Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **661** Type: **Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)**

(G*) Super-resolution Ghost-Imaging

Tuesday 8 June 2021 17:14 (7 minutes)

In microscopy, the imaging of light-sensitive materials has been a persistent problem, as the sample being studied may be altered or damaged by the illumination itself. Naturally, to overcome over-illuminating the sample, one can reduce the intensity of the classical light source; however, reducing the source intensity comes with a trade-off which affects noise and image quality. In recent years, it has been shown that using quantum illumination as a source for imaging schemes significantly reduces photon illumination of the sample while maintaining image quality. In fact, in our previous work [1] we combine two quantum imaging and detection schemes in a technique coined "Interaction-free-ghost-imaging"and achieve results with low photon number and high contrast images.

A further limitation of all direct imaging schemes, whether they be quantum or classical, is the so-called diffraction limit. When measuring intensity directly, the maximal resolution is dictated by the size of optical apertures in the imaging system. Recent results [2] [3] have shown that performing phase-sensitive measurements, as opposed to intensity measurements, could increase resolution by several orders of magnitude.

We propose an experiment implementing the super-resolution technique in a quantum ghost-imaging scheme. We aim to show that the added benefits of low photon counts along with increased resolution show promise for imaging small light-sensitive objects such as biological cells, and further challenges the notion of how many photons are needed to form a visible image.

[1] Zhang,Y., Sit, A., Bouchard, F., Larocque, H., Grenapin, F., Cohen, E., Elitzur, A., Harden, J. Boyd,R., Karimi, E, "Interaction-free-ghost-imaging of structured objects", Optics Express 27, 2212-2224 (2019).

[2] Tsang, M., Nair, R., Lu X, "Quantum Theory of Superresolution for two Incoherent Optical Point Sources" , Physical Review X 6, 031033 (2016).

[3] Tham, W., Ferretti, H., Steinberg, A, "Beating Rayeigh's curse by Imaging Using Phase", Physical Review Letters 118, 070801 (2017).

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Session Classification: TS-7 Sensors and Metrology Symposium (NRC) / Symposium sur les capteurs et la métrologie (CNRC)

Track Classification: Symposium Day (NRC) - Physics for the next generation of sensors and metrology (NRC)