PhD project: **Nonlinear magnetization dynamics triggered by surface acoustic waves**

Context: RF signals are everywhere in today's connected society. On one side, surface acoustic wave (SAW) devices built on piezo-electric substrates are widely used to distinguish between frequencies. While quite energy efficient, SAW devices mostly operate in narrow-band applications and perform linear, frequency-conserving operations. On the other side, magnonic devices rely on the specific properties of spin-waves (SW) in ferromagnetic materials and are highly tunable and nonlinear, but suffer from significant insertion losses. Fortunately, magneto-elastic and magneto-rotation effects can couple the dynamics of magnetization in a thin ferromagnetic film deposited on top of a piezo-electric substrate to the one of its lattice. For instance, it has recently been demonstrated that it is possible to excite the linear magnetization dynamics of a ferromagnetic CoFeB nanodisk thanks to SAW electrically actuated in the underlying LiNbO3 substrate [1].

Workplan and expected results: The objective of this thesis will be to demonstrate that the excitation from SAW to SW can also be achieved in the nonlinear regime. A ferromagnetic disk will first be magnetized in the plane. In this configuration, the precession of magnetization is elliptical, which allows to parametrically excite SW eigenmodes using an RF magnetic field parallel to the disk's magnetization with a frequency close to twice the eigenfrequencies [2]. The originality here will be to replace the RF excitation field usually produced by an inductive antenna by the effective tickle and rolling fields associated to the magneto-elastic and magneto-rotation terms active when a SAW is excited in the substrate. These measurements will be performed thanks to a highly sensitive magnetic resonance force microscope developed at SPEC on samples fabricated in collaboration with another laboratory (C2N). Micromagnetic simulations will also be conducted to understand the SAW excitation threshold to be overcome to excite parametric SW modes in the disk. Then, other well-known nonlinear phenomena occurring when the magnetization is excited by an RF magnetic field, such as the nonlinear shift of the SW resonance frequency [3], transverse parametric excitation [4] and SW instabilities [5], will be investigated with the excitation provided by a SAW. The demonstration of these various nonlinear regimes of magnetization dynamics using a SAW excitation will pave the way for the future development of new devices combining acoustic waves and spin waves that offer nonlinear functionalities, such as power limiters and frequency converters.

Work environment: This thesis will take place at Service de Physique de l'État Condensé in CEA Paris-Saclay under the supervision of Grégoire de Loubens and Aurélie Solignac in a collaborative environment, in the context of the recently funded ANR project NELSON ("nonlinear surface acoustic wave platform enabled by spin wave hybridization").

Required skills: Strong background in solid-state physics (Master's degree in Physics, specializing in condensed matter physics / materials / nanophysics). Interest in experimental measurements and familiarity with coding, evidenced by at least one laboratory internship. Interest in a project encompassing a wide range of methods, from device fabrication to advanced characterization using state-of-the-art spectroscopy techniques and the modeling of complex physical effects.

Application: To apply please send a detailed application including a cover letter, an up-to date CV, transcripts of grades and reference letters to gregoire.deloubens@cea.fr and aurelie.solignac@cea.fr.

Additional information: application deadline: 30/09/2026
start date: Oct.-Dec. 2026
contract duration: 36 months

[1] R. Lopes Seeger et al., Phys. Rev. Lett. **134**, 176704 (2025)
[2] T. Srivastava et al., Phys. Rev. Appl. **19**, 064078 (2023)
[3] Y. Li et al., Phys. Rev. X **9**, 041036 (2019)
[4] H. Merbouche et al., Phys. Rev. Appl. **21**, 064041 (2024)
[5] I. Ngouagnia et al., Phys. Rev. Lett. **135**, 056703 (2025)