Master proposal : towards neuromorphic applications with 2D ferroelectrics materials

Join the **2D+ Research Group at CRHE**A on the French Riviera near Nice, France. We are looking for a highly motivated and talented candidate to contribute to pioneering research in nanophotonics with 2D materials. This position offers an exceptional opportunity to investigate emerging phenomena including sliding ferroelectricity, ultra-low-threshold nonlinear photonics, and exciton engineering. The work is conducted within the European-funded 2DFERROPLEX consortium, which unites leading experts in the field.

Research Focus

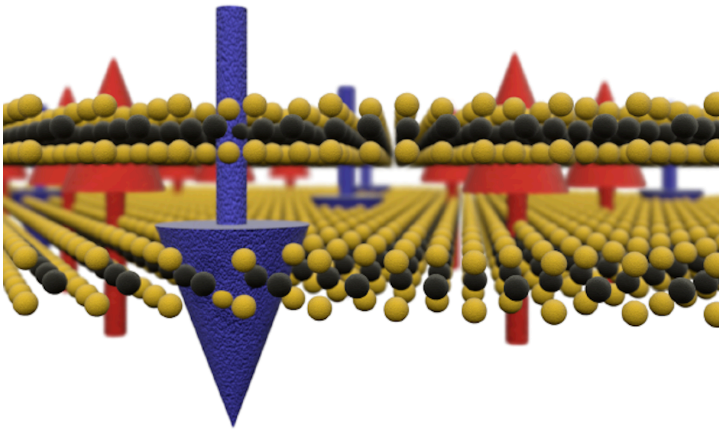
By simply **sliding** one 2D crystal atop another, the electronic properties of the resulting heterostructure can change dramatically. Remarkably, a large-bandgap insulator can become **ferroelectric**, solely due to this relative twist—without any additional modification. This phenomenon gives rise to out-of-plane ferroelectric domains.

The goal of this master's internship is to **optically detect, track, and ultimately control the ferroelectric state** in such materials. Key objectives include imaging ferroelectric domains in a new class of 2D ferroelectrics using state-of-the-art cryogenic micro-spectroscopy techniques. This work involves understanding the influence of the dielectric environment on interlayer excitons and unraveling the mechanisms governing domain dynamics, such as flipping and domain wall propagation—central to the emerging physics of sliding ferroelectricity.

The ultimate ambition is to develop a strategy for **optically switching** these domains, thereby laying the groundwork for a novel optoelectronic device. Such a system could serve as a non-linear optical activation function in photonic neuromorphic computing, where no fully compatible component currently exists.

Facilities and Equipment

Our **state-of-the-art cryo-optics lab** covers 100m² and includes cutting-edge tools such as a fully functional cryostat for **micro-photoluminescence, reflection spectroscopy, and optoelectrical measurements**. We also have a fully equipped **FabLab** dedicated to building custom van der Waals heterostructures, which are essential for the assembly of quantum devices. These advanced facilities will enable the intern to contribute to groundbreaking experimental research directly.



Responsibilities

- Conduct in-depth literature reviews, experimental design, and data analysis focused on the optical properties of 2D ferroelectric materials.
- Design and implement experiments to monitor and control ferroelectricity using optical techniques and atomic force microscopy (AFM).
- Contribute to the fabrication and optimization of 2D heterostructure devices in a state-of-the-art cryogenic optics laboratory.
- Drive innovation toward emerging applications in 2D quantum photonics and light-based neuromorphic computing.

Desired Skills and Qualifications

- **M1** (or equivalent) in physics, photonics, or condensed matter.
- **Genuine enthusiasm** for photonics, nanofabrication, and hands-on experimental physics.
- **Proficiency in Python**; familiarity with Arduino, robotics, or 3D printing is a plus but not essential.
- **Strong organizational and communication skills**, with a proactive and collaborative approach to teamwork.

Opportunities for Professional Growth

- **Present your research findings** at international conferences and publish in high-impact peer-reviewed journals.
- **Collaborate with leading researchers** in the 2D materials community, both at CRHEA and across the 2DFERROPLEX (2dferroplex.eu) consortium (Barcelona, Manchester, Munich, Strasbourg, Prague).
- **Develop hands-on expertise** in a state-of-the-art cryogenic-optics laboratory and FabLab, acquiring the skills vital for a successful career in photonics or semiconductor physics, whether in academia or industry.

References:

- **Interfacial ferroelectricity in marginally twisted 2D semiconductors**. Weston, A. et al. Nature Nanotechnol. 17, 390–395 (2022).
- **Photonic and optoelectronic neuromorphic computing**. El Srouji, L. et al. APL Photonics 7, 051101 (2022).
- **A Scalable Network Model for Electrically Tunable Ferroelectric Domain Structure in Twistronic Bilayers of Two- Dimensional Semiconductors.** Enaldiev, V. V., Ferreira, F. & Fal'ko, V. I. Nano Lett. 22, 1534-1540 (2022).

How to Apply

Interested candidates are encouraged to send a CV, cover letter, and academic transcript to Dr. Antoine Reserbat-Plantey (arp@crhea.cnrs.fr). For further details on the project opportunities or other projects in the team, do not hesitate to get in touch.