Ghost Imaging Using Tuneable Spatial Correlations

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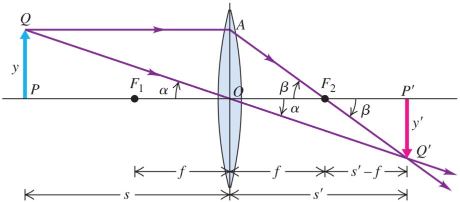
Imaging



Most Common Imaging Process

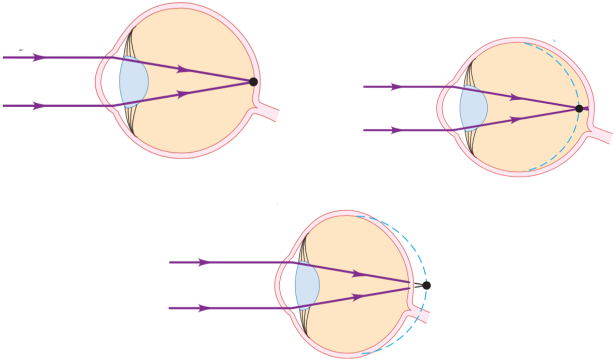


Figure: Normal eye, Myopie and Hypermetropia

Ghost Imaging Experimental Setup

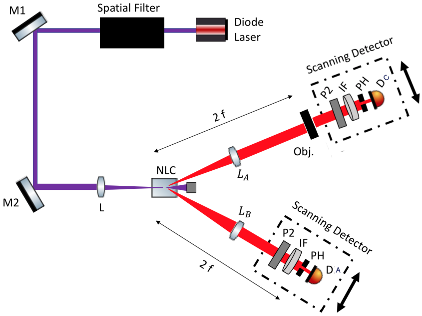


Figure: Experimental Setup for Alignment

Ghost Imaging Experimental Setup

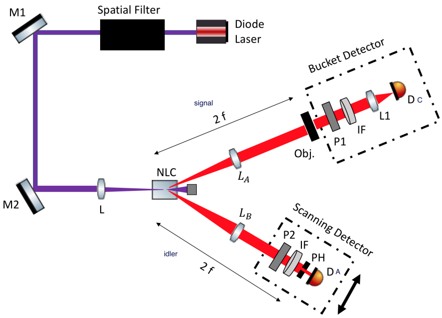


Figure: Experimental Setup for Ghost Imaging

Biphoton

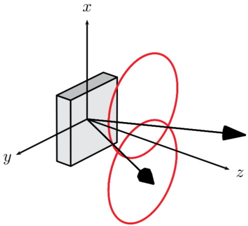
$$|\Psi\rangle = \int dq_s dq_i d\Omega_s d\Omega_i$$
$$\text{x}\left[\Phi(q_s, \Omega_s; q_i, \Omega_i)\hat{a}^\dagger(\Omega_s, q_s)\hat{a}^\dagger(\Omega_i, q_i)\right.$$
$$\left. + \Phi(q_i, \Omega_i; q_s, \Omega_s)\hat{a}^\dagger(\Omega_s, q_s)\hat{a}^\dagger(\Omega_i, q_i)\right]|0\rangle$$

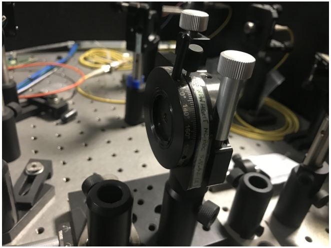
(1)

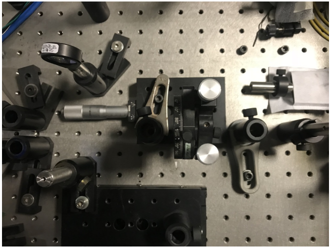
After using Polarisers this reduces to:

$$|\Psi\rangle = \int dq_s dq_i d\Omega_s d\Omega_i x[\Phi(q_s, \Omega_s; q_i, \Omega_i)\hat{a}^\dagger(\Omega_s, q_s)\hat{a}^\dagger(\Omega_i, q_i)]\,|0\rangle$$

Nonlinear Crystal (BBO)







Tracing Out Temporal Correlations

To Observe the transverse correlations the frequency information has to be traced out.

$$\mathcal{F}_{frequency}(\Omega_n) \approx exp\left[-\frac{\Omega_n^2}{4\sigma_n^2}\right]$$

$$\tilde{\Phi}(q_s, q_i) = \int d\Omega_s d\Omega_i \mathcal{F}_s(\Omega_s)\mathcal{F}_i(\Omega_i)\Phi(q_s, \Omega_s; q_i, \Omega_i)$$

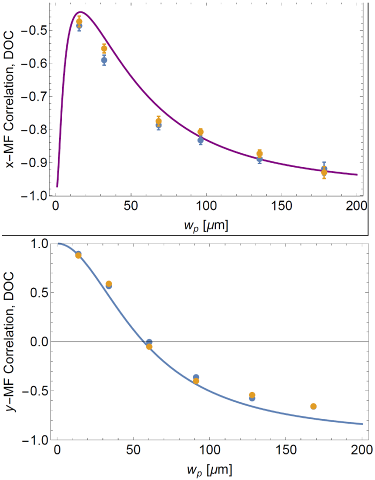
Correlations Degree (DOC)

A way to quantify the degree of spatial correlation we shall define 'correlation parameter':

$$K^{\lambda} = \frac{C_{si}^{\lambda}}{\sqrt{C_{ss}^{\lambda} C_{ii}^{\lambda}}}$$

calculated for each direction ($\lambda = x, y$) from the covariance matrix C^{λ} with elements $C_{kj}^{\lambda} = \langle q_k^{\lambda} q_j^{\lambda} \rangle - \langle q_k^{\lambda} \rangle \langle q_j^{\lambda} \rangle$.

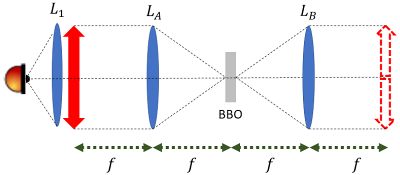
DOC vs w_p



x−MF Correlation, DOC
−0.5
−0.6
−0.7
−0.8
−0.9
−1.0
0
50
100
150
200
w_p [μm]
y−MF Correlation, DOC
1.0
0.5
0.0
−0.5
−1.0
0
50
100
150
200
w_p [μm]

Fourier Plane

Using Fourier one to one correspondence between the transverse momentum and position $q = \frac{2\pi}{\lambda f} r$.

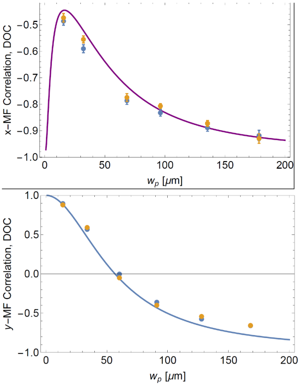


Detection

The coincidence counts that will be measured by the Detectors will be proportional to the magnitude square of the resulting biphoton function $\Phi_1(r_2)$.

$$S(r_2) \propto |\int d^2 r_1 \, T(r_1) \Phi(\frac{2\pi}{\lambda f} r_1, \frac{2\pi}{\lambda f} r_2)|^2 \tag{2}$$

Numerical Example



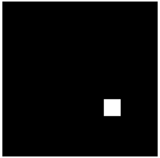
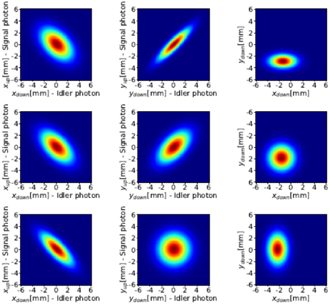
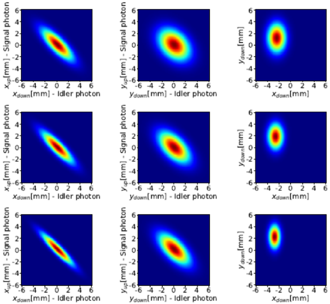


Figure: Mask used

Numerical Example





Experiment at Uniandes: Results

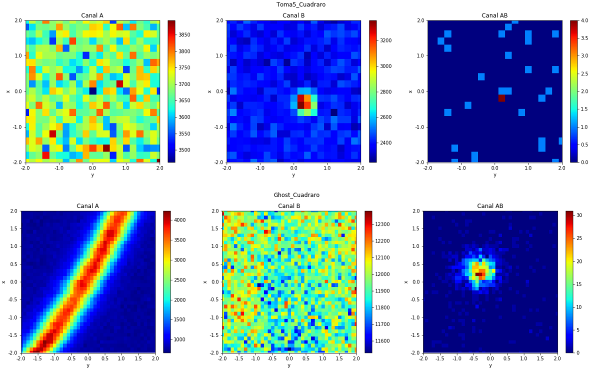


Figure: Alignment and Ghost Image square 4x4 μm

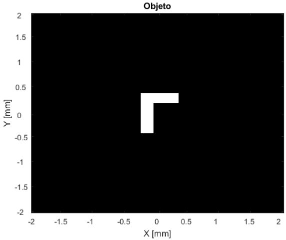


Figure: Mask Used so far

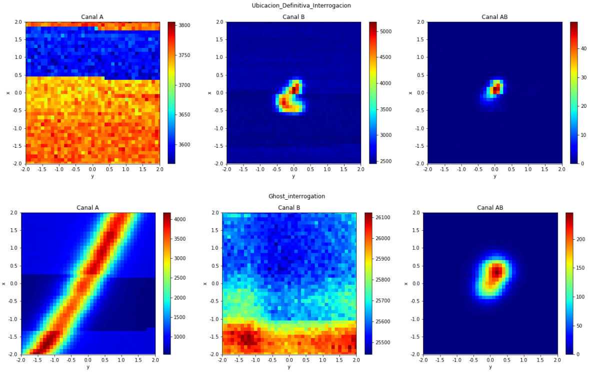


Figure: Alignment and Ghost Image interrogation

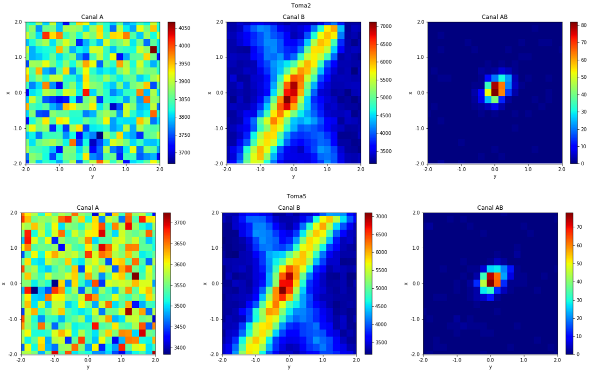


Figure: Alignment for the L

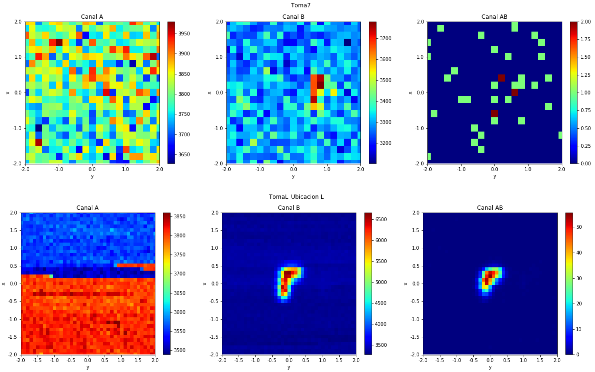


Figure: Alignment for the L

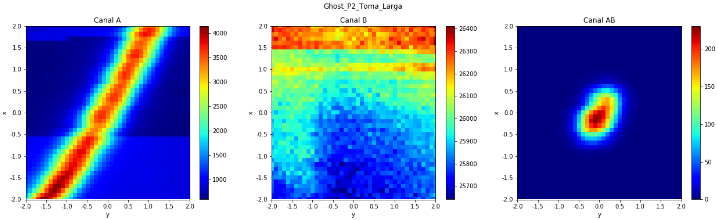


Figure: Ghost Long Measurement

Experimental vs. Simulation Results

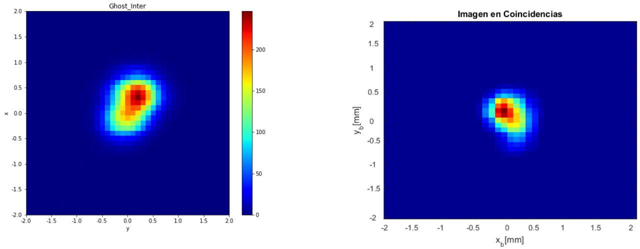
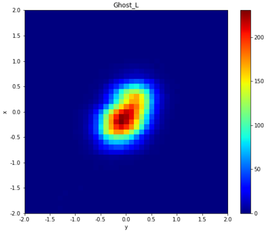


Figure: Comparison for the Interrrogation



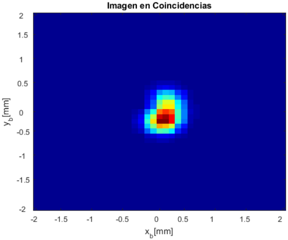


Figure: Comparison for the L

Bibliography