Scientific Area	Developing quantum hardware
Topic title	A diamond-based spin-photon interface
Main host institution	Department of Physics, University of Basel https://physik.unibas.ch/en
Supervisor/institution	Patrick Maletinsky and Richard Warburton https://quantum-sensing.physik.unibas.ch/en/ https://nano-photonics.unibas.ch
Co-Supervisor/institution	Johannes Schachenmayer https://isis.unistra.fr/en/
Mentor[1]/institution	Tomasz Smolensky https://physik.unibas.ch/en
Secondment institution	Quantum Basel https://quantumbasel.com/

Topic description

A future quantum network will consist of a matter qubit at each node with each node connected via single photons. The matter-photon interface must be both efficient and coherent. From a technological point of view, the matter qubit should ideally be hosted in a solid-state material. It is presently an open question which solid-state matter qubit is best suited.

Diamond is an attractive host. The matter qubit – photon interface can be implemented with a colour centre. It is unclear however which colour centre works best – each has its own advantages and disadvantages – and it is also unclear how to create a high-efficiency system.

In this project, an efficient spin – photon interface will be created using a colour centre in diamond. The efficiency will be boosted massively by embedding the colour centre in an optical microcavity. The microcavity modifies the photonic environment of the emitter, leading to both increased photon emission rates (the Purcell effect) and a "funnelling" of the emission into the cavity mode. To achieve a high efficiency, we will employ open microcavities as the cavity mode is naturally mode-matched to an optical fibre. In terms of colour centre, we will focus on negatively charged nitrogen-vacancy and silicon-vacancy centres both of which have a coherent spin at low temperature. We will also consider the charge-neutral silicon-vacancy complex, a little-explored colour centre that potentially provides the elusive combination of a coherent spin, a coherent optical transition at a technologically relevant wavelength, all at an amenable temperature.

This project is part of an ongoing, close collaboration between the groups of Patrick Maletinsky and Richard Warburton at Basel University. The project involves nano-fabrication (creation of thin diamond membranes), photonics engineering (design and realisation of next-generation open microcavities), spin control, and quantum optics.

Recommended applicant's profile

Physics or Engineering Physics

[1] Mentor: The primary role of the mentors will be to identify and facilitate specific training objectives, advise on any problems faced by the DC including career matters with an external perspective and provide mediation in the case of disputes.

The Gen-Q programme has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement number 101217386.