INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG
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Séminaire AXE 1 - Sciences et Matériaux Quantiques

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Laying the experimental foundations for quantum magnonics

Spin waves are collective excitations in magnetically ordered materials, featuring non-reciprocal propagation and the ability to transport angular momentum. These properties form the basis of proposals for non-Boolean electronics, in which microwave-frequency spin waves carry information between transducers and interact non-linearly upon propagation for processing [1]. At a more fundamental level, spin-wave excitations are quantized into bosonic quasi-particles called magnons [2]. The quantum behaviors of magnons have long been a powerful inspiration for theoretical works, with a view on quantum transduction or magnetic-field metrology [3]. However, non-classical magnon states remain particularly difficult to achieve in the laboratory. Except for a few iconic works [4], it is rare that the quantum characteristics of magnons can be accessed experimentally, and applications of magnonics are limited to large macroscopic systems held at room temperature and behaving classically.

In this seminar, I will outline our start in assembling the experimental pre-requisites for realizing quantum magnon states. Central to this effort are material considerations, with the selection and engineering of magnetic insulators aiming to isolate magnon modes from other degrees of freedom and to preserve their coherence. I will first review our progress in the epitaxial synthesis (sputtering and liquid phase epitaxy) of thin films of magnetic insulators, which exhibit enhanced magnon coherence at cryogenic temperatures [5,6]. Then, we will discuss the pathways to scaling down magnonic systems to regimes that let their quantum nature emerge [7]. Finally, I will present our recent experimental findings in dynamical stabilization exploiting spin currents [8], linking them to future directions that can step away from the classical picture in magnonics.

[1] P. Pirro et al., Nat. Rev. Mater. **6**, 1114–1135 (2021)
[2] T. Holstein & H. Primakoff, Phys. Rev. **58**, 1098–1113 (1940)
[3] H. Y. Yuan et al., Phys. Rep. **965**, 1–74 (2022)
[4] Y. Tabuchi et al., Science **349**, 405 (2015)
[5] W. Legrand et al., Adv. Funct. Mater., 2503644 (2025)
[6] J. Ben Youssef et al., arXiv:2509.06242 (2025)
[7] D. Petrosyan et al., submitted.
[8] E. Karadža et al., arXiv:2601.09569 (2026)

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