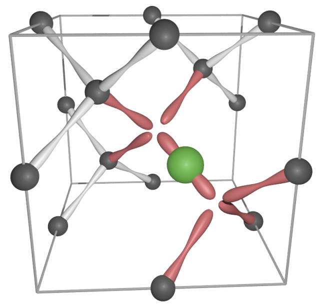
Identification of novel diamond defects for quantum technologies

Exceptional technological progress in diamond means that it is now at the forefront of many quantum technologies. For instance, diamond-based sensors can detect the magnetic field of a single atom and determine precisely what and where it is; or probe the fundamental nature of our universe by employing quantum entanglement between two diamonds.

These amazing capabilities are enabled by "point-defects" – atomic-scale "faults" in the diamond crystal formed by displacing, replacing, and/or removing carbon atoms – within the diamond structure. Different point defects have different properties: the defect formed by a nitrogen atom next to a missing atom (called the "negatively charged nitrogen-vacancy centre", NV^-) is currently the world's highest-spatial-resolution magnetic field sensor [1–3]; the "neutral and negatively charged silicon-vacancy centre", $SiV^{0/-}$ [see right for cartoon], is a leading platform for next-generation quantum communication networks [4–7].



Quantum technologies based on diamond rely on the ability to optically control and readout the spin state of the electron(s) associated with the underlying defect: this process is known as "optically detected magnetic resonance" (ODMR). This (highly unusual) optical spin access is typically based on a change in light absorption or fluorescence. A plethora of optical emission and absorption peaks have been observed in diamond (a result of diamond's broad transparency in the visible and near infrared), the vast majority of which have not been definitively linked to an underlying chemical and geometric structure. The identification of new ODMR-active defects in diamond will open brand-new avenues of research for functional diamond-based quantum technologies, as well as increasing our fundamental understanding of the material by linking known behaviour of optical transitions to their chemical constituents.

This exciting project will combine Warwick's world-leading understanding of diamond point defects and their spin properties with recently-developed capabilities in ODMR and optical spin control. It is anticipated that this work will result in the identification and characterisation of several new ODMR-active defects, with potential quantum technology applications dictated by their functional optical and spin properties.

The research will be carried out in the physics department at Warwick, and will involve but is not limited to:

- identification and characterization of novel color centers using cryogenic optical and magnetic resonance techniques;
- understanding of defects' electronic properties to deduce their chemical constituents and atomic configuration;
- development of experimental protocols to exploit the properties of these defects;
- production of defects by irradiation and heat treatment to optimize their properties and help understand their interactions with other defects

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