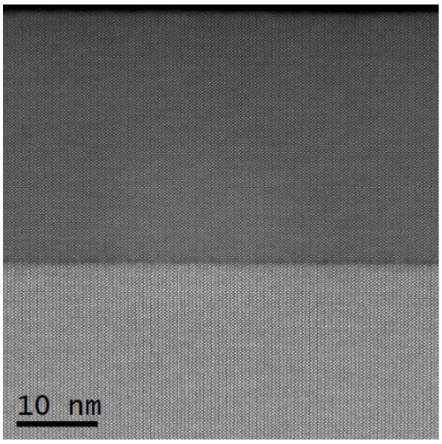
NÉEL – SPINTEC – LNCMI, Grenoble
Ph.D. thesis – QuantAlps Spring 2025 Call

Antiferromagnetic spintronics for quantum excitations

General Scope: The recent years have witnessed a renewed interest in the mutual coupling of condensed-matter excitations of different nature (incl. photons, phonons, magnons, etc.), aiming to build hybrid devices with new functionalities to be leveraged in quantum engineering. In this context, the transfer of angular momentum between photons, phonons, magnons and electrons in antiferromagnets is a vast subject of fundamental research that could pave the way for the generation, manipulation and electrical conversion of chiral antiferromagnetic spin waves in the sub-THz to THz frequency range. The THz dynamics of the antiferromagnetic order parameter is directly related to the internal exchange interactions between the spin sub-lattices (~100T), which is several orders of magnitude larger than the internal fields involved in the GHz dynamics of ferromagnetic materials. This experimental approach is supported by the tremendous progress made over the recent years in the synthesis of ultrathin (<100 nm) epitaxial films of antiferromagnetic insulators. While applications of antiferromagnets to room-temperature common electronics are now thoroughly investigated, there remains a largely unexplored potential for turning them into compact, cryogenic devices operating in the THz. They would present superior immunity to thermal fluctuations and thus be able to operate at temperatures of a few K, instead of the mK range. This investigation has potential to shape future key enabling technologies with quantum devices operating in the sub-THz to THz frequency range.

Research topic and facilities available: The core of this Ph.D. work will be to explore the fundamental coupling mechanisms of ferrimagnetic and antiferromagnetic magnons in the sub-THz to THz frequency range. You will benefit from the holistic knowhow in Grenoble covering from materials and spintronics to high fields and THz spectroscopies: NEEL (W. Legrand) [1], SPINTEC (V. Baltz and U. Ebels) [2,3] and LNCMI (A.-L. Barra) [4], as well as national and international collaborations [5]. You will work with state-of-the-art techniques of oxide synthesis, fabrication and characterization at the nanoscale, cryogenic temperatures, strong magnetic fields (15 T) and large frequencies (600 GHz). Your goals will be to exhibit the coupling mechanisms between magnons and electrons in the sub-THz to THz range, and to exploit them in nanodevices.



A cross-sectional scanning transmission electron microscopy image (collab. U. Zaragoza) of a 30-nm-thick epitaxial film of yttrium-enriched iron garnet, hosting low-dissipation magnons.

Required skills: Excellent academic record is mandatory. Applicants should have a Master's degree in Physics, good practical skills, and the will to pursue work on experimental physics, material science, and solid-state physics with a commitment to advanced instrumentation.

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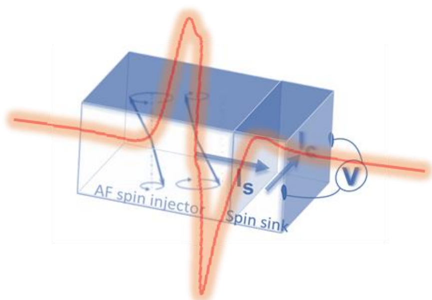

Concept for cryogenic sub-THz and THz spectroscopy of antiferromagnetic magnons in insulators, detected by electronic spin-orbital pumping.

[1] W. Legrand et al., arXiv:2407.06850 (2024)
[2] V. Baltz et al., Rev. Mod. Phys. **90**, 015005 (2018) ;
L. Frangou et al., Phys. Rev. Lett. **116**, 077203 (2016)
[3] D. Houssameddine, U. Ebels et al., Nat. Mater. **6**, 447 (2007)
[4] Y. Li, A.-L. Barra et al., Phys. Rev. B **92**, 140413 (2015)
[5] R. Lebrun et al., Nature **561**, 222 (2018)