Quantum sensors for fundamental physics

We are looking for a post-graduate student to join the quantum information science group of Animesh Datta at the University of Warwick. The goals of this theoretical project are to produce the design principles for quantum sensors that can tackle some of the most fundamental open problems in physics. Instances include the direct detection of dark matter, testing the validity of quantum mechanics in macroscopic systems, searching for time variation of fundamental constants, and the direct detection of gravitational waves from exotic sources. The principle underlying all of these quests is the precise sensing of physical observables such as exquisitely small forces, phases, displacements and 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. Quantum metrology, using ideas from quantum information science, is ushering in a new era of precision sensing. This spans the sensing of time, position, force, magnetic and electric fields, temperature and many other physical parameters with unprecedented precision.

Project: This PhD project shall leverage the concepts and development underlying these recent advances such as multi-parameter [1] and multi-mode [2] quantum metrology to invent new routes for attacking open problems in fundamental physics. It will apply quantum metrology to physical systems such as atomic, optical, and opto-mechanical interferometers, and their performance in the real world. Each one of these systems possesses 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 imaging, magnetometry, and time keeping.

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,* In preparation.