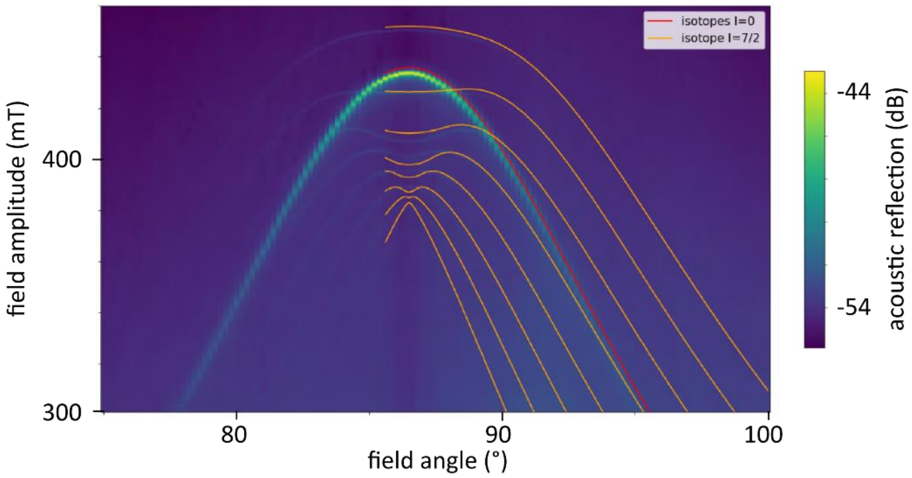
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Controlling and detecting spins with an engineered acoustic interface

General Scope : Most solid-state spins are coupled to their environment via spin-phonon interactions. Instead of considering these spin-phonon interactions as detrimental, we aim to use them as a resource for spin-based quantum technologies.
For this purpose, we engineer acoustic systems in which the phononic excitations are well controlled, and we use them to drive and detect electron spins. In our group, we have developed a technique to couple acoustic wave resonators (bulk modes) to microwave circuits at low temperature via piezoelectric components. We use these acoustic modes to detect the spin of dopants via intrinsic spin-phonon interactions (see figure). On the long term, this idea could be used to couple single spins with superconducting microwave circuits or to mediate controlled interactions between distant spins.



Acoustic resonance spectroscopy of Erbium spins at ≈5 GHz. Colorscale data is measured at 50 mK, lines is theory from the known Hamiltonian or Erbium isotopes.

Research topic and facilities available: On the short term, we will use this technique to measure the coherence and the anisotropy of spin-phonon interactions for relevant dopant spins (rare earth, diamond vacancy centers). The project will then move on, either to the control of spin ensembles for quantum functionalities, or to the development of acoustic nanostructures for the coupling to single spins.

The student will start with learning how to design, fabricate and operate bulk acoustic wave resonators at microwave frequencies (several GHz) and cryogenic temperatures (tens of mK). The fabrication takes place in the clean room of the Néel institute using state-of-the-art techniques. The cryogenic microwave measurements are performed in a dedicated dilution refrigerator.

Possible collaboration and networking: We collaborate with colleagues (in Paris and Grenoble) who provide us with samples containing dopant spins.
Possible extension as a PhD: Yes
Required skills: We are looking for a student motivated to learn a wide variety of skills in experimental physics, willing to be part of a project involving both fundamental and technical challenges.
Starting date: Flexible

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