Centre de Nanosciences & de Nanotechnologies

C2N Seminar

Wednesday October 27th - 15h00

(A005-A007)

“Quantum imaging with entangled photons”

Dr. Hugo Defienne

University of Glasgow, United Kingdom

Quantum imaging harnesses quantum properties of light and their interaction with the environment to go beyond the limits of classical imaging or to implement unique imaging modalities. In conventional quantum imaging systems, a non-classical state of light illuminates an object from which an image is formed on a set of photodetectors. In this respect, sources of entangled photon pairs are very prolific. Over the last decades, they have been used to achieve super-resolution [1] and sub-shot-noise imaging [2], as well as to develop new imaging approaches such as ghost imaging [3], quantum illumination [4] and quantum holography [5].

However, most of these experimental schemes require to measure intensity correlations between many spatial positions in parallel, a task that is much more delicate than forming an image by photon accumulation. Originally, this was performed using raster-scanning single-pixel single-photon detectors, but this process is very photon inefficient and time-consuming. In recent years, these systems were substituted by single-photon sensitive cameras, such as electron multiplied charge coupled device (EMCCD), to achieve faster quantum imaging with photon pairs and move this field closer to practical applications [6,7].

In this presentation, I will detail the technique that we have developed to image entangled photon pairs using cameras. I will then describe some specific approaches that were implemented thanks to this novel imaging ability, including quantum image distillation [4] and entanglement-enabled quantum holography [5]. Finally, I will discuss the perspectives and general interest of developing quantum imaging system based on entangled photon pairs.

[1] Boto, Agedi N., et al. "Quantum interferometric optical lithography: exploiting entanglement to beat the diffraction limit." *Physical Review Letters* 85.13 (2000): 2733.
[2] Brida, Giorgio, Marco Genovese, and I. Ruo Berchera. "Experimental realization of sub-shot-noise quantum imaging." *Nature Photonics* 4.4 (2010): 227-230.
[3] Pittman, Todd B., et al. "Optical imaging by means of two-photon quantum entanglement." *Physical Review A* 52.5 (1995): R3429.
[4] Defienne, Hugo, et al. "Quantum image distillation." *Science advances* 5.10 (2019): eaax0307.
[5] Defienne, Hugo, et al. "Polarization entanglement-enabled quantum holography." *Nature Physics 17, 591-597 (2021).*
[6] Moreau, Paul-Antoine, et al. "Realization of the purely spatial Einstein-Podolsky-Rosen paradox in full-field images of spontaneous parametric down-conversion." *Physical Review A* 86.1 (2012): 010101.
[7] Edgar, Matthew P., et al. "Imaging high-dimensional spatial entanglement with a camera." *Nature communications* 3.1 (2012): 1-6.