Shaping Entangled Photon Correlations

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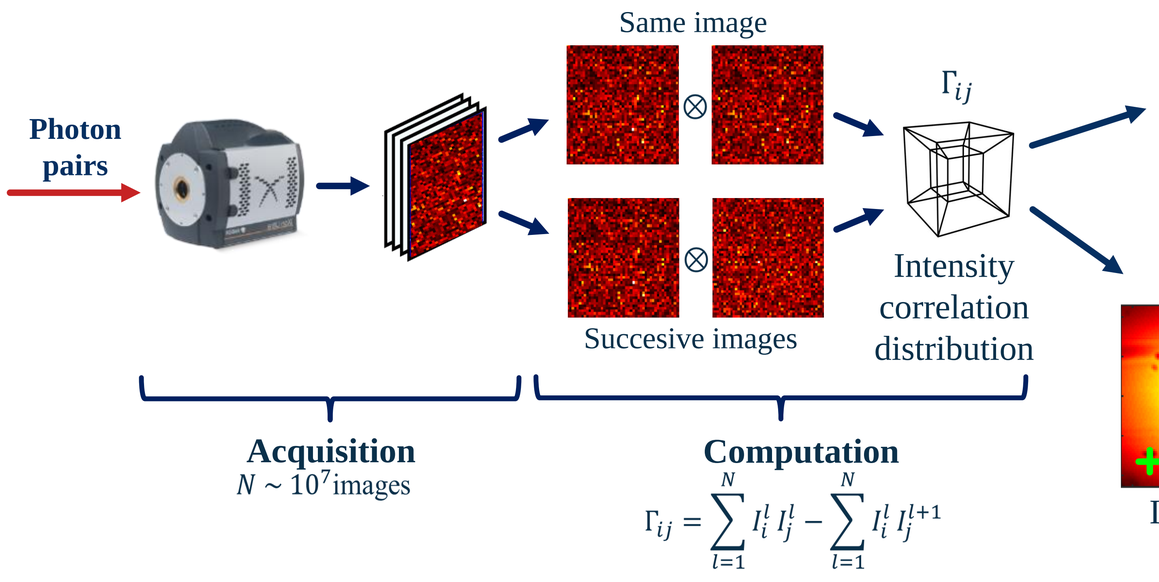
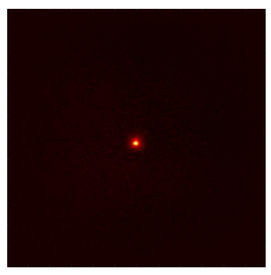
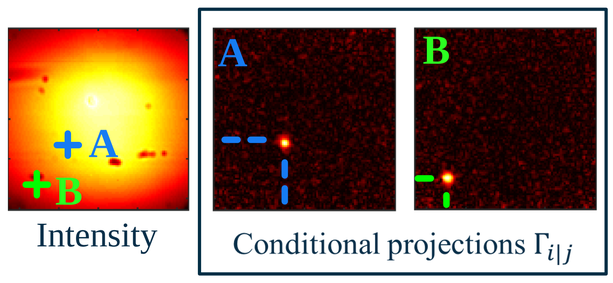
Imaging spatial correlations

- **Measuring correlations:**





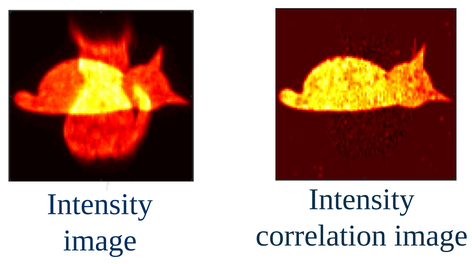
Minus-coordinate Projection



Intensity

Conditional projections $\Gamma_{i|j}$

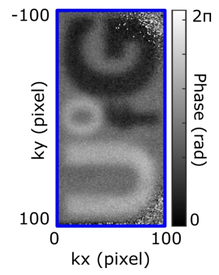
- **Imaging applications:**
  - Quantum image distillation:



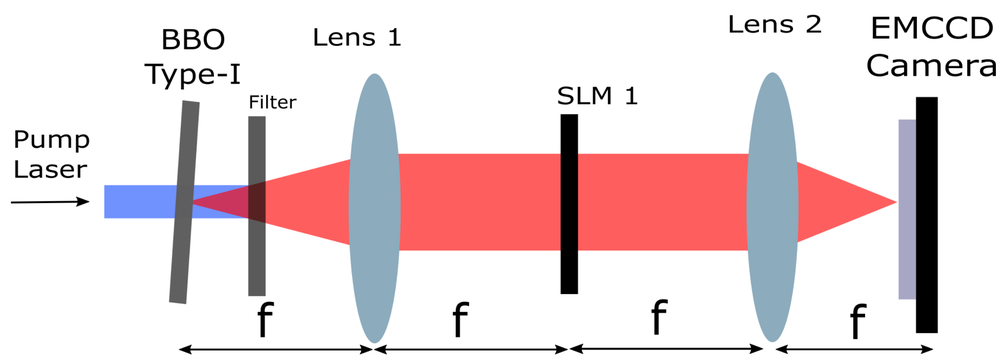
Intensity image

Intensity correlation image

  - Entanglement-enabled holography



Shaping the Intensity Correlations



Generate spatially correlated photons → Shape with SLM → Capture with EMCCD camera → Calculate intensity correlations

- **Theory behind photon pair shaping:** For an SLM pattern $\theta(k)$,

Classical case:

$$I(x) = \left|F\left[e^{i[\theta(k)]}\right](x)\right|^2$$

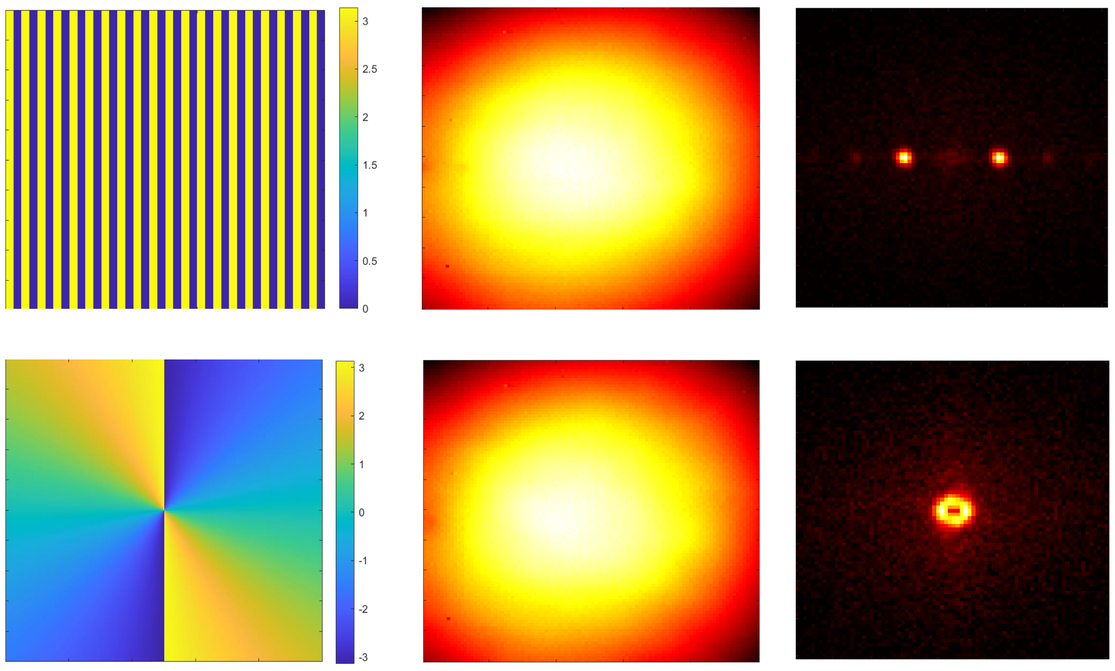
Quantum Case:

$$\Gamma(x_1, x_2) = \left|F\left[e^{i[\theta(k)-\theta(-k)]}\right](x_1 - x_2)\right|^2$$

Minus coordinate projection:

$$C_r(\delta x) = \left|F\left[e^{i[\theta(k)-\theta(-k)]}\right](-\delta x)\right|^2$$

- **Examples of shaping:**

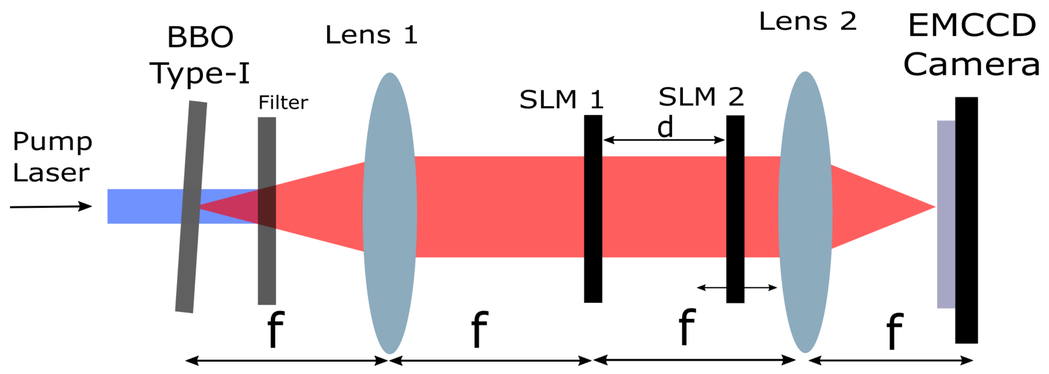


SLM phase mask

Direct intensity image

Correlation image (minus-coordinate projection)

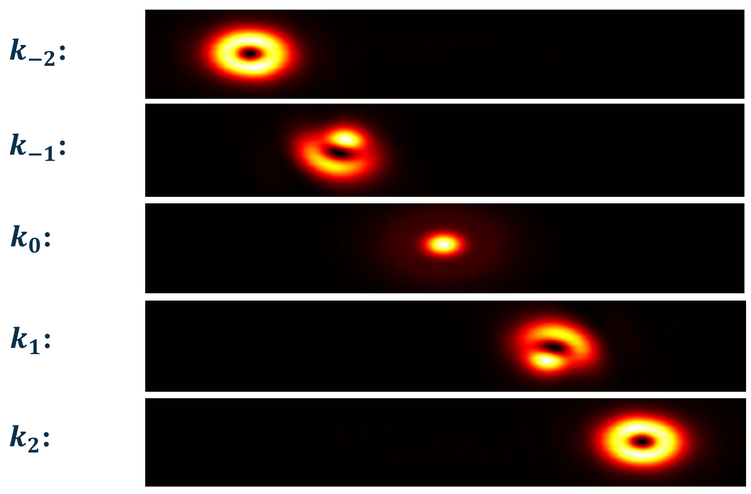
Prospective work: more control with 2 SLMs



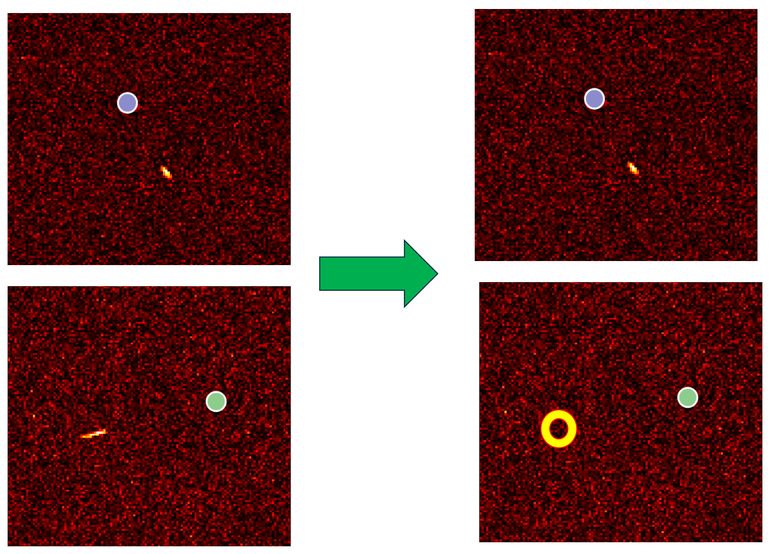
- **Classical analogue: k-dependent shaping**

Input with wavevector k → Imaging System → Output image dependent on input k

- **Simulated example:**



- **Goal - spatially varying conditional images:**



References

Intensity correlation imaging with an EMCCD camera:

P-A. Moreau, J. Mougin-Sisini, F. Devaux and E.Lantz, PRA 86, 010101 (2012)

M.P. Edgar, D.S.Tasca, F. Izbedski, R.E. Warburton, J. Leach, M. Agnew, G.S.Buller, R.W.Boyd and M.J. Padgett. Nat. Comm. 3, 984 (2012)

H.Defienne, M.Reichert and J.W.Fleischer, PRL 120, 203604 (2018)

Imaging Applications:

Defienne, H., Reichert, M., Fleischer, J.W., Faccio, D. SciAdv 5(10) (2019)

Defienne, H., Ndagano, B., Lyons, A. *et al.* Nat. Phys. 17, 591–597 (2021).

Potential Applications

- **Quantum imaging with 2-photon PSF engineering**
- **Sensing non-linear optical effects with shaped correlations**