Quantum strategies for super-resolution microscopy

The Quantum Information Science group at the University of Warwick is seeking a PhD student starting October 2017 in the area of quantum enhanced imaging. This is a theoretical project funded by QUANTIC (UK National Quantum Technology Hub in Quantum Enhanced Imaging). By exploring possibilities of modifying source and/or detector characteristics, the project aims to design microscopy schemes with resolution not limited by Rayleigh’s criterion.

Background: Rayleigh’s criterion forbids the resolution of two point sources of light in microscopy below a certain limit determined by the wavelength of light. This limit is however a consequence of implicitly assuming incoherent thermal sources and direct intensity detection.

Project: The methodology will rely on combining concepts from classical and quantum optics with ideas from quantum metrology to overcome Rayleigh’s limit. Tools from quantum metrology such as the quantum and classical Cramer-Rao bound are now standard in the quantitative analysis of microscopy systems [1], and will be central to this project. The project will extend prior results on the simultaneous estimation of multiple parameters using coherent light [2] to incoherent or partially coherent sources. It will exploit recent results in multi-parameter quantum metrology [3] to minimise perturbations in samples, a vital issue in biomedical imaging. This should enable tackling of a ubiquitous challenge in microscopy - resolution of multiple point sources in 2 and 3 dimensions. The project will advance the field of optical microscopy, seeking optimal optical (quantum, classical or mixtures thereof) states for active super-resolution quantum imaging of multiple sources.

While the project is theoretical, a goal of the project shall be to produce feasible microscope designs that can demonstrate sub-Rayleigh imaging. To that end, the project will involve interactions with experimental groups in microscope design and classical and quantum optics in Warwick and elsewhere in the UK, especially within the QUANTIC hub. International collaborations in the areas of optical microscopy and quantum optics will also be a part of the project.

Interested students should have a strong background in mathematics and theoretical quantum mechanics and classical optics. Familiarity with quantum information theory and quantum optics would be beneficial.

For informal queries, please contact animesh.datta@warwick.ac.uk with a CV and statement of interest.

References: