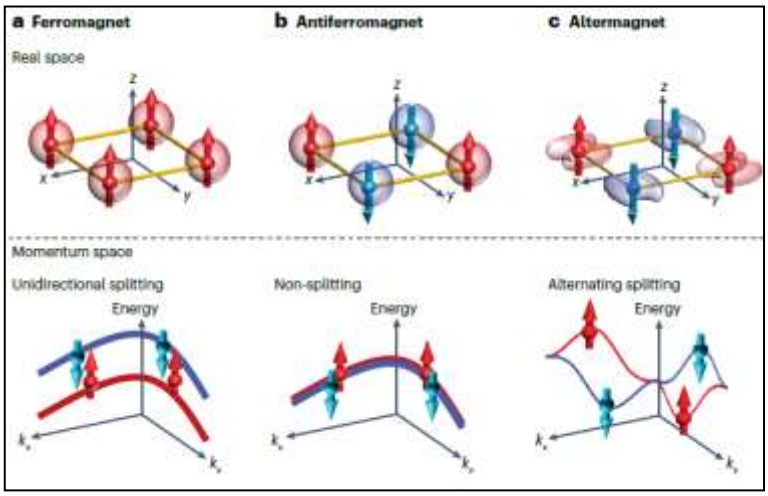
INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire Albert Fert
CNRS identification code: UMR 137
Internship director'surname: Villegas
e-mail:javier.villegas@cnrs-thales.fr Phone number:01 69 41 58 56
Web page: javierevillegas.wordpress.com
Internship location: 1 avenue A. Fresnel, 91767 Palaisuea
Thesis possibility after internship: YES
Funding: proposal submitted (ANR) If YES, which type of funding:

Proximity effects in superconductor/altermagnet interfaces

Altermagnets (AMs)[1,2] form a recently proposed third class of magnetic materials. Unlike ferromagnets, which exhibit parallel spins, or antiferromagnets, which show no net magnetization, AMs combine alternating spin alignment with unique symmetry connections (e.g., mirror or rotation). This results in spin-momentum locking enabling anisotropic spin transport and spin-polarized currents without net magnetization. Thus, from a technological perspective, AMs merge the advantages of ferromagnets (spin polarization of conduction electrons) and antiferromagnets (vanishing stray fields and high-frequency spin dynamics), making them promising for applications in spintronics and magnonics[3]. Since their theoretical proposal in 2022, AMs have attracted significant research attention, with experimental efforts focused on identifying materials that exhibit their subtle properties. However, their demonstration is challenging, often requiring sophisticated probes to distinguish AM responses from other effects, such as spin-orbit coupling. Thus key challenges include developing efficient probes for AMs and leveraging their unique spin properties for novel functionalities. We propose that exploring the interaction between superconductors (Ss) and AMs could provide a powerful approach to address these challenges[4]. We will experimentally explore three main mechanisms: proximity effect (penetration of superconducting correlations in the AM), the effect of the exchange field on superconductor's properties, and the dynamic interaction between magnetization dynamics in the AM and the superconducting state. **1**. Šmejkal Phys. Rev. X 12, 040501 (2022) ; **2**. Krempaský Nature 626, 517–522 (2024); **3.** Song et al. Nature Reviews Materials 10, 473–485 (2025); **4**. Mazanik et al. https://arxiv.org/pdf/2603.06188 (2026).



Techniques/methods in use: This is an experimental internship. The student will characterize d-wave superconductor/altermang heterostructures using transport measurements and FMR experiments in a cryogenic environment. The student will interact and work with postdocs, permanent researchers, as well collaborators experts in theoretical modelling.

Applicant skills: Excellent team player, rigorous and enthusiastic, the candidate has a strong scientific curiosity

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: NO