IRAMIS : Institut Rayonnement Matière de Saclay

Saclay

SPEC/LNO

Injection de spin dans des interfaces bidimensionnelles d'électrons

Spécialité Physique de la matière condensée

Niveau d'étude Bac+5

Formation Master 2

Unité d'accueil SPEC/LNO

Candidature avant le 28/03/2018

Durée 5 mois

Poursuite possible en thèse oui

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Résumé

Le but du stage est d'injecter des spins dans des systèmes électroniques bidimensionnels à fort couplage spin-orbite afin d'étudier la conversion spin/charge.

Sujet détaillé

Spintronics relies on the discrimination of spin up and down carriers originally generated by charge currents in metallic ferromagnets. Recent developments aim to get rid of this source of dissipation by manipulating pure spin currents without their charge counterpart. One convenient way of achieving this is to use the spin-orbit coupling (SOC) interaction in a non-magnetic heavy metal like Pt. The interaction relies on a preferential directional scattering of electrons of different spins resulting in the generation of a spin current transverse to a charge current called the Spin Hall Effect (SHE). As signals should eventually be read as voltages, it is important to efficiently convert spin into charge, which can also be done using the inverse Spin Hall effect. Very recently, another SOC effect based on the Rashba interaction was shown to be more efficient. The effect stems from the joint action of the SOC and built-in electric potentials in two-dimensional electron gases existing at surfaces, interfaces or semiconductor quantum wells. Lastly, similar physics is at play in topological insulators, materials which are insulating in the bulk but conducting at their surfaces due to broken symmetry inducing topological states.
The Inverse (Rashba) Edelstein Effect (IEE) was first demonstrated in 2013 in the Ag/Bi interface. We have confirmed the origin of this effect and also studied other 2-D gases like that at the $LaAlO_3/SrTiO_3$ interface. A 2D electron liquid appears between these two insulators when $LaAlO_3$ is epitaxially grown on TiO_2-terminated $SrTiO_3$ along the [001] direction. Electrons are transferred to the interface to compensate for the polar discontinuity present between the two materials. A strong Rashba spin-orbit interaction also results from the breaking of inversion symmetry, whose strength can be tuned by applying an external electric field. Several measurements remain to be carried out in this system including in-plane dependences of the Rashba coefficient, tunneling of a pure spin current through the $LaAlO_3$ barrier and the influence of the ferroelectric instability in doped $SrTiO_3$. Some other systems can also be envisioned like interface states in topological insulators like the irridates $SrIr_2O_4$.
The ‘stage’ proposed here will consist in measuring these properties as spins are injected by ferromagnetic resonance and laser induced ultra-fast excitation of a ferromagnet. Both techniques are mastered in our laboratory and the latter

is very promising as it can give very interesting information concerning time-resolved injection and spin lifetime. The LAO/STO samples come from the University of Geneva while irridates are synthesized in our group by Pulsed Laser Deposition.

Mots clés

spintronique

Compétences

Logiciels

Python, origin.

Spin injection in 2-D interface states

Summary

The subject aims at studying the spin to charge conversion by 2-D interface states with strong spin-orbit coupling.

Full description

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Keywords

Skills

Pulsed laser deposition (PLD). Structural characterizations (X-ray and electron diffraction), near field microscopies (AFM). Optical magnetic imaging with second harmonics (SHG). Lasers (Nd-YAG, femto-second Ti:Al_2O_3). Magnetism (SQUID, VSM). Electronic transport measurements.

Softwares

Python, origin.