Quantum sensing of multiple parameters

We are looking for a post-graduate student to join the quantum information science group of Animesh Datta at the University of Warwick. This theoretical project will produce the design principles for quantum sensors that sense multiple parameters simultaneously. These range from fundamental open problems in physics such as the direct detection of dark matter and testing the validity of quantum mechanics in macroscopic systems to spectroscopy of complex quantum systems such as light-harvesting complexes. The principle underlying all of these quests is the precise sensing of physical quantities such as exquisitely small forces, phases, or temperature.

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

Background: The laws of quantum mechanics set the fundamental limit of precision sensing. Quantum metrology is the study and application of these fundamental limits. Non-commutativity in quantum mechanics introduces non-trivial challenges in sensing multiple parameters with quantum-limited and quantum-enhanced precision simultaneously.

Project: This project will leverage new results from our group to invent new routes to quantum sensing of multiple parameters. These include advances in multi-parameter [1,4] and multi-mode [2] quantum metrology. It will apply quantum metrology to atomic, molecular, and opto-mechanical system and gauge their performance in the real world. Each of these systems posses features that make them ideal for specific open problems. For instance, opto-mechanical systems with massive objects in quantum superpositions are ideal for testing the validity of quantum mechanics in macroscopic systems.

An aim of the project is to advance recent results from Warwick [3] towards experimental systems that can be realized in the coming years. The outcomes of this project will also have applications in designing the next generation of quantum-enhanced interferometry, spectroscopy, and magnetometry.

A close interaction between theory and experimental systems will place the student in a uniquely beneficial position for a future in fundamental physics and the quantum technologies market. The interaction with premier scientific missions will provide the student a privileged perspective on quantum sensing and metrology in a complementary setting, unavailable to any other in the UK or elsewhere.

1. Magdalena Szczykulska, Tillmann Baumgratz, Animesh Datta, *Multi-parameter quantum metrology*, arXiv:1604.02615
2. Dominic Branford, Haixing Miao, Animesh Datta, *Fundamental Quantum Limits of Multicarrier Optomechanical Sensors*, Phys. Rev. Lett. 121, 110505 (2018)
3. Dominic Branford, Christos Gagatsos, Animesh Datta, *Quantum enhanced estimation of diffusion* *Phys. Rev. A* ***100*** *022129 (2019)*
4. Francesco Albarelli, Jamie F. Friel, Animesh Datta, *Evaluating the Holevo Cramér-Rao bound for multi-parameter quantum metrology, arXiv:1906.05724 (Accepted in Physical Review Letters)*