Hong-Ou-Mandel interference observation with an intensified camera for quantum imaging applications

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Abstract

We report high-visibility Hong-Ou-Mandel (HOM) interference observation between perfectly spatially overlapping modes in a 50:50 beam splitter using an intensified CCD camera in a ghost imaging set up . Using the intensified camera operating in a coincidences scheme it was possible to recover the high interference visibility in the HOM dip obtained in the classical arrangement where avalanche photodiodes were used. The maximum visibility was 97.34% and it was obtained using a spectral width of 3 nm for the photons-pairs from the optical non-linear process Spontaneous Parametric Down Conversion (SPDC). This scheme will allow to reduce the acquisition times of some of the quantum imaging techniques that use two-photon interferometry such as Quantum Optical Coherence Tomography (QOCT) or Single Photon Holography.

Theory

The HOM experiment consists of generating a pair of photons and make them converge onto the input ports of a beam splitter. Detectors placed at the output ports of the beam splitter detect coincidences. When the photons are indistinguishable no coincidences are recorded. The photons for the experiment come from a single source: photon pairs produced simultaneously by spontaneous parametric down conversion (SPDC). In order for the photons to be indistinguishable they have to arrive at the beam splitter at the same time within the coherence time of the light, and be in the same polarization, spatial and momentum modes. For a 50:50 beam splitter, we obtain a two-photon entangled state:

$$|\psi\rangle_{Out} = (|2,0\rangle - |0,2\rangle)/\sqrt{2} \quad (1)$$

Experimental setup

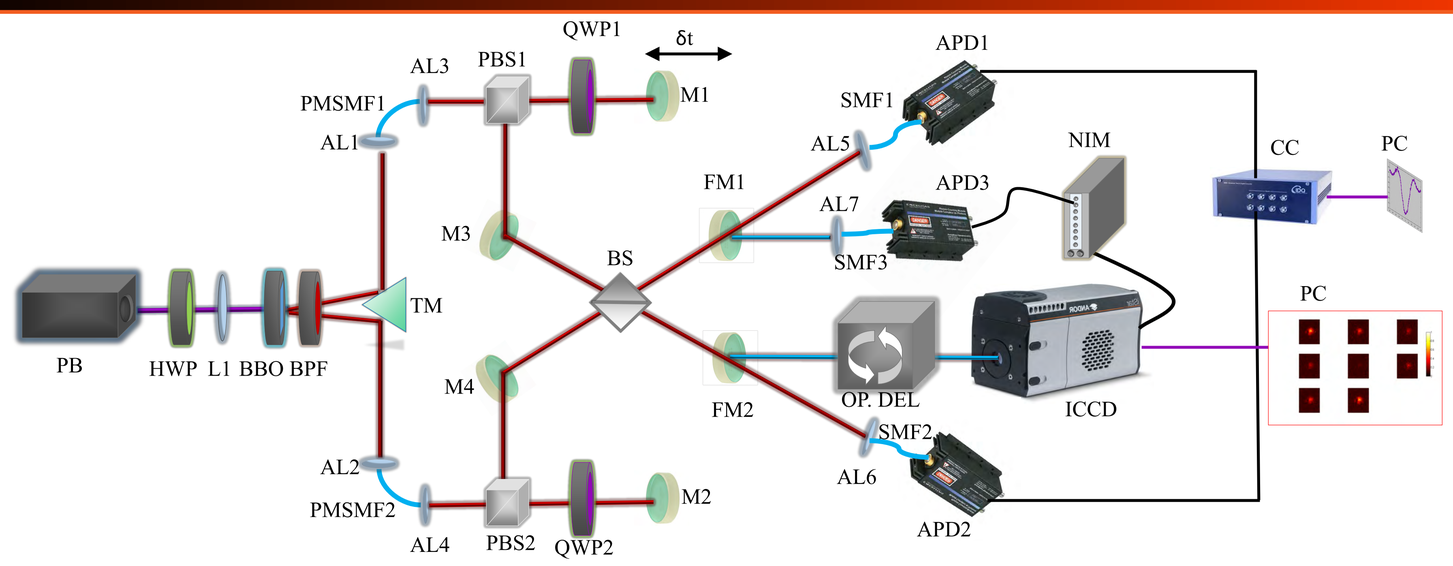
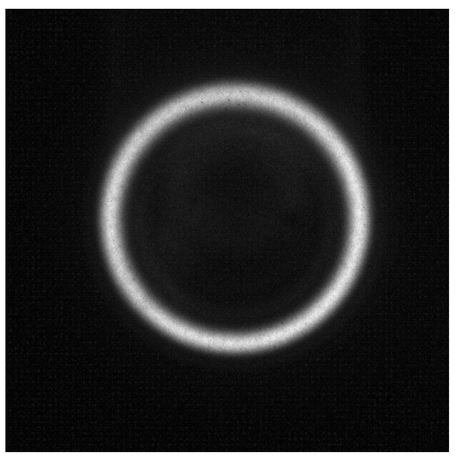
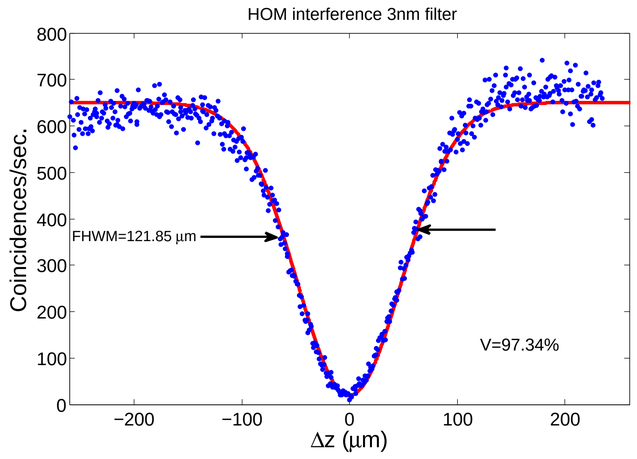


Fig. 1: Experimental setup to observe HOMI using an ICCD working in coincidence.

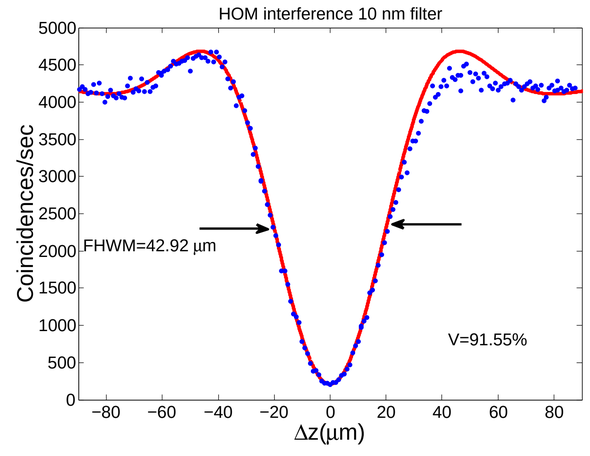
HOM interference using APD's coincidences system.



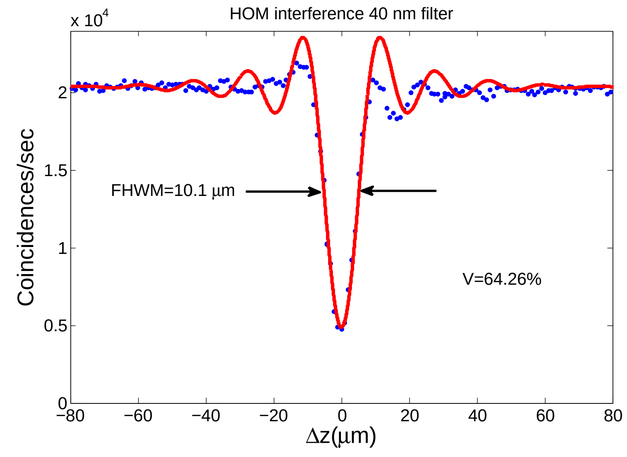
(a) SPDC Type I ring.



(b) HOM interference dip using a 3 nm filter

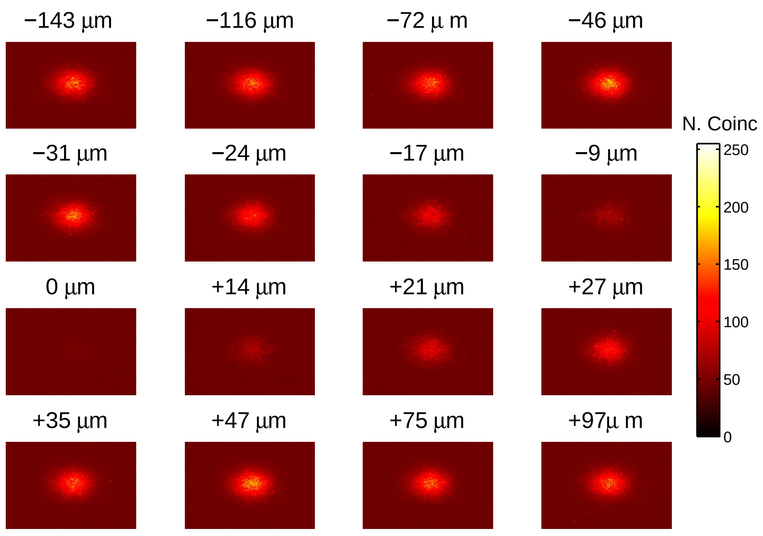


(c) HOM interference dip using a 10 nm filter

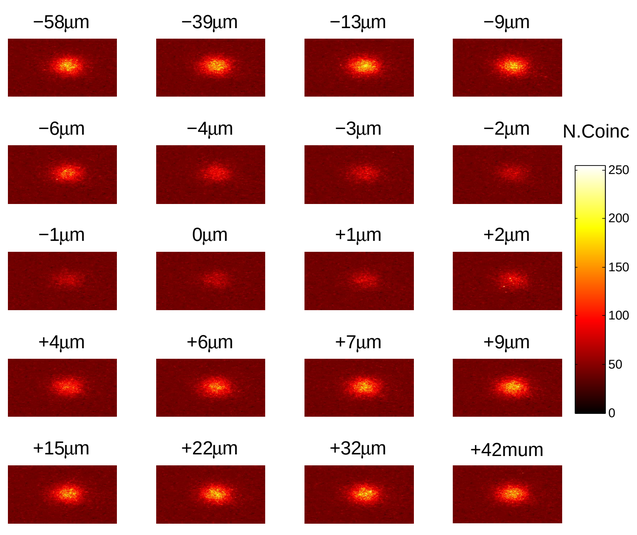


(d) HOM interference dip using a 40 nm filter

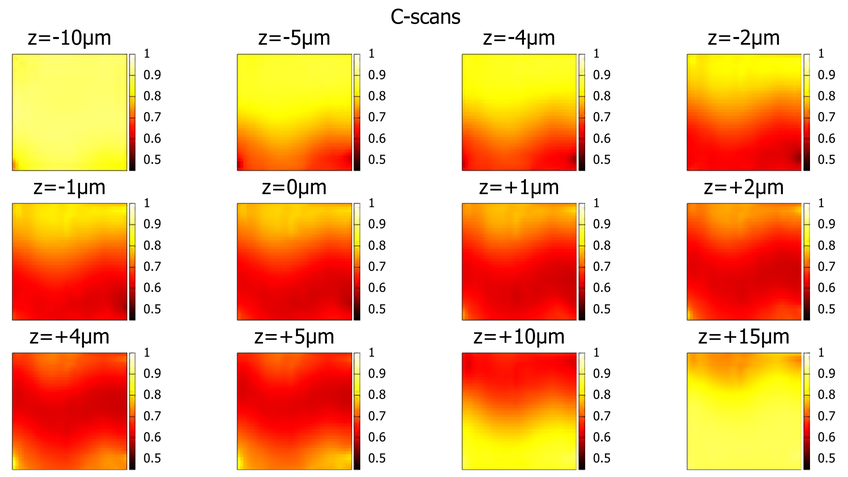
HOMI using a ICCD in a ghost imaging setup



(e) HOMI using a 10 nm filter.

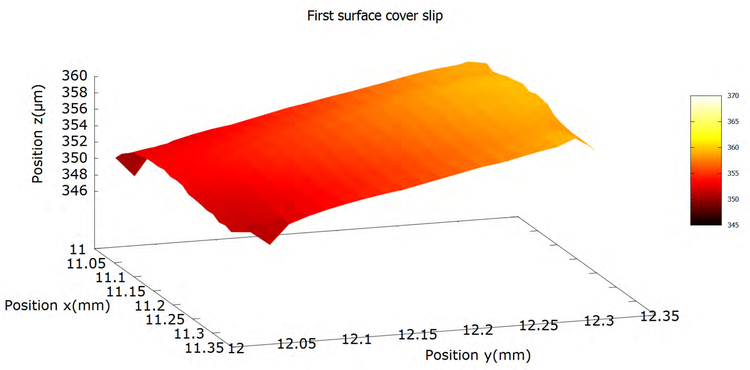


(f) HOMI using a 40 nm filter.

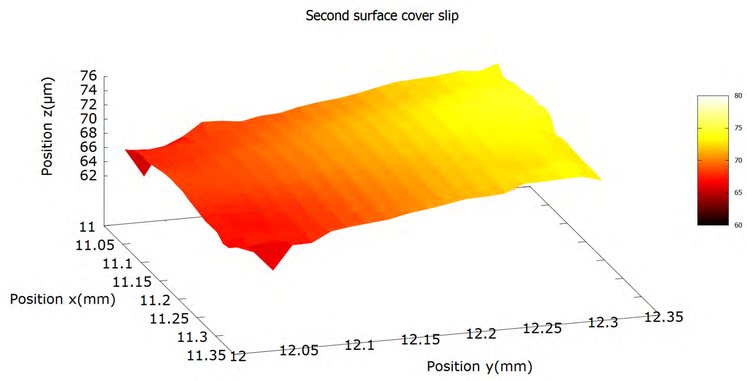


(g) Two-dimensional transverse (xy) QOCT sections (C-scans) of coverslip at different axial depths z. .

Quantum imaging applications



(h) Three-dimensional image of the first surface constructed from the collection of all A-Scans.



(i) Three-dimensional image of the second surface constructed from the collection of all A-Scans.

Conclusions

We have implemented a high visibility HOM interferometric system using an intensified camera, which can be applied in quantum imaging techniques to reduce acquisition times. This system can be used mainly in the implementation of QOCT taking advantage of the cancellation of dispersion effects in the axial resolution of this technique.

References

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[3] Michał Jachura, Radosław Chrapkiewicz. *Shot-by-shot imaging of Hong–Ou–Mandel interference with an intensified sCMOS camera* Optics Letters, 40, 1540-1543(2015)