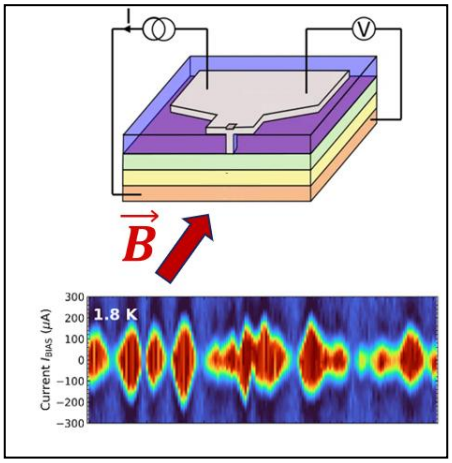
INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Albrert Fert
CNRS identification code: UMR137
Internship director'surname: Vincent Humbert & Javier Villegas
e-mail: vincent.humbert@cnrs-thales.fr **Phone number:** 0169415934
Web page: https://laboratoire-albert-fert.cnrs-thales.fr/en/research-topics/superconductivity/
Internship location: Laboratoire Albert Fert
1 A. Fresnel, 91767 Palaiseau
Thesis possibility after internship: YES
Funding: NO (fellowship)

Tunable Josephson Junctions based on 2D materials and d-wave superconductors

Superconducting electronics plays a central role in diverse fields, from astrophysics to telecommunications and quantum information. Among its fundamental components, the Josephson junction is a key building block for developing devices that exploit **quantum coherence** and the specific properties of superconductivity. When coupled with **two-dimensional materials**, it enables the development of new tunable functionalities.



This project aims to develop and characterize **novel Josephson junctions** combining high-critical-temperature d-wave superconductors with various families of two-dimensional (2D) materials, beyond graphene. Thanks to their tunable electronic properties and atomic thickness, 2D materials offer numerous opportunities to **design hybrid devices with controllable properties**. The project will focus on two complementary architectures: planar junctions, where transport occurs laterally within the 2D material, and vertical junctions based on multilayer heterostructures. The goal is to explore how material choice, geometry, and interfaces influence superconducting coupling and device properties.

During the internship, we will fabricate devices using home-developed processes and characterize them through low-temperature electronic transport measurements. Electrostatic control will enable the study of Fermi level influence on the critical current and Josephson properties. This work will establish the foundations for new tunable junctions with fundamental interest and application prospects in superconducting electronics and quantum information, particularly through the group's existing collaborations.

References: Seurre et al., APL 125, 092603 (2024) ; Perconte et al., Annalen der Physik 534 (8), 2100559 (2022), Perconte et al., PRL 125 (8), 087002 (2020)

Techniques/methods in use: The internship will involve the fabrication of superconducting heterostructures in a cleanroom environment, and measuring their electronic transport in a cryogenic setup with magnetic field.

Keywords: Superconductivity, Van der Waals, Transport measurements, Lithography, Film growth, Teamwork

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:	YES	Theoretical Physics:	YES