Intern – 6 months – 2021 – Nancy / Paris

Design of magnetic nano-gates for control and manipulation of spin-qubits

Objective of the internship

Spin qubits coupled to a microwave resonator is a promising and scalable platform for quantum information processing. Interfacing spins with microwave photons brings interesting perspectives for their individual control and manipulation as well as for the circuit architecture.

The objective of the internship is to **pioneer a new approach for designing spin qubits in semiconducting quantum dots hosted by carbon nanotubes**. By developing further the concept of suspended spins and relying on spintronic elements, our aim will be to bring together two complementary nano-material breakthroughs to this qubit platform (Fig. 1), improving experimental performance and functionality.

This effort will contribute to the mid-term objectives of a broader scientific project organized around the quantum start-up C12: (i) to obtain **ultraclean nanotubes** free of nuclear spins where all major sources of dephasing noise will be eliminated; (ii) to achieve **optimal design of their spin spectrum** from the engineering of a distribution of dipolar fields, generated by scalable nano-magnets introduced among the control gates of the quantum dots [1]. You will work on an **elegant spin-qubit design** [2] that will allow adjustable and highly coherent spin transitions all in the same device.

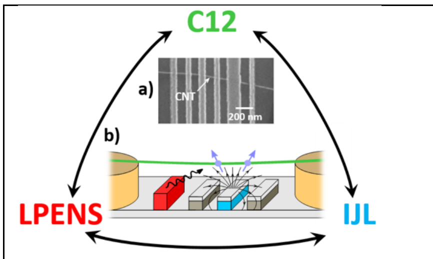

Figure 1: a) SEM image of a prototypical spin qubit device with contact electrodes, narrower cavity/DC gates in between and assembled CNT. b) Type of device to be fabricated, where a double quantum dot in suspended CNT has a spin spectrum controlled by magnetic gate(s) and can be electrically manipulated by cavity RF field.

A few words about C12 Quantum Electronics & its academic partners

C12 develops **quantum processors** with the goal of **speeding-up highly complex computing tasks**, currently out of reach of classical computers.

Building a quantum computer still needs **scientific innovators** ready to tackle exciting challenges.

C12 is taking a different path from all the existing solid-state architectures that display at least one roadblock on their scaling trajectories. Its technology offers unique advantages both in the near term (ultra-low error) and in the long term (scalability) [3].

At C12, not only spins will be entangled, but also **science and business**. Scientific excellence and technology are at the heart of the company, with a team of six PhDs coming from different fields of quantum physics. **Business drive, product focus development and ambition to accelerate** are also rooted in C12's culture.

You will contribute to achieve landmark results in quantum computing, making a difference in the emerging quantum technologies. We will take care of building a diverse team of curious and excellent individuals, driven by scientific integrity.

The project will be carried out in the framework of **a strong collaboration between** 2 **internationally recognized academic partners**: **LPENS** (Paris) for quantum transport and sensing, and **IJL** (Nancy) for the materials aspects and nano-magnetism, together with the company C12, combining complementary expertise and supervision.

You will be based in Nancy. If feasible, you will also be welcome in Paris at C12's lab for some time (the end of the internship for example). The internship will open **the possibility of continuation in a Ph.D. project** at the interface of the three partners.

Your role

During this research internship, your will learn how to work around spin-qubits and will be taught the **basics of the physics of spin manipulation and spin-photon coupling in quantum dots**. You will be introduced to nano-fabrication techniques, carbon nanotube assembly [4].

You will play a key role in growing and characterizing magnetic materials as well as in the design and measurement of the nano-magnetic elements [5]. You will design and study magnetic gates based on perpendicular magnetic anisotropy, likely by performing magnetic force microscopy, transport measurements, and micro-magnetic simulations.

Join the quantum race and contact: Stéphane Mangin (stephane.mangin@univ-lorraine.fr), Matthieu Desjardins (matthieu.desjardins@c12qe.com);

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[3] L. Vandersypen et al., npj Quantum Inf. 3, 34 (2017).
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