PhD Position: Optimal control of quantum systems

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An optimal control problem consists in bringing a physical system from one state to another to a given accuracy with minimum expenditure of time and resources. Originally developed in 1960s to facilitate engineering work and famously applied to minimize fuel consumption during the landing of Apollo lunar modules, optimal control theory has evolved and expanded with the rest of physics – it is presently found in areas as diverse as optical spectroscopy, photochemistry, magnetic resonance, spin dynamics and quantum engineering.

As the human society evolved to be more responsible, the requirement for energy efficiency and optimal utilization of resources has become more stringent. This happened not just with fuel consumption, resource conservation and other matters of general public concern, but also in fundamental physics, where experimentalists are facing steep instrumental challenges with finite time and energy budgets. This is particularly true for quantum engineering – an extremely demanding area where a single fundamental particle must often be steered individually, with high precision and virtually no dissipation. The recent successes of optimal control theory are well documented and include highly accurate NMR / EPR pulses, error-tolerant atom chips and highly efficient dynamic nuclear polarization protocols. In all cases the theoretical modelling of the control process is critical for the success of the optimization procedure.

Objective of this project is to improve the performance of current Optimal Control algorithms and apply them to magnetic resonance (NMR, EPR and DNP) as well as other quantum dynamics processes. The current algorithms are very computationally demanding, but our preliminary work indicates that massive acceleration is possible that would lead to a major improvement in usability and applicability of quantum optimal control procedures. Our current experience also indicates that dramatic improvements are possible in the core NMR, EPR and MRI methodology if the traditional experimental protocols are replaced with optimal control ones.

This project is a part of the iMR CDT Doctoral Training Programme that provides high-level training courses, industry internship opportunities, conference and collaboration travel funds, high-performance workstations as well as research networking opportunities within the six participating UK universities.

Further information on this project is available at http://spindynamics.org

For further information about applying contact Ilya Kuprov (i.kuprov@soton.ac.uk) or iMR.CDT@warwick.ac.uk.

The Centre for Doctoral Training in Integrated Magnetic Resonance is a collaboration between researchers at the Universities of Warwick, St Andrews, Dundee, Southampton, Aberdeen and Nottingham.