Spin-active color centers in silicon carbide for telecom-compatible quantum devices

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Optically-active impurities with spin in crystals can realize light-matter entanglement protocols necessary for quantum-communication and sensing applications. Various transition-metal defects in SiC are unique in that they are strong emitters directly at telecom wavelength in an industrially-mature semiconductor. They have in common that a single electron of *d*-orbital origin is responsible for their electronic behaviour [1,2,3,4]. We carried out a comprehensive research line on the Mo and V defect, and report our insights into how strong spin-orbit coupling, the symmetries in SiC, and the highly anisotropic hyperfine coupling together give new and unexpected spin states and dynamics, with favourable properties for quantum technologies. We found experimentally and theoretically that spin-orbit coupling stabilizes the defect spin, leading to seconds-long spin-relaxation times and limited possibilities for microwave spin control [2]. We found, however, that strong electronic spin driving is still possible, both with magnetic and electric-microwave fields, for systems with hyperfine coupling to a central nuclear spin [3]. Our results help in understanding how macroscopic figures of merit relevant for quantum operation are related to the microscopic configuration of defect centers, and may lead to engineering of defects for specific applications. We found that these insights are also relevant for spin behaviour in a broader class of materials.

References

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Figures

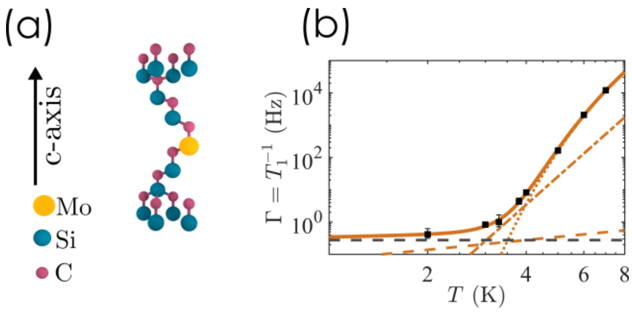

Figure 1: (a) A transition metal defect in SiC is formed as the transition metal impurity substitutes a Si in the SiC lattice. (b) Temperature dependence of the spin-relaxation rate of Mo defects in SiC, showing that for ensembles with zero nuclear spin, the spin-relaxation rate is above seconds at low temperatures despite the presence of strong spin-orbit coupling.