INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Charles Coulomb
CNRS identification code: UMR 5221
Internship director'surname: Vincent Jacques
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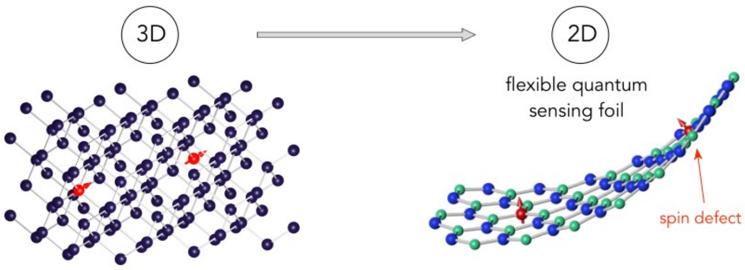
Internship location: Montpellier

Thesis possibility after internship: YES
Funding: Requested If YES, which type of funding: ANR, QuantEdu

Quantum sensing with spin defects hosted in a two dimensional material



Quantum sensing technologies powered by solid-state spin defects have already shown a huge potential for covering the growing need for high-precision sensors, both for basic science and for industrial applications. State-of-the-art quantum sensing methods rely on spin defects hosted in three-dimensional (3D) materials which are facing several obstacles including (i) a limited spatial resolution resulting from the dim proximity that can be achieved between the quantum sensor and the target sample, and (ii) the inability to engineer ultrathin and flexible quantum sensors that could be easily transferred onto the samples to be probed or integrated into complex multifunctional devices. The objective of this research project is to overcome these limitations through the design of a flexible, quantum sensing foil based on an atomically-thin two-dimensional (2D) material. Our approach consists in using optically-active spin defects hosted in 2D hexagonal boron nitride (hBN), a wide-bandgap material which is a key building block of van der Waals heterostructures. More precisely, the work will be focused on the study of the spin and optical properties of the boron vacancy (VB) defect in hBN, in order to assess its potential for quantum sensing applications, with a focus on magnetic field detection. The objective of the internship will be to analyze the performances of ultrathin hBN flakes (down to the monolayer limit) doped with VB centers for quantitative magnetic field imaging at cryogenic temperature (4K). On a longer-term perspective, the goal will be to integrate this quantum sensors into van der Waals heterostructures in order to probe, in situ, the physics occurring at the interfaces between atomically thin 2D materials assembled in vertical stacks, with a focus on 2D magnets and 2D superconductors.

Some recent publications of the host group linked to the project:

- A. Durand et al., Physical Review Letters 131, 116902 (2023)
- T. Clua-Provost et al., Physical Review Letters 131, 126901 (2023)
- T. Clua-Provost et al., Nano Letters 24, 12915 (2024)
- Z. Mu et al., Nature Communications 16, 8574 (2025)

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: NO