2023-2024

Master thesis proposal

Campus Pierre et Marie Curie
Tower 23 – 3rd floor – 23-22
Director: Massimiliano Marangolo

Title: Surface acoustic waves for magnonic devices

Keywords: Magnetism, magnonic, spintronic, magneto-acoustic

Scientific description: A substantial portion of today's magnetism research community dedicates its efforts to achieving highly integrated, rapid, and energy-efficient information and communication technologies that can operate at room temperature. In this context, Spin Waves (SW) emerge as promising contenders. SW, often referred to as magnons, represent collective excitations of electron spins within magnetic materials, traversing the spin lattice to convey information (see Fig.1). At INSP, our primary interest lies in instigating SWs within nanostructures through external stress and acoustic means. Indeed, the advent of spintronic devices that manipulate magnetization through strain rather than conventional inductive methods (like antennas) holds the potential for substantial reductions in energy dissipation.

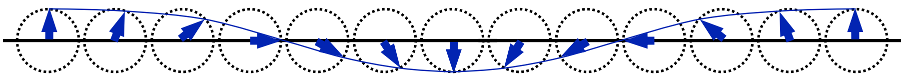

Figure 1: Spin wave, collective excitation of spin

In **our pioneering approach**, SWs find their ignition in the propagation of surface acoustic waves (SAW), a well-established technology already employed in contemporary sensors, filters, and microwave circuitry. Recently, our research group demonstrated that SAWs, initiated through interdigitated transducers (IDT), can effectively generate SWs in Fe epitaxied on GaAs [1,2]. These SWs typically span frequencies ranging from 800 MHz to 2 GHz, meticulously selected to align with the resonance frequencies of SWs. Notably, voltage-controlled IDTs replace conventional inductive antennas for SW emission in devices composed of Fe dots coupled to a SW waveguide (see Fig. 2).

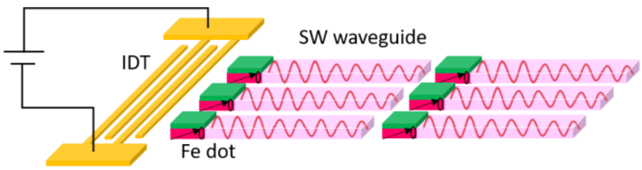

Figure 2: Fe dots and SW waveguide excited by SAW

During the internship, our focus will revolve around inducing magnetization precession in Fe, thereby eliciting SWs within the waveguide. We will employ TR-MOKE (Time Resolved-MagnetoOptical Effect), a potent method for scrutinizing magnetization dynamics [3,4]. After observing the acoustically-induced propagation of SWs within the waveguide, we will endeavor to regulate SW emission by applying an external voltage to a piezoelectric layer situated atop the Fe. This piezoelectric layer will induce deformations in the Fe pads, thereby altering their magnetic properties, which we will assess through acoustic measurements and TR-MOKE.

The student's involvement will progress through several stages, commencing with device fabrication and the comprehensive examination of its magnetic characteristics. Subsequently, the student will delve into magnetoacoustics measurements and participate in TR-MOKE experiments. This multifaceted experience will encompass hands-on exposure to clean room protocols, optics, and RF electronics equipment essential for conducting magnetoacoustics experiments. Ultimately, the student will actively contribute to the development of a phenomenological model aimed at elucidating the observed phenomena.

[1] Duquesne et al., Phys. Rev. Appl. 12, 024042 (2019) [2] Rovillain et al., Phys. Rev. Appl. 18, 064043 (2022) [3] Kuszewski et al., Phys. Rev. Appl. 10, 034036 (2018) [4] Kraimia et al., Phys. Rev. B 101, 144425 (2020).

Techniques/methods in use: Clean room techniques, RF electronics, magnetoacoustics and TR-MOKE measurements techniques

Applicant skills: Good background in magnetism, Taste for experimental physics.

Industrial partnership: No

Internship supervisor(s): Laura Thévenard (thevenard@insp.jussieu.fr 01 44 27 46 29), Pauline Rovillain (rovillain@insp.upmc.fr 01 44 27 40 47), and Max Marangolo (marangolo@insp.jussieu.fr)

Internship location: Institut des Nanosciences de Paris (22-23 215 et 22-32 311)

Possibility for a Doctoral thesis: Yes funded by agence national de recherche (PEPR SPIN)