

PhD Position: Nanoscale Magnetic Resonance Imaging using Single Spins in Diamond

Recently, the first imaging vector magnetometer using an array of NV^- spins combined with a fast camera readout has been reported [Rev. Sci. Instrum. 81, 043705, 2010]. Although the reported magnetic sensitivity ($20 \text{ nT}/\sqrt{\text{Hz}}$) and spatial resolution (250 nm) are impressive considerable potential for further sensitivity and resolution enhancements reside in coherent spin manipulation techniques exploiting long phase memory times and enhanced readout fidelities. The functionality under ambient conditions leads to the conclusion that the NV^- magnetometer is a prime candidate for a variety of applications in science and technology. One practical application for such sensitive magnetic field detection is to perform Magnetic Resonance Imaging (MRI) at the microscopic scale or to probe ionic fluctuations across single membrane channels.

An alternative and flexible approach to MRI exploiting the NV^- centre involves producing a NV^- centre in a diamond nanocrystal which is attached the tip of an Atomic Force Microscope (AFM) probe. The single NV^- centre spin can then be used as a scanning probe magnetometer to map nanoscale magnetic field variations [Nature **455**(7213), 648-651, 2008]. Controlling the surface properties of dispersed nanodiamonds and positioning them is demanding!

There are significant challenges to converting both proof of principle demonstrations into a widely exploitable MRI technology and ultimately achieving single spin detection sensitivity. This project will address:

- The maximisation and control of spin coherence time (T_2) in the diamond material through the control of parasitic magnetic impurities, in bulk single crystal diamond and in nanodiamonds.
- Improving the magnetic properties of NV^- centres close to the surface. NV^- centres are stable from a chemical point of view, which allows them to emit as in bulk when they are located at even a few nanometers below a surface, but their spin properties can be corrupted by the vicinity of the surface.

Others are working on improving the photon detection rate through both/either efficient photon detection efficiency and/or coupling to plasmonic structures which will enhance the emission rate of the NV centre, and where practical such advances will be exploited.

The device technology objectives of this project are to

- Build magneto imaging devices using arrays of NV^- centres in diamond.
- Perform nanometre scale magnetic imaging of test objects at room temperature thus establishing the limits to magnetic field sensitivity.

The project will involve collaboration with Stuttgart University (world leaders in single spin manipulation) and Element Six Ltd who are the world leaders in diamond synthesis and processing. We particularly encourage students who have or hope to obtain a good degree in physics or related discipline and have an interest in developing and applying new technologies and techniques.

For further information contact Mark Newton (m.e.newton@warwick.ac.uk) or iMR.CDT@warwick.ac.uk.

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