

Master 2 Experimental Research Internship Academic Year 2024/2025

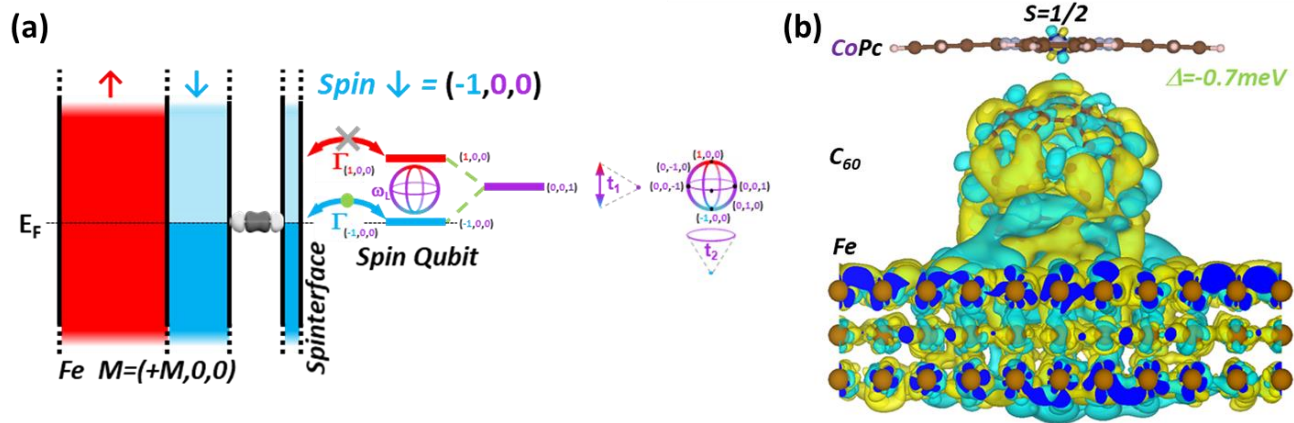
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Quantum Spintronic Qubit: first experiments



Many hardware platforms exist to implement qubit operations for quantum technologies, but these platforms, although conceptually elegant, do not offer a straightforward path toward consumer applications in terms of energy/resource usage (#QEI)¹: low/very low temperatures, external magnetic fields, lasers/microwave sources, a room-full of optical/electrical/vacuum/cryogenic equipment, difficulty to entangle qubits... To address this challenge, **we propose a new platform: the quantum spintronic qubit.** It is an atomic paramagnetic atom that electronically interacts with a simple ferromagnetic metal across a fully spin-polarized interface ('spinterface', see panel a). Thanks to its solid-state implementation, this qubit paradigm offers many advantages: large/built-in magnetic field, spintronic initialization/manipulation/readout of the qubit along the Bloch sphere² (panel a), potential for room-temperature operation^{2,3}, built-in entanglement⁴. Our prior experiments and theory have identified several qubit candidates, from C atoms in MgO ^{2,5} (the spintronic reference spacer) to commercially available paramagnetic molecules (CoPc^{3,6}, see panel b).

Despite first successes the areas of quantum information^{5,6} and energy harvesting^{2,3}, this quantum spintronic qubit platform is extremely immature compared to existing quantum technologies. We therefore propose as a Masters 2 project to undertake initial magnetotransport experiments across a CoPc-borne qubit embedded into a molecular spintronic nanojunction. The project's samples will be grown and processed into nanojunctions by Jan 2025, and the M2 candidate will oversee the measurements in close interactions with the research team, which includes two experimental PhD candidates.

This initial M2 work will segue into a possible experimental PhD program to evaluate the relevant time scales of the qubit's spintronic operational sequences. The M2 candidate will acquire skills on how to

intuitively construct experimental measurement protocols based on scientific knowledge and experimental data-driven intuition. In a possible PhD program, this research track offers solid training for academic/industrial career opportunities: UHV growth/characterization , clean-room, magneto-transport measurements, thinking outside the box.

References

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