SCIENCES SORBONNE UNIVERSITÉ

Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie

Campus Pierre et Marie Curie
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Director: A. Marco Saitta

2021-2022

Master thesis proposal

Title: Electronic correlations and instability of the Fermi liquid in 2D chalcogenides

Keywords: metal-insulator transition (MIT), excitons

Scientific 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.

The candidate 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 and Ginzburg, 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*. 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.

Main objective of the internship is to uncover experimentally the signature of excitons in the system by using advanced spectroscopic techniques, such as EELS (coll. D. Taverna, IMPMC). This activity will be supported by *ab initio* calculations that take into account many-body effects (coll. M. Helgren and M. Casula, IMPMC). A systematic study 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.

Techniques/methods: single-crystal growth, thermodynamic and transport measurements at low temperatures, EELS

Applicant skills: In order to realize successfully the proposed project, the candidate shall have a strong background in solid state physics and good skills in the experimental work.

Industrial partnership: N

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Internship location: IMPMC-Sorbonne Université, Pierre and Marie Curie Campus

Possibility for a Doctoral thesis: Y (possibility of PhD grant provided by the ED397)