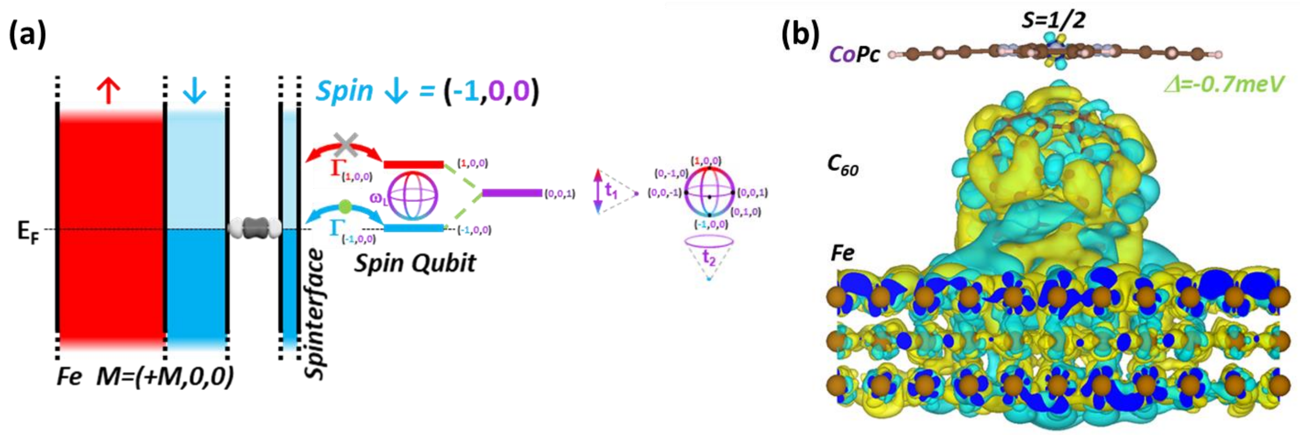
Master 2 Experimental Research Internship
Academic Year 2025/2026

Laboratory : Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS)
Team: M. Bowen, B. Gobaut, L. Joly, S. Boukari, W. Weber
Address : IPCMS-DMONS, 23 rue du Loess BP 43, 67034 Strasbourg Cedex 2
Supervisor : M. Bowen, CNRS Research Director bowen@unistra.fr

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 sphere[2] (panel a), potential for room-temperature operation[2,3], built-in entanglement[4]. 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 2026, and the M2 candidate will oversee the measurements in close interactions with the research team.

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

1. Auffèves, A. Quantum Technologies Need a Quantum Energy Initiative. *PRX Quantum* **3**, 020101 (2022).
2. Katcko, K. *et al.* Spin-driven electrical power generation at room temperature. *Communications Physics* **2**, 116 (2019).
3. Chowrira, B. *et al.* Quantum Advantage in a Molecular Spintronic Engine that Harvests Thermal Fluctuation Energy. *Adv. Mater.* **34**, 2206688 (2022).
4. Arnesen, M. C., Bose, S. & Vedral, V. Natural Thermal and Magnetic Entanglement in the 1D Heisenberg Model. *Phys. Rev. Lett.* **87**, 017901 (2001).
5. Lamblin, M. & et al. Encoding information onto the charge and spin state of a paramagnetic atom using MgO tunnelling spintronics. *arXiv:2308.16592* (2023).
6. Katcko, K. *et al.* Encoding Information on the Excited State of a Molecular Spin Chain. *Advanced Functional Materials* 2009467 (2021) doi:10.1002/adfm.202009467.