2D gases in oxide nanostructures revealed by high space, energy and momentum resolved spectroscopy

PhD thesis

université PARIS-SACLAY

Title: 2D gases in oxide nanostructures revealed by high space, energy and momentum resolved spectroscopy
Scientific Responsibles: Jean-Pascal Rueff and Alexandre Gloter
Laboratory : SOLEIL synchrotron and Laboratoire de Physiques des Solides @ Paris Saclay
Type of Contract: PhD Student contract (36 months)
Start date of the PhD thesis: September/December 2021

Summary

Complex oxides such as ABO_3 perovskites form a vast class of materials with a plethora of fascinating, intrinsic physical functionalities. The intriguing interplay of charge, spin, and orbital ordering in these systems superimposed by lattice effects opens a scientifically rewarding playground for both fundamental and application-oriented research. In particular, the possibility of externally modifying the properties of thin-film complex oxides by epitaxial strain or artificial boundaries, and thus potentially generating novel properties (2D gas, superconductivity, magnetism, ...) at the interfaces between films opens up many perspectives and new applications [1]. **Among these properties, the occurrence of 2D electron gases and their possible applications for spin-to-charge conversion, and/or in contact with ferro-electric, could result in new devices with reduced energy consumption [2].**
In this thesis, the student will use and develop a combination of state-of-the-art synchrotron spectroscopy and electron spectro-microscopy techniques to unravel the structural and electronic structure of such oxide materials at the atomic scale in connection with their optical and transport properties [3]. The thesis will focus on novel oxide materials prepared as bulk, thin films or heterostructures such as $SrTiO_3$/manganite, $SrTiO_3$/metal, $BaTiO_3$/metal, or $BiFeO_3$/metal. Their electronic structure will be investigated by advanced synchrotron techniques including hard x-ray photoelectron spectroscopy (HAXPES) and inelastic X-ray scattering (IXS) [4] at high resolution which can probe the electronic properties and fundamental excitations of materials. In parallel, the PhD student will perform space and momentum resolved scanning transmission electron microscope - electron energy loss spectroscopy (STEM-EELS) [5] with unprecedented resolution with the aim at unravelling the electronic and orbital / symmetry reconstruction of thin film, interface or superlattices. These structural and electronic properties will be discussed with respect to the physical measurements and *ab-initio* modelling.

Keywords

2D gases, interface physic, thin film, ferro-electricity, electron microscopy, electron spectroscopy, X-Ray inelastic scattering, material modelling.

Supervision and host institution

J.-P. Rueff (jean-pascal.rueff@synchrotron-soleil.fr) and A. Gloter (alexandre.gloter@universite-paris-saclay.fr) will supervise the PhD thesis.

The thesis will be conducted jointly in the STEM group at the Laboratoire de Physiques des Solides and at SOLEIL synchrotron, both at Université Paris-Saclay, France.

The STEM group is a world leading electron microscopy team well recognized for its work on the structural, optical and electronic characterization of nanomaterials combining experimental spectro-microscopy and numerical modeling. High-technology facility, SOLEIL is both an electromagnetic radiation source covering a wide range of energies (from the infrared to the x-rays) and a research laboratory at the cutting edge of experimental techniques dedicated to matter analysis down to the atomic scale

Located south of Paris, the Paris-Saclay University is at the core of the biggest scientific pole in France and it has been recently ranked first European university in physics by the Academic Ranking of World Universities.

https://www.synchrotron-soleil.fr/fr/lignes-de-lumiere/galaxies

https://www.stem.lps.u-psud.fr/

The student will be part of a collaborative network involving the research group synthetizing the thin film samples and measuring the transport properties at the Unité Mixte de Physique CNRS-Thales (collaboration with Manuel Bibes).

http://oxitronics.cnrs.fr

Applicant

The candidate holds an MSc or equivalent degree in Physics or related fields (condensed matter physics, applied physics, material science, ...). Students with an interest for experimental physics are welcome to apply. Affinity with spectroscopy (synchrotron), microscopy techniques (TEM, STEM, HAADF, ABF, EELS, etc..) will be an asset. PhD student will work in an international competitive context requiring a high motivation to learn and a strong intellectual curiosity.

Contract

36 months PhD contract following the CNRS French regulation.

Starting date: Sept-Dec 2021 for 3 years.

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References

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