INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Solides (LPS)
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Internship location: LPS – Université Paris Saclay – Bat 510 – ORSAY - LUTECE Team

Thesis possibility after internship: YES
Funding: YES **If YES, which type of funding**: LPS/SOLEIL

Inducing Exotic Electronic Phases of Quantum Matter by Tuning Crystal Symmetries

The electronic properties of condensed matter systems are intimately linked to the arrangement and species of atoms that constitute the atomic lattice.
In the last years, at LPS, we developed a new way to induce controllable strain in 2D quantum materials at cryogenic temperatures using a **cryogenic biaxial tensile strain device**, which is compatible with several probes to access structural and electronic properties of the materials under consideration. The scientific aim of this device is to study such electronic phases as **charge density waves (CDW), spin density waves (SDW) and superconductivity (SC) in strained 2D systems**. We successfully used a combination of x-ray diffraction (XRD) and transport measurements to demonstrate that when the quasi-tetragonal system TbTe3 is strained, the CDW modulation direction can be tuned by a change of in-plane symmetry of the Te planes in TbTe3, so that the relevant parameter is the in-plane crystallographic aspect ratio a/c. We also showed that the gap value saturates rapidly when a/c=1, but that Tc diverges linearly, with an impressive increase of ~40K [A. Gallo-Frantz et al, Nat. Comm. 2024]. This behaviour is unexpected within the framework of usual theories, that establish a direct link between the gap and Tc. These exotic electronic orders thus deserve to be studied further.
These results are a good example that we need to go beyond those measurements and access other relevant quantities to have a clear overall comprehension of such **strain-induced exotic electronic phenomena**. The aim of this work is to develop and perform new experiments under biaxial tensile stress to determine: what is the microstructure of the CDW during the orientational switching phenomenon? can we directly measure the gap associated to these CDW? how general is this behaviour in 2D CDW systems? how are other electronic states such as SC affected by strain?
To answer those questions, we propose a **methodology based on laboratory and large-scale instruments (synchrotron and XFELs) experiments** involving strained 2D quantum systems such as RTe3 systems, or Transition Metal Dichalcogenides (1T-TaS2 and NbSe2).
. In the laboratory, we will access **structural parameters by XRD**, and perform **transport measurements** to get the transition temperatures and electrical conductivity properties.
. **ARPES measurements** will be performed in the LUTECE group at LPS, but also in Synchrotron to directly measure the gaps under deformation, using home-made device compatible with UHV. Those sample holders will also be used to **perform STM** to directly determine whether the two CDW lie in the same Te planes.
. A **synchrotron experiment will be planned at the ESRF** (European synchrotron facility in Grenoble) in spring 2025 to perform nano-XRD, and get the nanostructure of the CDW of TbTe3 in the coexisting state.
This internship can be **followed by a funded PhD thesis**, in collaboration with SOLEIL synchrotron, to study **light-induced and mechanically-induced strained CDW systems**.

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