INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Matériaux et Phénomènes Quantiques
CNRS identification code: UMR 7162
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Internship location: Université Paris Diderot - CNRS UMR 7162
Bât Condorcet - 10, rue Alice Domon et Léonie Duquet
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Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Ultrafast light-control of electronic orders in van der Waals materials

Understanding and controlling emergent phases in low-dimensional systems is a key challenge in condensed matter physics. **Van der Waals (vdW) materials**, composed of atomically thin layers, provide an ideal platform for addressing this challenge. Their structure, held together by weak interlayer forces, allows access to unique quantum phenomena such as magnetism, charge density waves (CDWs), and superconductivity in the two-dimensional (2D) limit. **The fragile nature of these phases, driven by enhanced fluctuations, offers exceptional tunability by external controls.** However, conventional methods like electrical gating or applying pressure face inherent limitations in the speed of phase switching and the selectivity for specific phases.

In this internship, which is expected to lead to a PhD thesis, the student will **use laser-based techniques to induce phase transitions in the least dissipative and fastest ways.** This will be achieved by using a novel ultrafast Raman scattering set-up (left panel in figure) capable of "probing" how the electronic ground state is modified by a "pump" pulse with sub-picosecond time resolution. During the internship the technique will be applied to 2D vdW transition metal dichalcogenides (TMD) like TaS_2 and $NbSe_2$ displaying CDW order coexisting with either chiral or superconducting order. Specifically, the student will investigate whether light can efficiently switch the balance between these orders, or even induces completely novel orders that do not exist in equilibrium (right panel in figure). **The ultimate goal will be to establish light as a selective control parameter of quantum phases.**

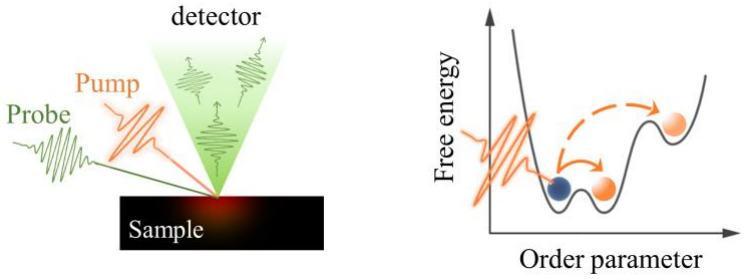

Figure 1. *Left panel*: schematics of ultrafast pump-probe Raman spectroscopy. *Right panel*: Laser pulses can switch or push the phase of a matter (in blue) to new metastable phases (orange) in ultrafast timescales.

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