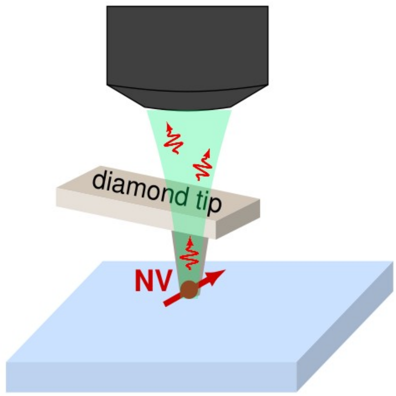
INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Charles Coulomb (L2C)
CNRS identification code: UMR5221
Internship director'surname: FINCO
e-mail: aurore.finco@umontpellier.fr Phone number: 0467144820
Web page: https://solidstatequantumtech-l2c.fr/
Internship location: L2C - Montpellier

Thesis possibility after internship: YES
Funding: YES, ANR JCJC grant QUAMION

Probing ferroelectric order with a quantum scanning probe microscope

Quantum sensors take advantage of the extreme sensitivity of quantum systems to external perturbations to accurately measure a broad range of physical quantities such as acceleration, rotation, magnetic and electric fields, or temperature. Among a wide variety of quantum systems employed for sensing purposes, the **nitrogen-vacancy (NV) defect in diamond** has garnered considerable attention in the last decade for the development of a new generation of magnetometers providing an unprecedented combination of spatial resolution and magnetic sensitivity under ambient conditions. The host group at Laboratoire Charles Coulomb (Montpellier) has played a major role in the development of this innovative magnetometry technique, with a focus on its **applications in condensed matter physics**.



Sketch of a scanning NV microscope

The goal of the present project is to extend the functionalities of NV-based quantum microscopes towards the **detection of electric fields at the nanoscale, in order to study ferroelectric textures.** The principle of the scanning NV microscope is sketched in Fig. 1. A single NV defect hosted at the apex of a nanopillar in a diamond scanning-probe unit is integrated into an atomic force microscope and scanned in close proximity of a sample. At each point of the scan, a quantitative electric field measurement is performed by recording the **Stark shift of the NV defect's electron spin sublevels** through optical detection of the electron spin resonance**.** The first task of the project will be to precisely **assess the electric field sensitivity of the single spin electrometer**. Since the sensitivity of the NV defect to electric field is expected smaller than its sensitivity to magnetic fields, we will design measurement protocols based on spin echo sequences, which allow the detection of weak AC signals. After a careful characterization of the performances of the NV-based electrometer, the second task will be to apply NV-based electrometry to the non-perturbative nanoscale imaging of domain walls in standard ferroelectric materials like $BaTiO_3$, $PbZrTiO_3$ or $LiNbO_3$, where it has recently been shown that some walls exhibit a unexpected noncollinear internal structure. We will then investigate more complex materials like the multiferroic $BiFeO_3$ or twisted bilayers of van der Waals materials like h-BN.

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