University of Basel

Swiss Nanoscience Institute

Swiss Nanoscience Institute
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A diamond-based spin-photon interface

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Summary An efficient spin-photon interface will be created using a colour centre in diamond, the SiV^0 complex. The SiV^0 is a little-explored colour centre but potentially provides the elusive combination of a coherent spin, a coherent optical transition at a technologically relevant wavelength, all at an amenable temperature.

An interface between a single spin and a single photon is a crucial to both nano-scale quantum sensing and to a quantum network. A requirement for a quantum network is that the spin should stay in the same quantum state as the photon propagates over long distances. This allows two remote spins to be entangled with each other using photons from each spin as the entangling “glue”. In turn, the photons created by one spin should be identical to those created by a second thus removing any “which path” information. Finally, each spin should create an entangled photon with high probability.

Nature is not immediately kind in this endeavour. The conundrum is that solid-state emitters which create very high-quality photons do not host a coherent spin; an emitter with a coherent spin does not create high-quality photons. The spectrum is spanned by a semiconductor quantum dot (high-quality photons, low-quality spin) to the NV^- centre in diamond (low-quality photons, high-quality spin).

This project will address the emitter conundrum. The crucial idea is to take a well-known and easy-to-create colour centre in diamond (a host with almost no magnetic noise) but in an unusual charge state. The colour centre is the SiV. Typically, the stable state is the SiV^-, which has the virtue of being insensitive to charge noise but the vice of possessing a coherent spin only at ultralow temperatures. The proposal is to operate the same complex but in the charge-neutral state, SiV^0. The first step is to understand the photo-physics of the SiV^0, the second step to boost massively the efficiency by coupling a single SiV^0 to an open microcavity.

The project will run as a collaboration between the Nano-Photonics Group (RJW) and the Quantum Sensing Lab (PM) – the student will be embedded in both groups. Applicants should have studied physics and/or nanoscience to masters level. Some experience in quantum optics and spin physics would be helpful but is not essential.

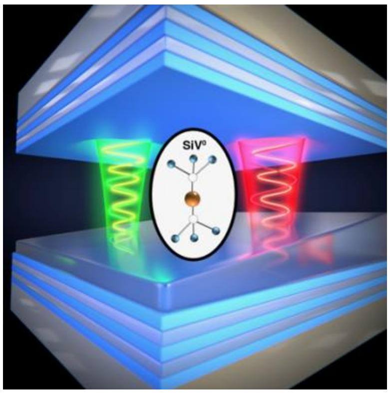

Figure: An SiV centre in an open microcavity