in Sub Shot Noise Imaging: Quantum-Enhanced Quantitative Phase Imaging

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The peculiar properties of quantum optical states represent a new resource for innovative imaging schemes [1], as sub shot noise imaging [2,3] or quantum illumination [4]. In particular, quantum entanglement and squeezing have significantly improved phase estimation and imaging in interferometric settings beyond the classical limits. In this talk, after a general introduction, I will describe the work on quantum imaging performed in INRIM. In particular, I'll present in detail two works.

The first consists of exploiting entanglement to enhance imaging of a pure phase object in a non-interferometric setting, only measuring the phase effect on the free-propagating field. This method, based on the so-called "transport of intensity equation", is quantitative since it provides the absolute value of the phase without prior knowledge of the object and operates in wide-field mode, so it does not need time-consuming raster scanning. Moreover, it does not require spatial and temporal coherence of the incident light. Besides a general improvement of the image quality at a fixed number of photons irradiated through the object, resulting in better discrimination of small details, we demonstrate a clear reduction of the uncertainty in the quantitative phase estimation. Although we provide an experimental demonstration of a specific scheme in the visible spectrum, this research also paves the way for applications at different wavelengths, *e.g.*, X-ray imaging, where reducing the photon dose is of utmost importance. Significant application, in particular in biology, can be envisaged.

In the second, we propose and experimentally demonstrate a novel imaging technique, named Light Field Ghost Imaging, that exploits light correlations and light field imaging principles to enable going beyond the limitations of ghost imaging in a wide range of applications. Notably, our technique removes the requirement to have prior knowledge of the object distance allowing the possibility of refocusing in post-processing, as well as performing 3D imaging while retaining all the benefits of ghost imaging protocols.

References

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