Exotic Quantum Devices Lab

A new generation of single photon emitters: Localised quantum states in van der Waal heterostructures

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The very recent discovery of a new class of atomically thin (two dimensional) semiconductor material is providing a completely new platform in which to observe and control quantum states. These materials known as the transition metal dichalcogenides (TMDs) can trap excitations at defect sites, which themselves can be tuned by applying electric, magnetic or even strain fields (stretching and compressing). Performing this level of control in a fully integrated way by means of nanofabricated control structures, is of utmost importance for their applications in a technological setting.

Amongst these applications are single-photon sources, which underpin many leading quantum technologies, from quantum cryptography, enhanced metrology and light-matter interfacing. Among the many solid-state platforms that host single photon emitters (SPE) two-dimensional materials are the least well understood, whilst at the same time providing an entirely unique approach to tailoring the band structure for solid-state SPEs. Given their ultra-thin forms, SPEs in two-dimensional systems avoid losses due to total internal reflection and can readily be coupled to integrated nanophotonic systems e.g. cavities and waveguides. Most importantly however, the nature of two-dimensional material surfaces---weak van der Waal forces bonding individual two-dimensional layers---permits the stacking of separate monolayers, as well as the ability to tune the angle between each crystal, layer-by-layer. It has recently been shown that such structures, known as van der Waal heterostructures (vdWh), can host interlayer excitons (electron-hole pairs) that possess different optical properties to those of the constituent materials alone.

This PhD project will exploit the unique approach of vdWh fabrication in the context of single-photon emitters, which rely on the spatial localisation of single exciton quasiparticles. Instead of relying on random defects or adatoms, as has been the case for monolayer SPE devices, our approach will be to restrict the lateral dimensions of a vdWh itself. This PhD project combines the fabrication of novel two-dimensional materials and quantum optics measurement techniques for the realisation of bespoke solid-state single photon emitters.

This PhD position will be aligned with the Materials Physics Doctorate scheme (go.warwick.ac.uk/MPDOC). This gives access to a tailored research degree to help you exploit our outstanding materials growth, fabrication, characterisation and computational capabilities, and those at central facilities. A broad education in Condensed Matter Physics is provided through dedicated modules under the Midlands Physics Alliance Graduate School, and external courses.

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