Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Institut des Nanosciences de Paris (INSP)
CNRS identification code: UMR7588
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Internship location: INSP, Jussieu, Couloir 22-32, 2ème étage

Thesis possibility after internship: YES
Funding: NO (Bourse ministerielle) If YES, which type of funding:

Superconductivity and charge density waves in the 2D limit

Since the discovery of graphene, it has become possible to produce perfectly 2D crystals composed of one or few atomic layers. Examples of these systems are transition metal dichalchogenides, single layer high Tc cuprates or FeSe iron pnictides. Moreover each 2D insulator can be made metallic via field effect doping (FET), i.e. by applying an external electric field in a capacitor geometry. It is then possible to explore the phase diagram of these 2D crystals simply by turning the voltage knob. This is a great chance for theory as it becomes possible to study the competition of superconductivity, charge density waves and Anderson insulating states in two dimensions. However, in literature there are no calculations able to describe superconductivity induced by strong electric fields.
In recent years, we developed several theoretical approaches to study electronic and vibrational properties of materials under strong electric fields. These approaches have to be extended to the treatment of 2D superconducting states. In this internship, we propose to (i) develop a theoretical approach to describe FET induced superconductivity and (ii) to apply it to 2D superconducting crystals.

The ideal candidate should have a strong theoretical background in quantum mechanics and solid state physics and show interest in developing new analytical and numerical approaches.

Publications of the supervisor related to the project are:

G Profeta, M Calandra, F Mauri, Nature physics **8**, 131 (2012), I. Errea, M. Calandra, C. J. Pickard, et al., Nature **532**, 7597 (2016), M. Calandra, P. Zoccante, F. Mauri, Phys. Rev. Lett. **114**, 077001 (2015)
Th. Sohier, M. Calandra, F. Mauri, Phys. Rev. B **96**, 075448 (2017)

More informations can be found on the web page or at
https://scholar.google.fr/citations?user=8EJhV9wAAAAJ&hl=en

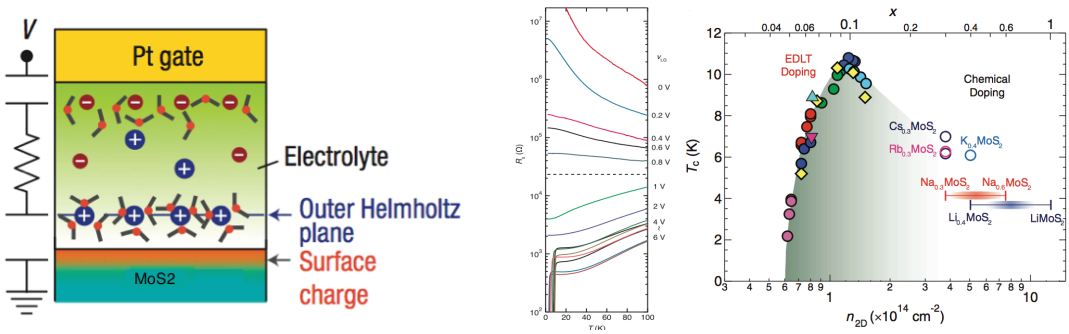

Fig. 1: Transforming the MoS_2 2D insulator into a metal. *Left*: FET device configuration. *Center*: transversal resistivity of the MoS_2 sample changing from insulating to metallic by increasing V. *Right*: Superconducting phase diagram of MoS_2 by FET doping and intercalation.

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: YES