Property testing for quantum engineering

We seek a post-graduate (PhD) student to join the quantum information science group of Animesh Datta at the University of Warwick.

The theoretical project will develop algorithms that answer the question: "Given an engineered quantum system, does it have the properties necessary to perform fault-tolerant quantum computation, or is it far from having them?" Methods of property testing from theoretical computer science will be used. Particular emphasis will be placed on minimising the space and time complexity of these schemes.

The student must be interested in a close interplay of quantum computation, information, and theoretical computer science.

Background: The laws of quantum mechanics promise more efficient solutions to certain classes of problems such as integer factoring and quantum simulation. This requires a fault-tolerant quantum computer (FTQC). While the properties required for a FTQC are known mathematically [1, page 497], achieving them in real-world, engineered systems remains challenging. One reason is that describing a quantum computer operating of n quantum bits (qubits) typically requires 4^n numbers. Once such a system is engineered, how can we decide if it can be used to build a FTQC?

Project: This PhD project will develop ultra-fast property testing algorithms [2] to answer this question. It will thus remove a severe bottleneck in the development of FTQCs by avoiding the present prohibitively expensive, time-consuming, and itself error prone testing regimen of measuring and processing exponentially many numbers to make a decision. This should accelerate the development of FTQCs and facilitate greater advances in quantum engineering and technologies more generally.

Another aim of this project is to advance recent results from Warwick on quantum accreditation [3,4]. Quantum accreditation is a practical and scalable method of ascertaining the correctness of the outputs of arbitrary-sized noisy quantum computers—the ultimate arbiter of the utility of the computer itself. Like FTQC, quantum accreditation relies on mathematical assumptions on the nature of the noise in the quantum computer and must be validated in real-world systems.

A close interaction between physics and theoretical computer science will place the student in a uniquely beneficial position for a future in physics, computer science, and the quantum technologies market.

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

1. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, 2000.
2. A. Montanaro and R. de Wolf, *A Survey of Quantum Property Testing*, Theory of Computing Graduate Surveys 7, 1 (2016).
3. S. Ferracin, T. Kapourniotis, and A. Datta, *Accrediting outputs of noisy intermediate-scale quantum computing devices,* New Journal of Physics **21**, 113038 (2019).
4. S. Ferracin, S. T. Merkel, D. McKay, and A. Datta, *Experimental accreditation of outputs of noisy quantum computers,* Physical Review A **104** (2021).