22nd March 2024

PhD contract offer

Electronic structure of low-dimensional systems with strong spin-Orbit coupling and remarkable topological properties remarkable topological properties

General information

Workplace: Institut Jean Lamour, Nancy, France
Type of contract: PhD contract
Contract period: 36 months
Expected date of employment: October 2024
Proportion of work: Full time
Remuneration: 2100 € (gross salary)

Missions / Activities

The existence of a strong spin-orbit coupling in 2D or 3D materials allows band inversion leading to the formation of a topologically non-trivial band structure [1-4]. The non-trivial character of the band structure in an insulator (i.e. topological insulator) induces robust metallic edge states under the effect of structural disorder because they are protected by topology or symmetry [5]. In addition, these edge states exhibit a singular spin texture (often chiral) that can be directly demonstrated by spin resolved photoemission spectroscopy (spin-ARPES) [6-9]. Another family of materials with strong spin-orbit coupling exhibits remarkable properties: transition metal dichalcogenides. These are lamellar solids made up of a stack of monolayers linked together by weak Van der Waals-type bonds. The strong spin-orbit coupling induces spin-valley coupling, which gives remarkable electronic and optical properties [10,11]. More recently, it has been shown that topological properties also occur in semi-metals (Dirac and Weyl semi-metals) where the topological signature is present in both bulk and edge states [12,13]. Photoemission is the most suitable technique for highlighting this type of property.

The subject we are proposing is part of the electron spectroscopy study of these materials with remarkable electronic properties. In this thesis project, the PhD student will study the electronic properties of materials with strong spin-orbit coupling (topological materials and/or transition metal dichalcogenides), produced in situ in the Davm tube at the Institut Jean Lamour or ex-situ, by using spectroscopic techniques (ARPES, STM/STS). Additional measurements, in particular spin resolved photoemission, will be carried out on synchrotron beamlines. The PhD student will have to implement ARPES and STM/STS measurements on the team's devices and on synchrotron (in particular on the SOLEIL synchrotron beamlines). A more theoretical part is also planned. The PhD student will have to simulate the photoemission spectra obtained experimentally by combining DFT calculations with spectral weight calculations [14].

Work context

Exotic properties of several families of materials (high-Tc superconductors, heavy fermions, Multiferroics) originate in electronic interactions, the coupling of different degrees of freedom (orbital, spin) and relativistic effects. These new states of matter are a subject of fundamental study, but also hold great promise for applications in electronics, spintronics, optronics and spin-orbitronics. Over the past twenty years, a new concept has emerged in condensed matter physics, that of the topological material, whose properties (quantum Hall effect or spin quantum Hall effect) are associated with the phase variation of wave functions in the Brillouin zone. An emblematic example is topological insulators, which exhibit metallic edge states whose propagation direction depends on spin, hence their interest in spintronics. In this thesis work supervised by Daniel Malterre and Geoffroy Kremer ("Surfaces Spectroscopies et Modélisations" team in the Physics of Matter and Materials department of the Institut Jean Lamour), the PhD student will study low-dimensional materials with strong spin-orbit coupling and non-trivial topological properties (topological insulators, Dirac and Weyl semi-metals, etc.) using spin spectroscopies.) using electron spectroscopy (ARPES, spin-ARPES, STM/STS...) in the laboratory and/or on synchrotron lines (especially for spin-ARPES).

Skills required

Candidates must hold a Master's degree in condensed matter physics (or equivalent), with solid experience in solid state physics, particularly in the study of the structural and electronic properties of solids, and an appetite for experimental work.

Enthusiasm, curiosity, initiative, the ability to work as part of a team and rigor would be appreciated. Programming skills or a taste for data analysis would be a plus.

About Institut Jean Lamour

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine.
Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics.
It regroups 183 researchers/lecturers, 91 engineers/technicians/administrative staff, 150 doctoral students and 25 post-doctoral fellows.
Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world.
Its exceptional instrumental platforms are spread over 4 sites; the main one is located on Artem campus in Nancy.

Application

Applicants are invited to send a CV, two names of recommending people together with diploma copies and grades to:
Pr. Daniel Malterre : daniel.malterre@univ-lorraine.fr
Dr. Geoffroy Kremer : geoffroy.kremer@univ-lorraine.fr

Bibliography

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