Hybrid Quantum Devices: Coupling Interlayer Excitons in 2D Semiconductors to Nitrogen Vacancy Centres in Diamond

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Atomically thin (two-dimensional) semiconductors are providing a completely new platform in which to observe and control quantum states of matter. A class of these materials known as the transition metal dichalcogenides (TMDs) have a direct band-gap in the optical region of the electromagnetic spectrum, and are therefore well suited to quantum opto-electronic applications. Furthermore, charge carriers in these materials possess unique spin-valley physics, with electrons and holes combining to form quasi-particles known as excitons that themselves exhibit specific behaviours according to their two-dimensional confinement potentials.

Alongside these appealing features of two-dimensional semiconductors is the potential to stack sheets of the same or differing material on top of one another, creating new solid-state environments with customised band-structures. This area, known as van der Waals heterostructure fabrication, is an emerging and exciting area of nanofabrication physics and has been exploited recently for the generation of a spatially separated exciton species known as the interlayer, or indirect, exciton. This electron-hole pair exists at the interface between two disparate 2D semiconductors, and owing to the spatial separation between its constituent charges, has a strong electric dipole moment that can be interfaced with other quantised systems for the creation of hybrid quantum devices.

This PhD project aims to exploit the strong electric-dipole moment of interlayer excitons in a van der Waal heterostructures for the realisation of hybrid quantum devices between two-dimensional semiconductors and nitrogen defects in diamond. The project combines the fabrication of novel two-dimensional materials and quantum optics measurement techniques for applications in quantum computation and quantum information processing.

This PhD position will be aligned closely with the Diamond Science and Technology Centre for Doctoral Training (https://warwick.ac.uk/fac/sci/dst/). This gives access to a tailored research degree to help you exploit our outstanding and expertise in quantum measurement, nanodevice fabrication, materials characterisation and computational capabilities. A broad education in condensed matter physics is also provided through dedicated modules under the Midlands Physics Alliance Graduate School, and external courses.

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