



Master thesis proposal



Laboratoire Charles Coulomb,
Uni. Montpellier and CNRS,
UMR 5221

Director: Pierre Lefebvre

Title: Spin control of single fluorescent defects in silicon

Keywords: spin, single photons, color centers, silicon

Scientific description: Building on the great success of microelectronics and integrated photonics industries, **silicon** is undoubtedly one of the most promising platforms for deploying large-scale quantum technologies. To date, silicon-based quantum chips mostly rely on long-lived electrical qubits, which are either weakly coupled to light or emitting in the mid-infrared range unsuitable for optical fiber propagation. In order to isolate artificial atoms that feature an optical interface enabling the long-distance exchange of quantum information while benefiting from well-advanced silicon integrated photonics, one strategy is to investigate **fluorescent point defects in silicon** emitting in the near-infrared telecom bands. In this context, the host group has recently shown that silicon hosts many point defects that can be optically isolated at single scale (see Fig. 1) and offer a **single photon emission at telecom wavelengths**.

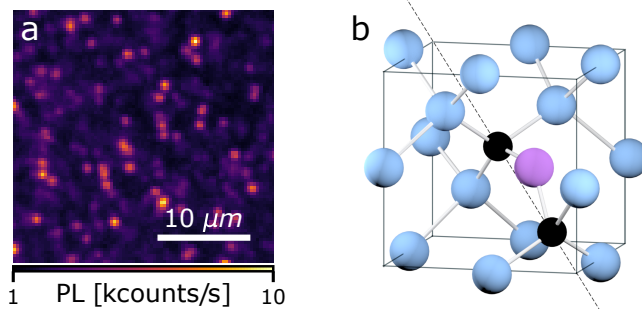


Fig. 1: **a-** Photoluminescence raster scan at 10K of a carbon-implanted silicon sample. The bright spots are individual crystal point defects emitting single photons. **b-** Atomic structure of the G center in silicon, made of 2 substitutional carbon atoms (black) and 1 interstitial silicon atom (purple).

This internship, which can be followed by a PhD, aims at tackling the **spin properties** of these new optically active defects in silicon and in particular of a common carbon-complex called the G center. The G defect is a promising quantum system in silicon as it features an optical telecom emission and a metastable triplet spin whose magnetic resonance can be optically detected. The first goal of this internship is to demonstrate the coherent control of a single electron spin by performing Rabi oscillations on an individual G center. The next step is to address and control nuclear spins, either intrinsic to the G center, such as ^{13}C or ^{29}Si , or nearby the defect in the silicon lattice, in order to use them as memory qubits. The final objective is to assess the potential of these fluorescent defects as solid-state spin qubits.

Some recent publications of the host group linked to the project:

- W. Redjem *et al.*, Nature Electronics **3**, 738 (2020)
- A. Durand *et al.*, Applied Physics Letters **121**, 084993 (2022)
- A. Durand *et al.*, Physical Review B **110**, L020102 (2024)

Techniques/methods in use: optically detected magnetic resonance spectroscopy, coherent spin manipulation, confocal microscopy.

Applicant skills: background in optics and quantum physics.

Industrial partnership: No

Internship supervisor: Anaïs Dréau, anais.dreau@umontpellier.fr

Internship location: Team « [Solid-State Quantum Technologies](#) », Laboratoire Charles Coulomb, Montpellier.

Possibility for a Doctoral thesis: Yes