Master Thesis: Diamond Group 4 Color Center Physics

Prof. Dr. Jonathan J. Finley and Prof. Dr. Kai Müller

Introduction

Group 4 vacancy (G4V) colour centres in diamonds have recently emerged as a promising platform for quantum sensing and quantum networking. A G4V is an optically active defect center formed by an element from Group 4 of the periodic table that combines with two carbon vacancies in diamond (see figure 1).

Unlike many other colour centres, G4Vs are inversion symmetric, which leads to a zero electric dipole moment [1]. This significantly reduces the negative effects of charge-related noise and decoherence, and leads to lifetime limited optical linewidths [2, 3]. Together with the high emission in the zero phonon line and the long electron and nuclear spin coherence times, this makes G4V excellent quantum spin-photon interfaces [4].

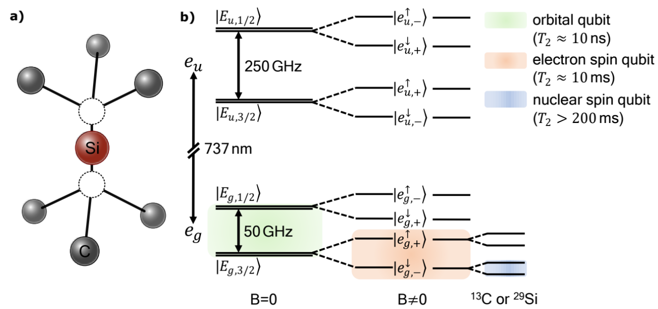

Figure 1: **a)** Schematic illustration of the atomic arrangement of a Silicon vacancy (SiV). **b)** SiV^- energy level diagram. Electron and nuclear spin qubits have long T_2.

Our Work

We are the Diamond team located in the Walter Schottky Institute at the chairs of Prof. Finley and Prof. Müller, led by Dr. Viviana Villafane. In addition to realising spin control of G4Vs, we have several projects aimed at understanding and mitigating the processes that currently limit them. Most of our work focuses on Silicon vacancies. For example, to unlock their full potential, it is essential to develop reliable protocols for controlling and stabilising the different charge states of the centers [5]. We have several thesis projects related to fundamental physics, tuning/optimisation and building experiments.

Your Profile

Students from any gender and nationality are welcome to apply. You are very interested in the physics of G4Vs and look forward to finally working hands-on in a state-of-the-art quantum optics lab or cleanroom. You are a team player and you do not give up easily when you face challenges. You have a background in physics, electrical engineering, physical chemistry, or similar.

We have several experimental projects available starting in WS24-25. Interested? → write us mail including a short motivation, a CV and your transcript of records to viviana.villafane@tum.de, finley@wsi.tum.de and kai.mueller@tum.de.

References

[1] Adam Gali and Jeronimo R. Maze. "Ab initio study of the split silicon-vacancy defect in diamond: Electronic structure and related properties". In: *Phys. Rev. B* (2013).

[2] Yu Zhou et al. "Coherent control of a strongly driven silicon vacancy optical transition in diamond". In: *Nature Communications* (2017).

[3] Johannes Görlitz et al. "Spectroscopic investigations of negatively charged tin-vacancy centres in diamond". In: *New Journal of Physics* (2020).

[4] Carlo Bradac et al. "Quantum nanophotonics with group IV defects in diamond". In: *Nature Communications* (2019).

[5] Manuel Rieger et al. "Fast optoelectronic charge state conversion of silicon vacancies in diamond". In: *Science Advances* 8 (2024).