

Optical sensing based on chaotic light multiphoton interference

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Bari Theory Xmas Workshop, University of Bari, 22.12.2016

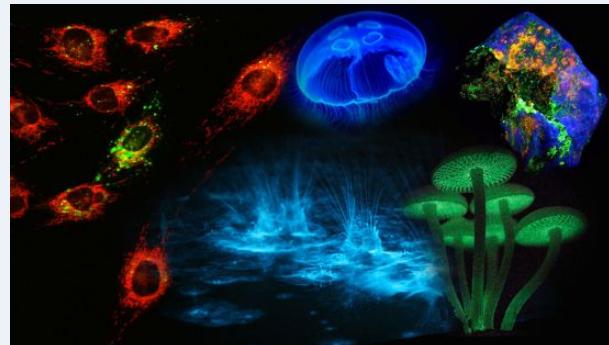
Multiphoton Interference

Metrology

- High-precision Sensing

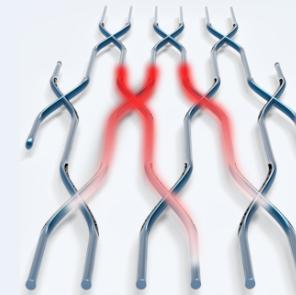


- Super-resolution Imaging



Information Processing

- Ultrafast Computing



- Secure Communications



Outline

- Interference between pairs of disjoint optical paths with a single chaotic source
- Monitoring relative phases between distant locations
- Spatial characterization of remote double slits: theory and experiment

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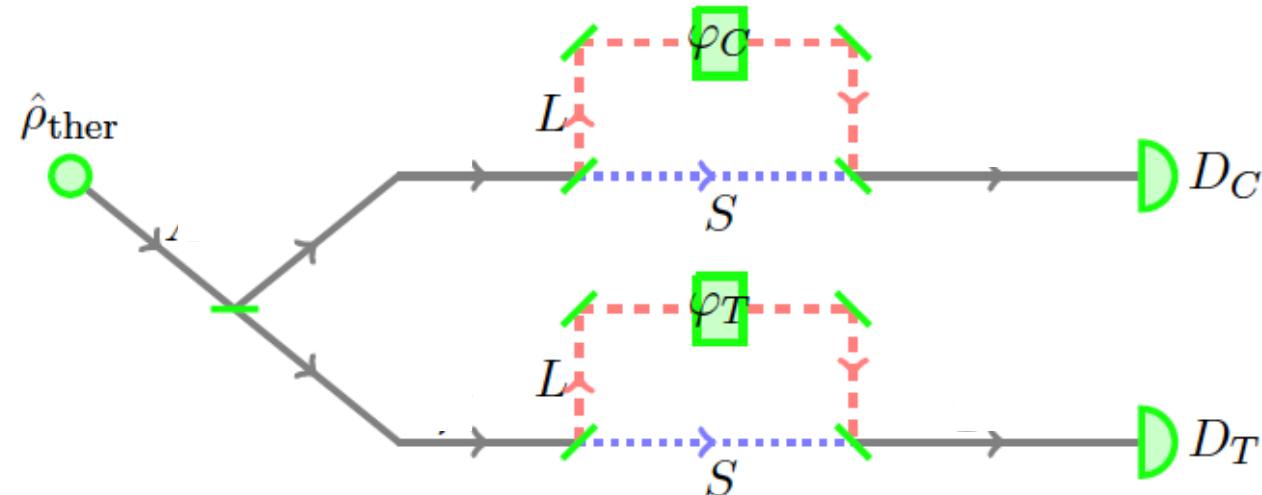
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FAST TRACK COMMUNICATION

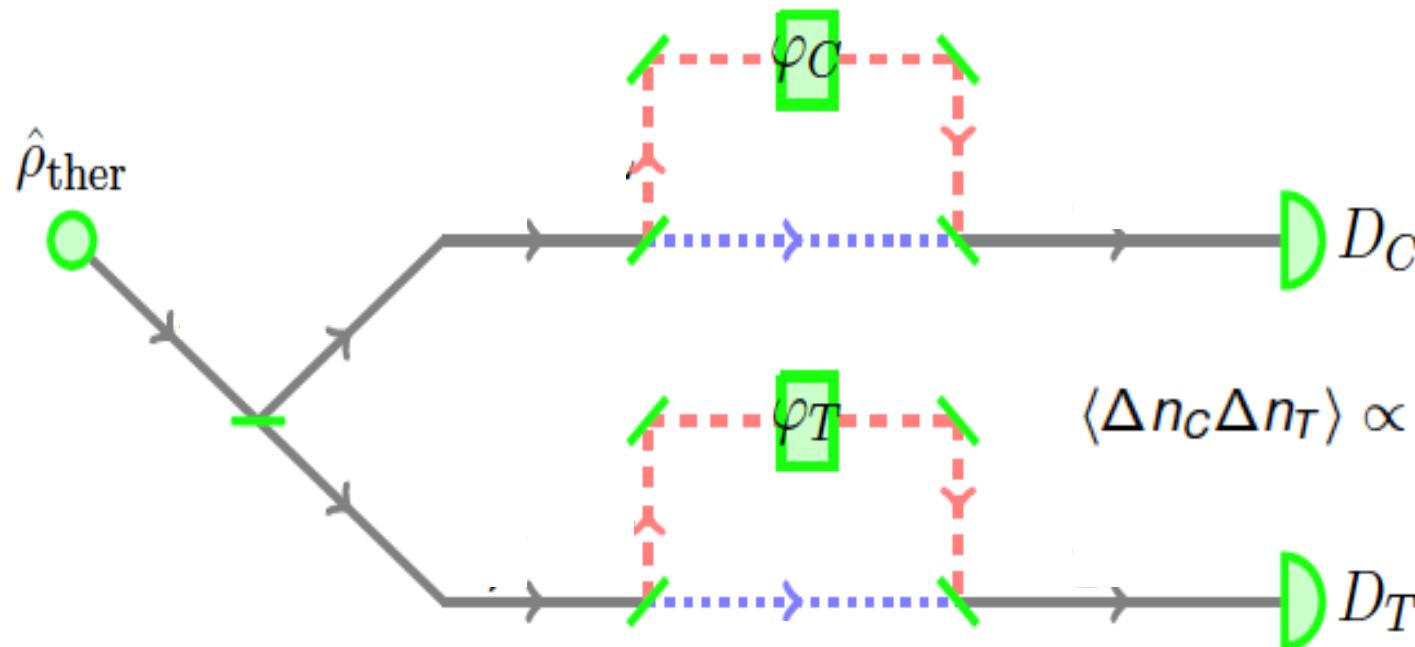
Multipath correlation interference and controlled-NOT gate simulation with a thermal source

Vincenzo Tamma¹ and Johannes Seiler

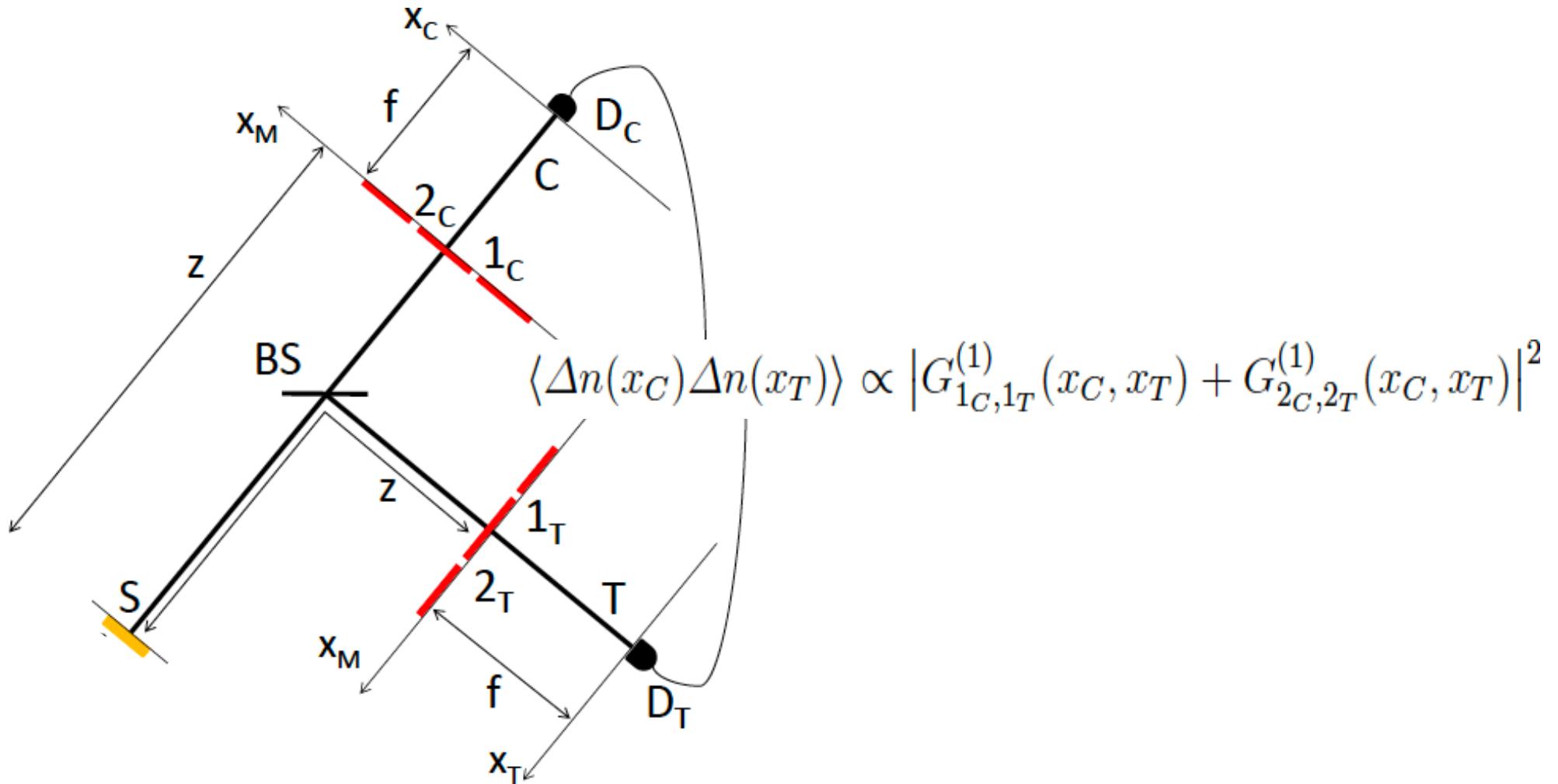


$$\langle \Delta n_C \Delta n_T \rangle \propto |G^{(L_C, L_T)}(t_C, t_T) + G^{(S_C, S_T)}(t_C, t_T)|^2$$

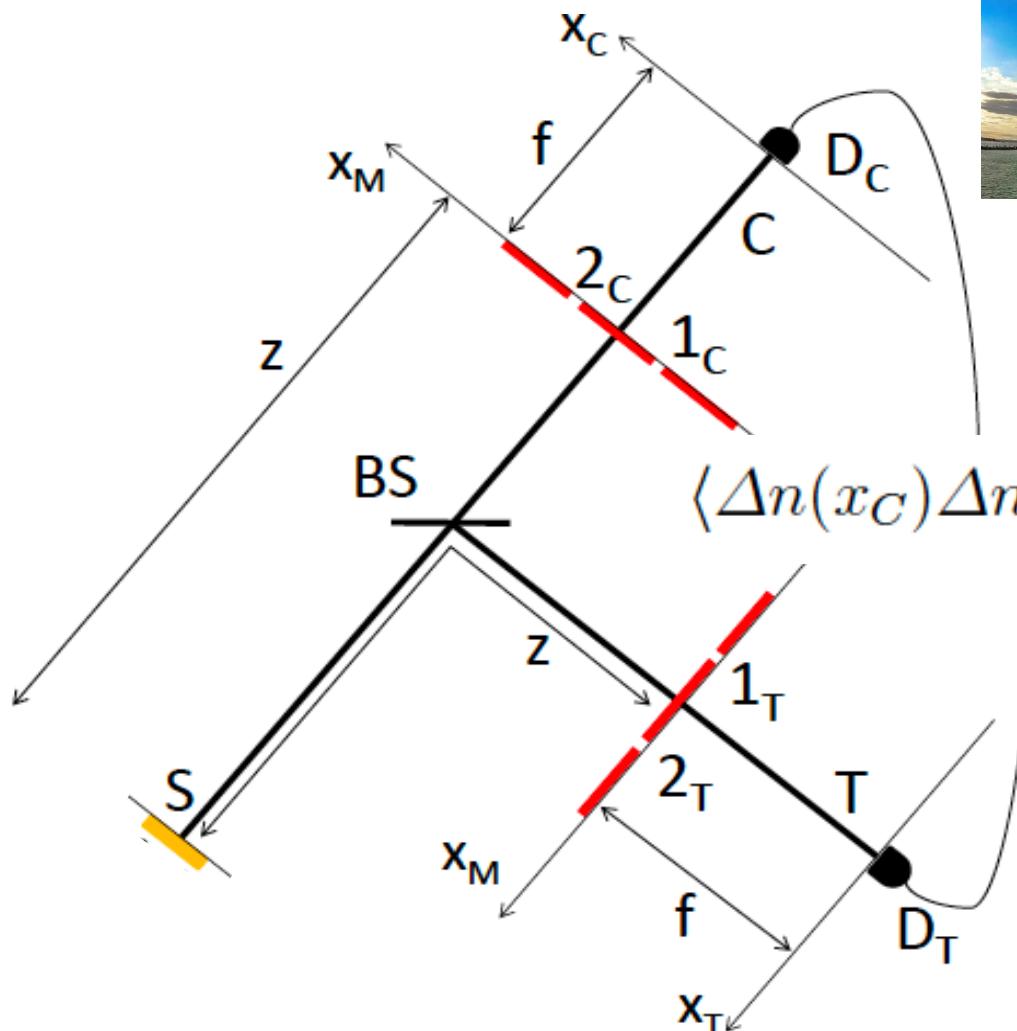
Monitoring relative phases between distant locations



Spatial interference between pairs of optical paths



Spatial characterization of remote double slits

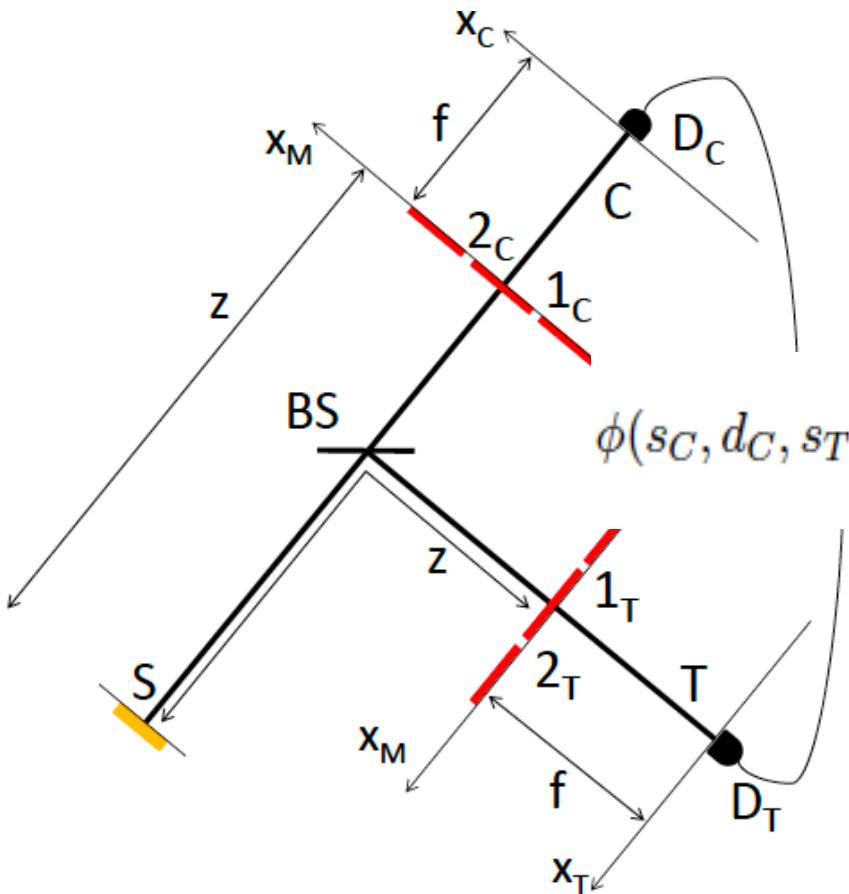


$$\langle \Delta n(x_C) \Delta n(x_T) \rangle \propto |1 + e^{i\phi(s_C, d_C, s_T, d_T, x_C, x_T)}|^2$$



$$\phi(s_C, d_C, s_T, d_T, x_C, x_T) = \frac{2\pi}{\lambda} \left(\frac{s_T d_T - s_C d_C}{f} - \frac{x_T d_T - x_C d_C}{f} \right)$$

Monitoring variations in the spatial structure and position of two masks

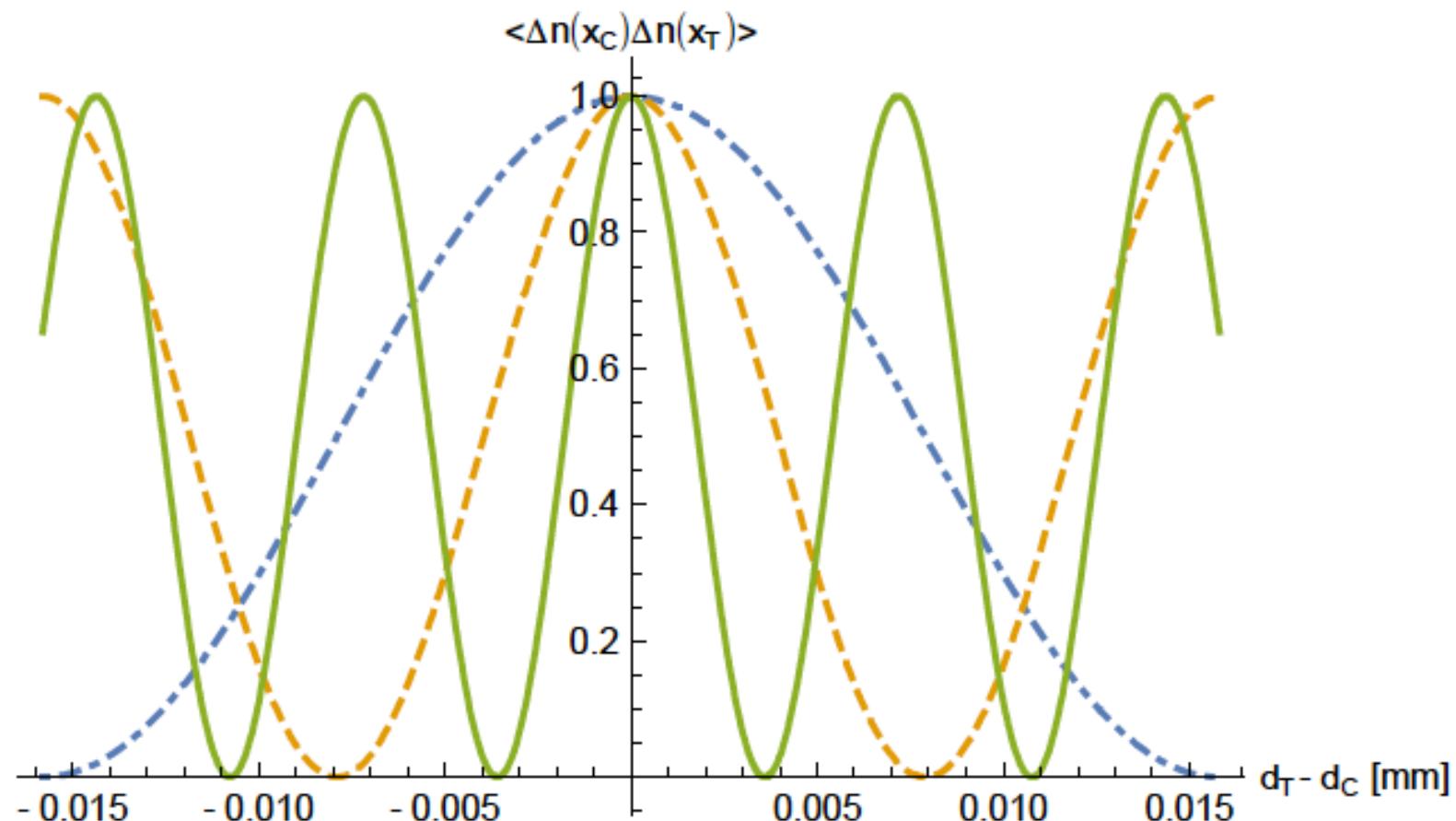


$$\phi(s_C, d_C, s_T, d_T, x_C, x_T) = \frac{2\pi}{\lambda} \left(\frac{s_T d_T - s_C d_C}{f} - \frac{x_T d_T - x_C d_C}{f} \right)$$

Experimental conditions	Variable parameter to monitor	Sensitivity enhancement
(1) $x_T = x_C, s_T = s_C$	$d_T - d_C$	$s_C/f - x_C/f$
(2) $x_T = -x_C, s_T = -s_C$	$d_T + d_C$	$-s_C/f + x_C/f$
(3) $d_T = d_C$	$s_T - s_C$	d_C/f

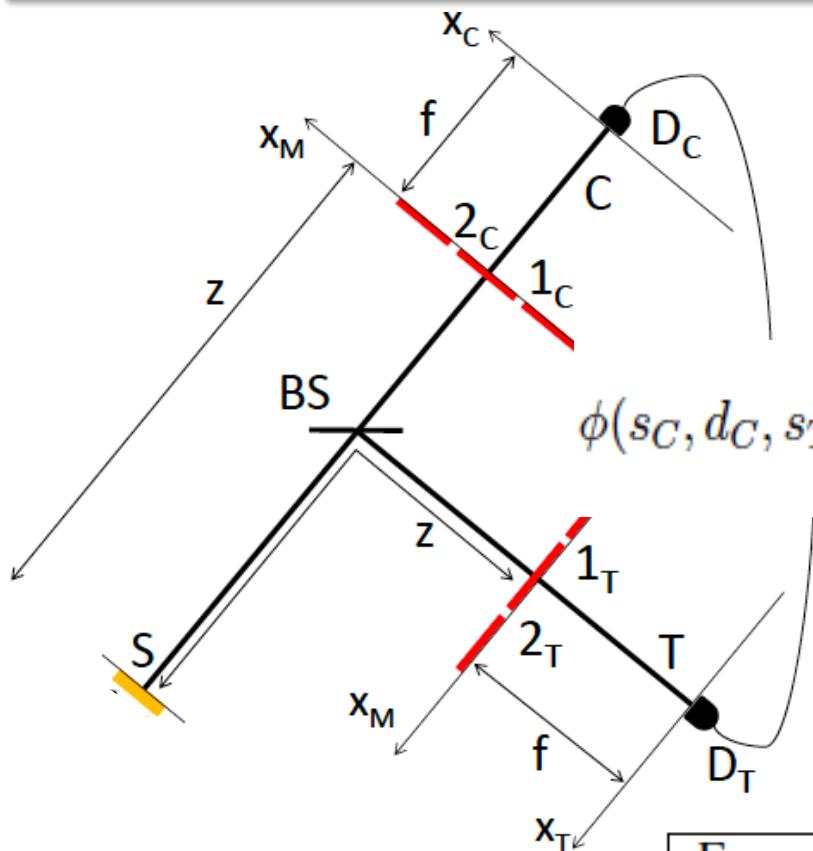
Stretching/shrinking of one mask with respect to the other

Experimental conditions	Variable parameter to monitor	Sensitivity enhancement
(1) $x_T = x_C, s_T = s_C$	$d_T - d_C$	$s_C / f - x_C / f$



- $s_C = s_T = 0, x_C = x_T = 0.02 f$
- $s_C = s_T = 0, x_C = x_T = 0.04 f$
- $s_C = s_T = -0.04 h, x_C = x_T = 0.04 f$

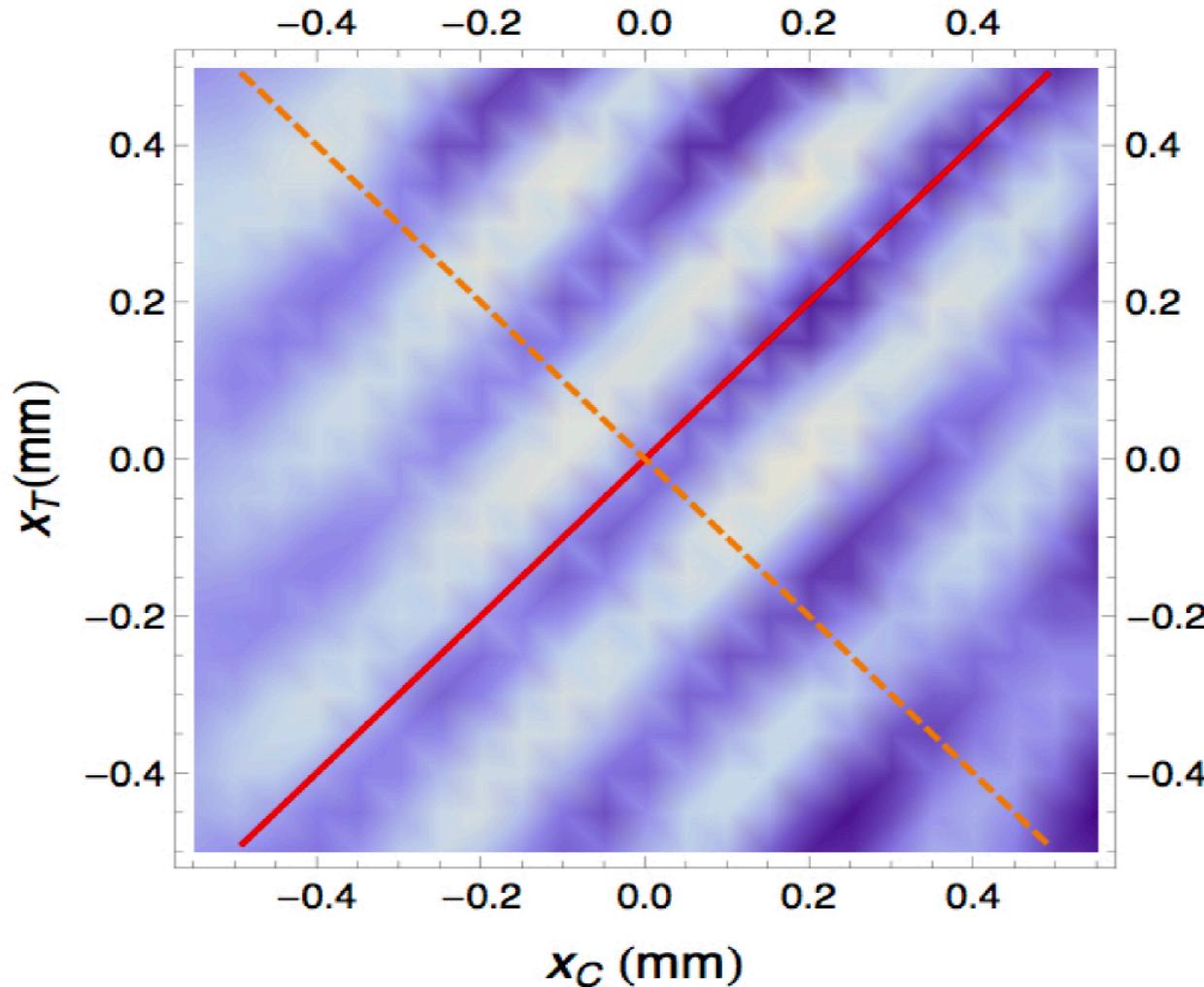
Indirect measurement of the position and spatial structure of the two masks



$$\phi(s_C, d_C, s_T, d_T, x_C, x_T) = \frac{2\pi}{\lambda} \left(\frac{s_T d_T - s_C d_C}{f} - \frac{x_T d_T - x_C d_C}{f} \right)$$

Experimental conditions	Experimental variable	Period of the interference pattern $\langle \Delta n(x_C) \Delta n(x_T) \rangle$
(1) $x_T = x_C$	x_C	$\lambda f / (d_C - d_T)$
(2) $x_T = -x_C$	x_C	$\lambda f / (d_T + d_C)$

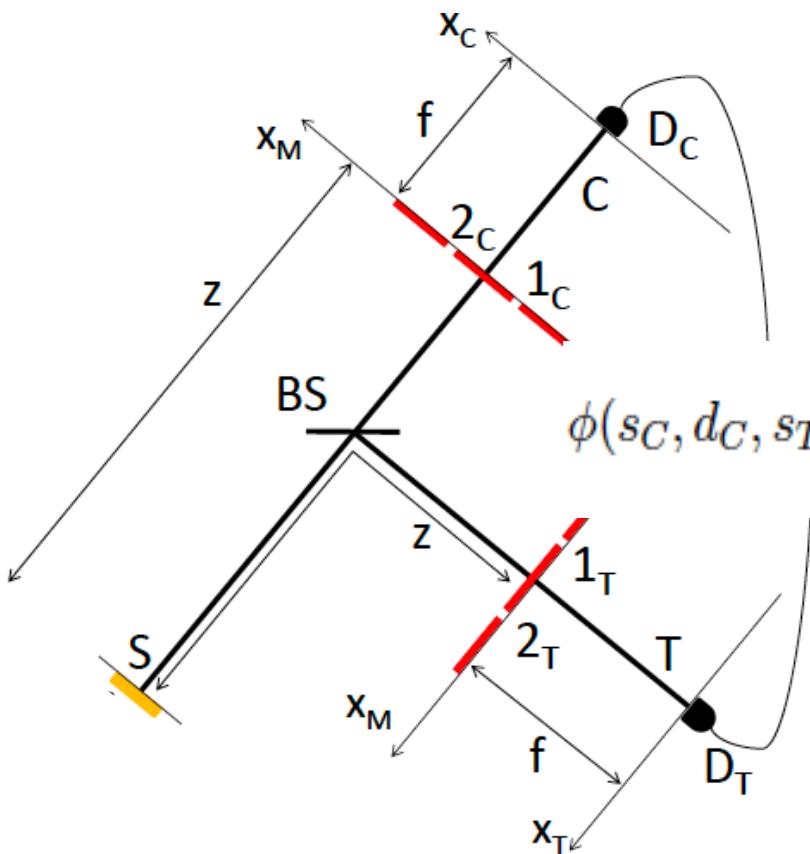
Experimental demonstration



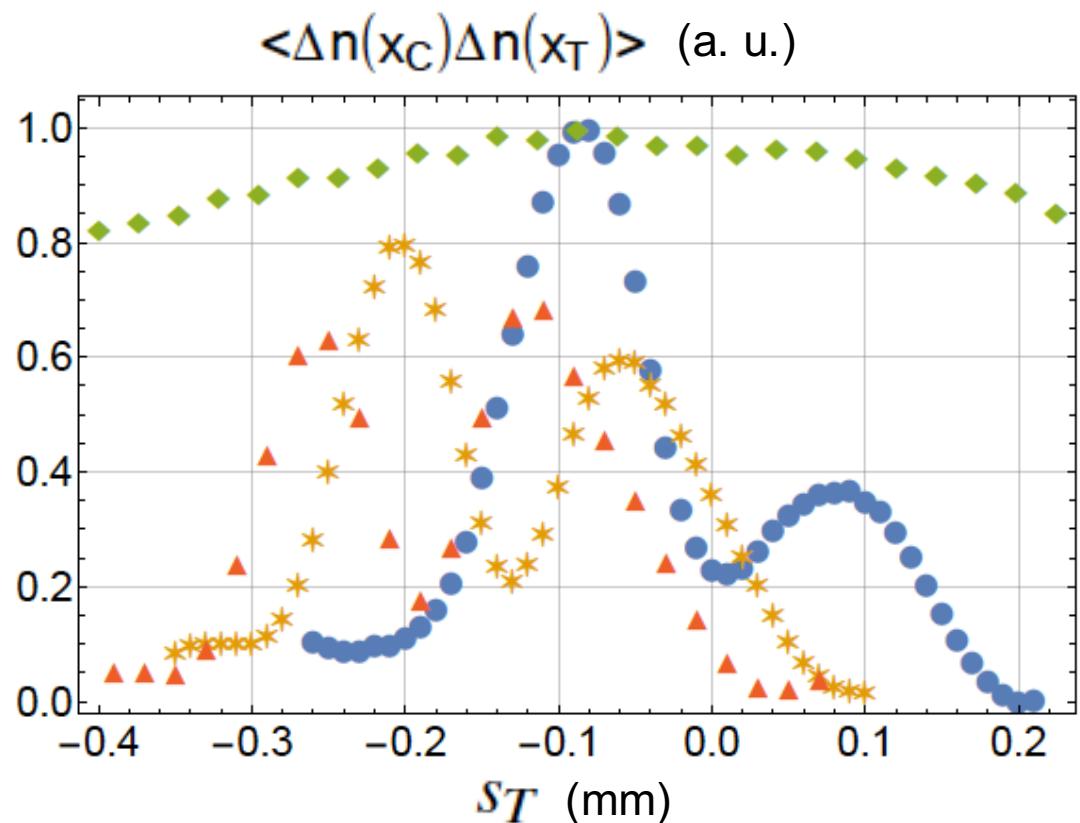
M. D'Angelo, A. Mazzilli,
F. V. Pepe, A. Garuccio,
and V. Tamma,
arXiv:1609.03416 (2016)

Experimental conditions	Experimental variable	Period of the interference pattern $\langle \Delta n(x_C) \Delta n(x_T) \rangle$
(1) $x_T = x_C$	x_C	$\lambda f / (\textcolor{red}{d}_C - d_T)$
(2) $x_T = -x_C$	x_C	$\lambda f / (\textcolor{red}{d}_T + d_C)$

Monitoring one mask's position while the other is fixed

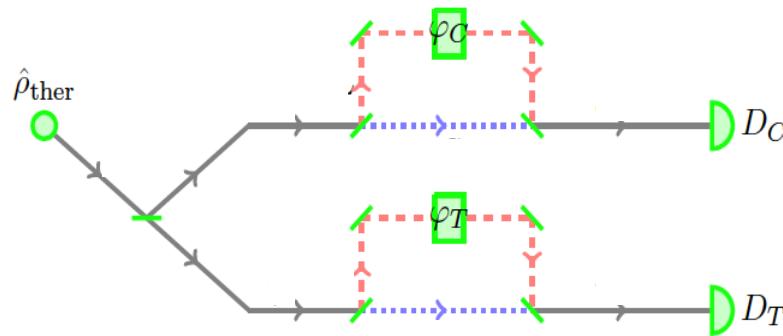


$$\phi(s_C, d_C, s_T, d_T, x_C, x_T) = \frac{2\pi}{\lambda} \left(\frac{s_T d_T - s_C d_C}{f} - \frac{x_T d_T - x_C d_C}{f} \right)$$



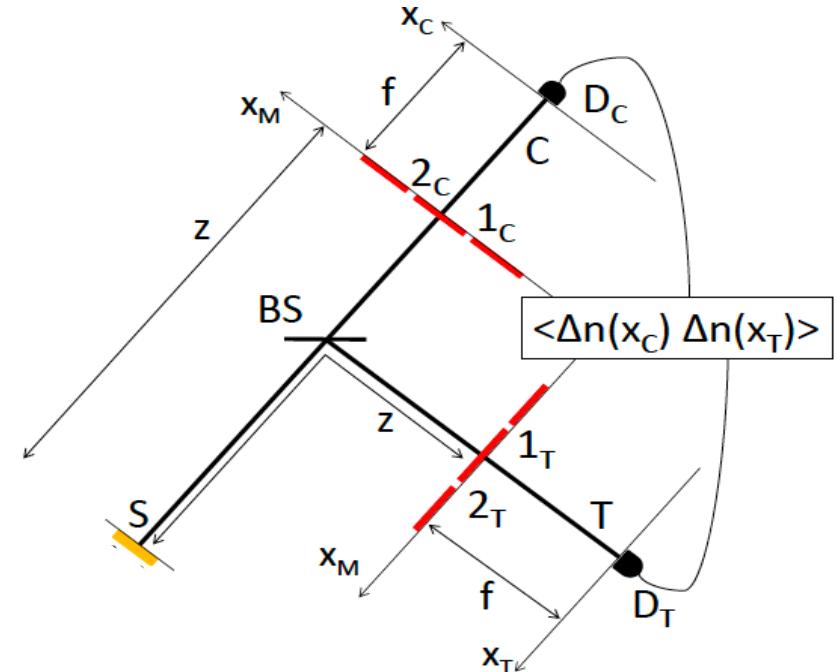
Summary

- Monitoring relative phases between distant locations



V. Tamma and J. Seiler, NJP **18** 032002 (2016)

- Spatial characterization of remote double slits



M. Cassano, M. D'Angelo, A. Garuccio, T. Peng, Y. Shih, V. Tamma, arXiv:1601.05045 (2016)
M. D'Angelo, A. Mazzilli, F. V. Pepe, A. Garuccio, and V. Tamma, arXiv:1609.03416 (2016)

- Further application: Simulations of Quantum Logic Gates

V. Tamma and J. Seiler, NJP **18** 032002 (2016)

T. Peng, V. Tamma, and Y.H. Shih, Scientific Reports **6**, 30152 (2016)

M. Cassano, M. D'Angelo, A. Garuccio, T. Peng, Y. Shih, V. Tamma, arXiv:1601.05045 (2016)

Buon Natale !