NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

Coupling molecular spin qubits to superconducting circuits

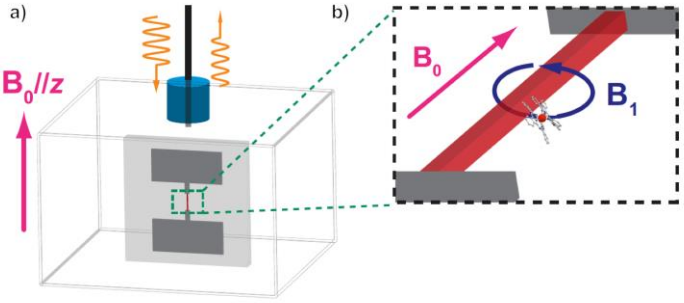

Fig.: extracted and adapted from Haikka et al., Phys. Rev. A (2017). a) 3D microwave cavity in which the superconducting resonator is integrated. b) The superconducting LC resonator consisting of 2 pads (capacitance C) and a nanowire (inductance L), interacts with a single magnetic moment carried by a molecular magnet.

Context: The realization of an operational quantum computer is one of the most ambitious technological goals of today's scientists. In this regard, the basic building block is generally composed of a two-level quantum system (a quantum bit). It must be fully controllable and measurable, which requires a connection to the macroscopic world. Among the different solid-state candidates, spin based devices are very attractive since they already exhibit long coherence times. Electrons possessing a spin 1/2 are conventionally thought as the natural carriers of quantum information, but alternative concepts make use of the outstanding properties of molecular magnets. In our team, we fabricate, characterize and study molecular spin qubits in order to manipulate them [1] and read them out [2] to perform quantum operations [3]. A current major limitation of our architecture is the readout speed. By coupling molecular spin qubits to superconducting resonators, we aim to improve readout speed by several orders of magnitude, and possibly enable the coupling of distant qubits via microwave photons.

[1] S. Thiele, F. Balestro, R. Ballou, S. Klyatskaya, M. Ruben, W. Wernsdorfer, Science 2014.
[2] R. Vincent, S. Klyatskaya, M. Ruben, W. Wernsdorfer, F. Balestro. Nature 2012.
[3] C. Godfrin, R. Ballou, S. Klyatskaya, M. Ruben,W. Wernsdorfer, F. Balestro, Phys. Rev. Lett. 2018.

Research topic and facilities available: We will first design, fabricate and characterize microwave resonators made out of superconducting materials that are resilient to magnetic fields. Molecular magnets will then be deposited on the resonators and external magnetic fields will be used to measure the spin-photon coupling rates and perform spin readout. The student will fabricate the samples using the clean room facilities of the Néel Institute. She/he will carry out the measurements of the device at very low temperature (20mK), using one of the five fully equipped dilution refrigerators of the team.

Possible collaboration and networking: This multidisciplinary research field is based on years of collaborations with teams from different scientific and technical cultures (cleanroom, technicians, collaborations with chemists and theoreticians, etc), in the framework of European projects and different national and regional funding.

Possible extension as a PhD: Yes

Required skills: We are looking for a motivated student who is interested in experiments that are challenging from the experimental point of view.

Starting date: Flexible

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