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High-Resolution Low-Radiation Ghost Imaging with an Incoherent X-ray Source

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Abstract

The groundbreaking experiments of Hanbury Brown and Twiss laid the foundations of quantum optics, which then led the way to the development of quantum information science. In another direction, "ghost" imaging based on second-order correlation has expanded into the classical domain with widespread practical applications in many fields wherever imaging is required. Our recent results in high-resolution ghost imaging with an incoherent x-ray source promise a new direction for radically reducing the radiation dosage in medical diagnosis and other biological studies, possibly down to single-photon levels.

The groundbreaking experiments of Hanbury Brown and Twiss in the fifties laid the foundations of quantum optics, which then led the way to the development of quantum information science in many other fields apart from optics. In another direction, quantum inspired "ghost" imaging (GI) has expanded into the classical domain over various spectral ranges with practical tangible applications on the horizon, while GI with atoms [1] and electrons [2] has even been demonstrated.

In the x-ray regime, GI was first performed with synchrotron radiation, requiring a monochromator and other complicated equipment, with an object consisting of one-dimensional slits [3,4]. Recently, we demonstrated x-ray GI with a very simple table-top setup using an ordinary incoherent x-ray source, and obtained images of planar and natural biological objects [5]. Moreover, the reconstructed images had a much higher contrast-to-noise ratio compared to traditional projection x-ray imaging for the same low radiation dose per unit pixel on the CCD detector. We have now realized ultra-low radiation computational GI with a true bucket detector; a resolution of 10 μm has been achieved for an x-ray tube source of size 37 μm, breaking the resolution limit of incoherent x-ray imaging.

Since reducing radiation dose is of paramount importance, it is envisaged that our x-ray GI scheme will find wide application in medical diagnosis and analysis of biological specimens in general. We hope that, with improved detectors, we can even lower the incident radiation to the single-photon level.

[1] R. I. Khakimov, B. M. Henson, D. K. Shin, S. S. Hodgman, R. G. Dall, K. G. H. Baldwin, and A. G. Truscott, *Ghost imaging with atoms*" Nature **540**, 100 (2016).
[2] S. Li, F. Cropp, K. Kabra, T.J. Lane, G. Wetzstein, P. Musumeci, and D. Ratner, *Electron Ghost Imaging*, Phys. Rev. Lett. **121,** 1–5 (2018).
[3] H. Yu, R. Lu, S. Han, H. Xie, G. Du, T. Xiao, and D. Zhu, *Fourier-Transform Ghost Imaging with Hard X Rays*, Phys. Rev. Lett. **117**, 113901 (2016).
[4] D. Pelliccia, A. Rack, M. Scheel, V. Cantelli, and D. M. Paganin, *Experimental X-Ray Ghost Imaging*, Phys. Rev. Lett. **117**, 113902 (2016).
[5] A.-X. Zhang, Y.-H. He, L.-A. Wu, L.-M. Chen, and B.-B. Wang, *Table-top x-ray ghost imaging with ultra-low radiation*, Optica 5, 374 (2018).