INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: YES/NO **If YES, which type of funding**: ANR

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. This behaviour is absolutely 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 role of electron-phonon coupling in these strain-induced transitions ? 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 that combines 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. Optical spectroscopy measurements, like optical photoluminescence, will give insight into the optical transitions and gaps when applicable. Finally, we will study the microstructure of CDW systems under strain with large-scale instrument techniques, as well as get an idea of electron-phonon coupling using femtosecond time-resolved techniques at synchrotrons and XFELs. These experimental studies will go along theoretical works, in collaboration with theoreticians of LPS.

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