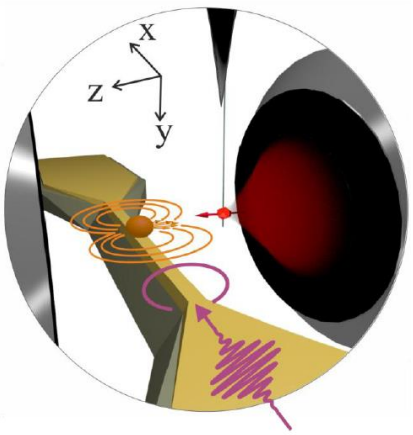
PhD thesis proposal - 2023-2026
Institut Néel, CNRS-Grenoble, France



Context: Nano-optomechanical systems, coupling a light field to a mechanical oscillator, have proven to be extremely sensitive for performing force measurements. Using a Silicon Carbide nanowire measured by optical means we have demonstrated sensitivities in the atto/zepto-Newton range (10^{-18} /10^{-21}N) at room and dilution temperatures [1,2]. The group spent the last decade exploring various force fields with these sensors, such as optical, electrostatic, Casimir, nano-optical and magnetic forces [1] as well as the optomechanical interaction down to the single photon level [3]. This knowledge will be employed to measure the faint interaction of a nanowire with a single spin qubit [4,5]. In the envisioned experiment, a single NV spin qubit hosted in a diamond nanocrystal attached to the vibrating extremity of a nanowire and coupled to its vibration by means of a strong magnetic field gradient. In analogy to the historical Stern and Gerlach experiment, the resulting strong hybrid spin-mechanical interaction will be used to perform a mechanical readout of the single spin quantum state.

Objectives : The goal of this PhD project will be to study the different aspects of the hybrid interaction between the SiC nanowire and the spin qubit, with the objective of implementing force sensing protocols to realize a non-destructive mechanical measurement of the spin qubit. This requires mastering both ultra-sensitive force sensing measurements and the NV centre manipulation and readout protocols with optical and microwave pulses. The spin of the NV centre being an exceptional magnetic field sensor, we will explore in parallel the potential of our hybrid system as a dual probe of electric and magnetic field close to surfaces and nanostructures. The PhD project mixes experimental developments such as nanowire manipulation, sensitive optical measurements and creating/assembling complex setup with theoretical modelisation involving spin dynamics, quantum optics and nanomechanics to predict and analyse the measurements.

References:

[1] L. Mercier de Lépinay *et al*., Nature Nano 12, 156 (2016)
[2] F. Fogliano *et al*., Nature Comm. 12, 4124 (2021)
[3] F. Fogliano *et al*., Physical Review X 11, 021009 (2021)
[4] O. Arcizet *et al*., *Nature Physics 7, 879 (2011)*
[5] B.Pigeau *et al*, Nature Comm. 6, 8603 (2015)

Required profile: The candidate should have a strong theoretical background in quantum physics, optics and/or nanomechanics. Experimental work will include optics, nanomechanics, vacuum an cryogenic technologies and microwave circuits. Programming skills (Python, C) will be appreciated.

Place: The Institut Néel - one of the major French research laboratories in condensed matter physics - is located in Grenoble in a unique scientific, industrial and cultural environment. It is part of one of the largest high-tech centers in Europe, in the heart of the French Alps. The Phd candidate will work at the Institut Néel in the Light-Matter Physics department, in the Nano-Optics and Forces team.

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