World Academy of Science, Engineering and Technology
International Journal of Nuclear and Quantum Engineering
Vol:17, No:10, 2023

Digital Phase Shifting Holography in a Non-Linear Interferometer using Undetected Photons

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Abstract : This work introduces a combination of digital phase-shifting holography with a non-linear interferometer using undetected photons. Non-linear interferometers can be used in combination with a measurement scheme called quantum imaging with undetected photons, which allows for the separation of the wavelengths used for sampling an object and detecting it in the imaging sensor. This method recently faced increasing attention, as it allows to use of exotic wavelengths (e.g., mid-infrared, ultraviolet) for object interaction while at the same time keeping the detection in spectral areas with highly developed, comparable low-cost imaging sensors. The object information, including its transmission and phase influence, is recorded in the form of an interferometric pattern. To collect these, this work combines the method of quantum imaging with undetected photons with digital phase-shifting holography with a minimal sampling of the interference. With this, the quantum imaging scheme gets extended in its measurement capabilities and brings it one step closer to application. Quantum imaging with undetected photons uses correlated photons generated by spontaneous parametric down-conversion in a non-linear interferometer to create indistinguishable photon pairs, which leads to an effect called induced coherence without induced emission. Placing an object inside changes the interferometric pattern depending on the object's properties. Digital phase-shifting holography records multiple images of the interference with determined phase shifts to reconstruct the complete interference shape, which can afterward be used to analyze the changes introduced by the object and conclude its properties. An extensive characterization of this method was done using a proof-of-principle setup. The measured spatial resolution, phase accuracy, and transmission accuracy are compared for different combinations of camera exposure times and the number of interference sampling steps. The current limits of this method are shown to allow further improvements. To summarize, this work presents an alternative holographic measurement method using non-linear interferometers in combination with quantum imaging to enable new ways of measuring and motivating continuing research.

Keywords : digital holography, quantum imaging, quantum holography, quantum metrology
Conference Title : ICQIM 2023 : International Conference on Quantum Imaging and Measurement
Conference Location : Tokyo, Japan
Conference Dates : October 09-10, 2023