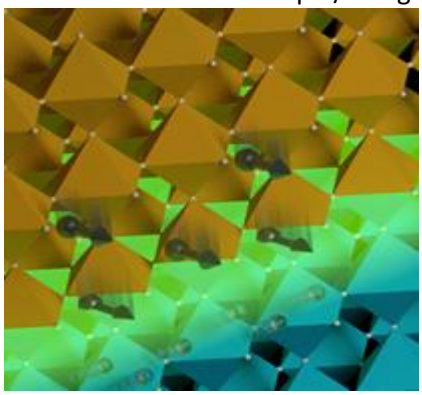
Unité Mixte de Physique CNRS/Thales – Université Paris-Saclay – 1 avenue Fresnel – 91767 Palaiseau- France

PHD THESIS PROPOSAL

Quantum oxide heterostructures for spin-charge interconversion

Spin-based electronics (spintronics) exploits the spin degree of freedom of electrons in addition to their charge to store and manipulate information. Traditionally, spintronics has relied on ferromagnetic metals such as Fe, Co or Ni and their alloys, but recently new pathways have emerged to generate spin currents from charge currents and vice-versa. This new paradigm, called **spin-orbitronics**, exploits the interplay between charge and spin currents enabled by the spin-orbit coupling (SOC). Two important physical effects of spin-orbitronics allowing the creation of pure spin currents from charge currents and vice versa are the Spin Hall Effect and Inverse Spin Hall Effect in bulk materials with SOC. In the last few years, another spin-charge interconversion mechanism has focused attention. Interface and surfaces states are two-dimensional in nature and can have broken inversion symmetry, which may result in a Rashba effect. This effect can in turn be utilized to realize spin/charge interconversion through the **direct and inverse Edelstein effects**. One of the most promising family of 2DEGs for spin-charge conversion is that of interfaces of $SrTiO_3$ (STO). While in the bulk stoichiometric STO is a wide band gap insulator (the gap is 3.1 eV), it becomes conductive for minute electron doping through the creation of oxygen vacancies, Sr substitution by La or Ti substitution by Nb. Even more remarkable is the discovery that STO can house an interfacial 2DEG when a few unit cells of another wide bandgap insulating perovskite, $LaAlO_3$, is epitaxially grown onto it. This 2DEG has a high mobility, is superconducting at low temperatures and possess a sizeable Rashba SOC tunable by a gate voltage. In 2016, we have shown that this Rashba SOC can be used to realize spin-charge conversion with a record efficiency. Interestingly, the conversion efficiency and its sign are tunable by a gate voltage, which can be understood from the electronic structure of the 2DEG.



Sketch of the 2DEG at the $LaAlO_3/SrTiO_3$ interface and the conversion of a vertical spin current into a planar charge current

The proposed PhD will focus at the exploration of the inverse (spin-charge) and direct (charge-spin) Edelstein effects in heterostructures and nanostructures based on $SrTiO_3$ and related oxides. Various approaches to define a 2DEG based on metal or oxide deposition onto STO will be investigated. Spin-charge conversion will be performed either through spin-pumping or in transport experiments. Charge-spin conversion will be used to induced a spin-torque on a ferromagnetic layer adjacent to the 2DEG, in order to manipulate magnetic domain walls or magnetization, and control magnetization dynamics.

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Techniques in use: Thin film growth by pulsed laser deposition and sputtering, optical lithography, magnetotransport, ferromagnetic resonance

Applicant skills: Affinity for experimental work, high motivation, good knowledge of condensed matter physics and magnetism, good organization skills, capacity to work in a group.

Funding already secured through an EU project. Start September or October 2018.

The proposed research will involve strong collaboration with Spintec (Grenoble) and LPEM-ESPCI (Paris).