Superconducting quantum circuits for high-sensitivity magnetic resonance

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Project Summary:

Electron spin resonance has already had widespread impacts on our society, from helping to understand fundamental process in semiconductors that underpin the modern computer, to unravelling mysteries in the mechanisms of enzymes underpinning disease or bioinspired technology. More exciting applications can be unlocked by developing more sensitive spin resonance instruments. This PhD topic takes advances in the field of quantum technologies and superconducting circuits and applies them to electron spin resonance (ESR) to redefine the state-of-the-art in instrumentation and methodology.

Through application-specific microwave resonators, amplifiers and control systems the project has the potential to show order-of magnitude advances in sensitivity. It will apply these methods to spin systems that are of wide application and interest, with the possibility to take ESR to the single-cell or even single-spin level. Key ingredients to be applied from work in quantum technologies include: cryogenic quantum-limited amplifiers, superconducting microresonators and quantum control techniques.

In this project you will gain a broad set of experience in microfabrication, operating dilution refrigerators, coherent control, finite-element modelling, microwave electronics, and be exposed to a wide range of spin systems, ranging from spin centres in complex membrane-bound proteins within cells (with potential applications in medical diagnostics, as well as near-surface donor spins in silicon of interest for quantum technologies, and thin films of relevance for spintronic devices.

The project will include collaborations with the Roessler group in Imperial College London, as well as a network of international collaborations in the field of magnetic resonance.