Quantum light spectroscopy of complex quantum systems

A PhD position is available in the quantum information science group of Animesh Datta at the University of Warwick. The theoretical PhD project will develop schemes for spectroscopy of complex quantum systems using quantum states of light. It will exploit the tools of quantum metrology for precisely estimating parameters of quantum matter systems coupled to quantum and classical environments. Instances include the estimation of parameters such as transition energies, dipole moments, and coupling strengths of molecules in natural or artificial environments. Emphasis will be placed on the experimental feasibility of these schemes.

The student must be interested in a close interplay of quantum mechanics, quantum optics, and open quantum systems with quantum metrology and quantum information science.

Background: The laws of quantum mechanics set the fundamental limit of precision sensing. Quantum metrology is the study of these fundamental limits and the design of experimental schemes of attaining them. It uses ideas from quantum information science and is ushering in a new era of quantum-enhanced sensing.

Project: This PhD project shall leverage the concepts and developments underlying recent advances in quantum-enhanced sensing [1]. It will apply quantum metrology to probing molecular systems, and their performance in the real-world using quantum states of light such as Fock, squeezed, and entangled states. Each one of these probe states possess features that make them ideal for specific tasks – such as estimating electric dipole moments in molecular systems.

This project shall advance recent results from Warwick on quantum-enhanced spectroscopy [2,3]. Its outcomes will also have applications in designing the next generation of quantum-enhanced spectroscopy using quantum entanglement [4] as well as the theory and practice of quantum light-matter interactions more generally. The latter is also central to the development of quantum communication and computation.

A close interaction between theory and experimental systems will place the student in a uniquely beneficial position for a future in physics and the quantum technologies market. The interaction with premier scientific projects (such as the EU Quantum Flagship project MIRAQLS) and within Warwick will provide the student a privileged perspective on quantum sensing and metrology in an international setting, unavailable in the UK or elsewhere.

For informal enquires, email Animesh Datta with a CV explaining your excellence and suitability for the project.

1. Magdalena Szczykulska, Tillmann Baumgratz, Animesh Datta, Multi-parameter quantum metrology, Advances in Physics: X **1**, 621 (2016)
2. Francesco Albarelli, Evangelia Bisketzi, Aiman Khan, Animesh Datta, Fundamental limits of pulsed quantum light spectroscopy: Dipole moment estimation, Phys. Rev. A **107**, 062601 (2023)
3. Elnaz Darsheshdar, Aiman Khan, Francesco Albarelli, Animesh Datta, On the role of chirping in pulsed single photon spectroscopy, Phys. Rev. A **110**, 043710 (2024)
4. Aiman Khan, Francesco Albarelli, Animesh Datta, Does entanglement enhance single-molecule pulsed biphoton spectroscopy? Quantum Science and Technology **9**, 035004 (2024)