'Physique et Chimie des Matériaux' – ED 397 – année 2022

PhD project for funding, to send by 28/02/2022 to

nadine.witkowski@sorbonne-universite.fr under PDF form « acronyme labo_nom PI.pdf »

Research unit (full name + acronym) : IMPMC
Team if applicable : DEMARE
Address : 4, place Jussieu, 75005 Paris

Project leader (PI): Andrea Gauzzi HDR? select Position : select
Tel 01 44 27 42 16 email : andrea.gauzzi@sorbonne-universite.fr
Nber of phD under supervision 0 Participation to supervisor training? select Year

Co-supervisor : Yannick Klein HDR? select Position : select
Tel 01 44 27 44 56 email : yannick.klein@sorbonne-universite.fr
Research unit : IMPMC
International co-supervision ? select

Keyword 1 : Excitons Keyword 2 : Superconductivity
Keyword 3 : Correlated electron systems Keyword 4 : Two-dimensional systems

Select co-funding programme if applicable : select

Project title : Excitons and superconductivity in two-dimensional chalcogenides

Project Description :

Quasi two-dimensional (2D) layered transition metal chalcogenides are remarkable for their tunable electronic and optical properties including semiconducting, semimetallic, superconducting (SC) and charge density wave (CDW) states. Typically, these properties are controlled by chemical intercalation, ionic gating or mechanical exfoliation. Common wisdom has been that electronic correlations are weak in these compounds and that the SC mechanism is of the conventional BCS electron-phonon type. In fact, the discovery of high-temperature SC in the FeSe system has led to propose an alternative scenario of a non-Fermi liquid state and of unconventional superconductivity driven by electronic excitations, such as magnons.

In the present PhD project, we shall address this open issue by investigating the electronic and transport properties of vanadium layered chalcogenides characterized by large charge fluctuations arising from the mixed-valence V^{3+}/V^{4+} properties. Following previous proposals by Little [1] and Ginzburg [2], we shall investigate the possibility that these fluctuations induce the formation of excitons stabilized by the poor screening of the charge carriers, a characteristic property of semimetals in 2D. In order to implement this research project, we shall focus on the M_xVS_2 system characterized by VS_2 layers intercalated with a transition metal M, such as CuV_2S_4 [3], V_5S_8 and V_3S_4. This crystal structure enables us to tune the electron doping and the bandwidth by using the intercalant concentration, x, and pressure as control parameters, respectively.

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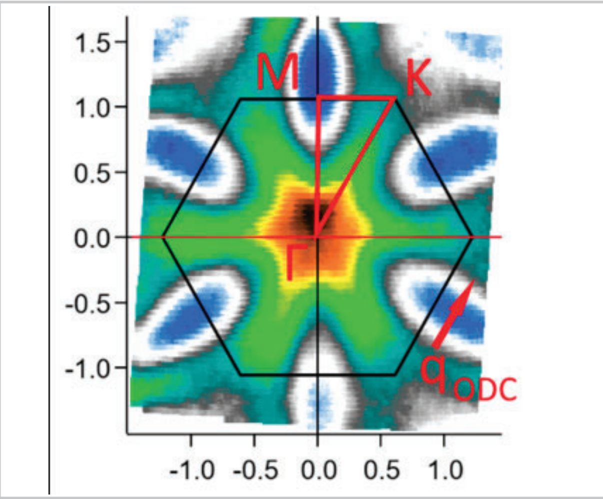
The main objective of the PhD project will be to uncover experimentally the signature of excitons in the system by using advanced spectroscopic techniques, such as EELS and angular photoemission spectroscopy (ARPES). This activity will be supported by ab initio calculations using density functional theory or many-body Green-function methods that take into account electronic correlations (coll. M. Helgren, B. Lenz and M. Casula, IMPMC).
A systematic study of the above systems by means of specific heat, magnetic, magnetotransport and thermopower measurements at low temperature and under high pressure shall provide complementary indications as to the signature of excitons on the thermodynamic and transport properties.
In order to realize successfully the proposed PhD project, the candidate shall have a strong background in solid state physics and good skills in the experimental work, such as single-crystal growth, thermodynamic and transport measurements at low temperatures and advanced spectroscopic methods.



Fermi surface of a V5S8 single crystal probed by ARPES.

[1] W. A. Little, Phys. Rev. 134, A1416 (1964).
[2] V. L. Ginzburg, Usp. Fiz. Nauk 101, 185 (1970).
[3] A. Gauzzi et al., J. Phys.: Condens. Matter 31, 31LT01 (2019).