PhD Project 2026-2029

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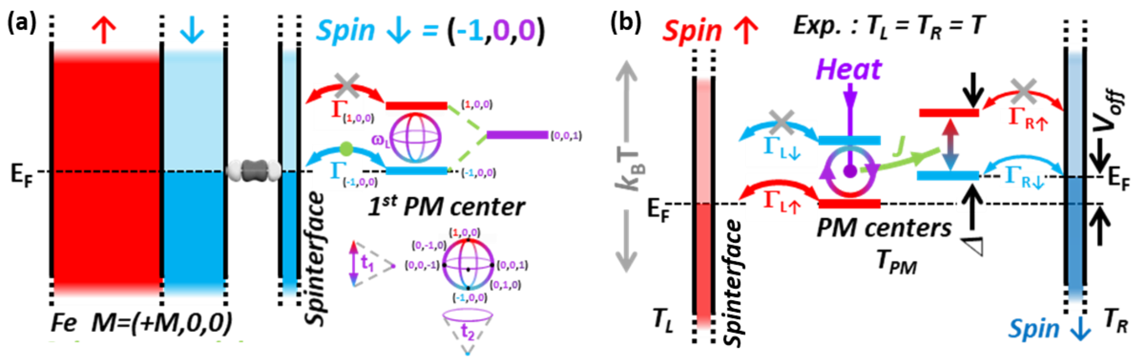

Spintronic crafting of a 1D spin ½ chain's quantum properties. *(a) Schematic of the spintronic interactions between a ferromagnetic metal and an initially spin ½ degenerate paramagnetic (PM) center across a spectrospatially confined low number of fully spin-polarized spin states (the spinterface). (b) Potential landscape of two qubits entangled by magnetic exchange energy[1] J sandwiched between the junction's two spinterfaces. The antiparallel magnetic orientation of the junction's ferromagnetic electrodes is represented. The transmission across the spinterface for only one spin population 1) describes the PM center's spintronic cavity confinement by each interface of the junction; and 2) results in the spin splitting Δ (as the competition between Γ_L and Γ_R). The project aims to study how the FM property of one electrode impacts the spin chain's quantum properties.*

Insights into the quantum spintronic engine

The quantum properties of atoms 1-dimensional (1D) spin chains are nowadays routinely tested using scanning tunneling microscopes[2]. Separately, intense research is focusing on how a quantum system can couple with the quantized levels of optical cavities[3]. To merge the physics of these research tracks onto an applicative path, our team has been studying the quantum properties of antiferromagnetic spin ½ 1D chains borne by molecules, when inserted into vertical spintronic nanopillar junctions[4–6]. Several published results, and preliminary measurements, depict how the quantum properties of the quantum entangled spin chain are profoundly altered due to fully spin-polarized charge transfer from the junction's metallic interfaces, and the resulting spintronic cavity confinement. A number of spintronic mechanisms have been invoked to explain the very strong on-site spin splitting ~5-100T of the potential qubit, and cyclical (i.e. engine), autonomous on-chip behavior of transport across such junctions. Compared to other quantum platforms, this device class can advantageously operate at/beyond room temperature, and given the industrial underpinnings of spintronics[7], is thus a promising new vector for quantum technologies. However, so far, several of these mechanisms, such as the fuel from measurements of quantum information[8], are intertwined, thereby requiring fundamental research[9].

To improve our understanding of these effects, we propose as the starting idea of a PhD project to control the solid-state property that dominantly alters the spin chain's quantum property: the ferromagnetic state of the electronically proximate metallic electrode. We will use alloying to tune its Curie temperature, and perform temperature-dependent magnetotransport measurements to test several spintronic scenario when pitting this FM energy parameter against relevant quantum parameters (spin splitting Δ, magnetic exchange energy J) of the spin chain.

We are looking for a bright, motivated candidate who relishes intellectual challenges, can think outside the box and build on this initial scientific framework with original ideas/proposals. The PhD candidate will interact with a mid-sized team (3 scientists, 3 engineers, 1 postdoc) and receive training along the nanotechnological chain that this team operates: growth/characterization, nanofabrication skills, and magnetotransport measurements. Ultimately, this mainly experimental PhD research project will confer expertise into spintronics, quantum physics and quantum thermodynamics (quantum information as fuel)[6,8] for use in academia and industry.

Starting References:

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