Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique de l'Ecole Normale Supérieure (LPENS)
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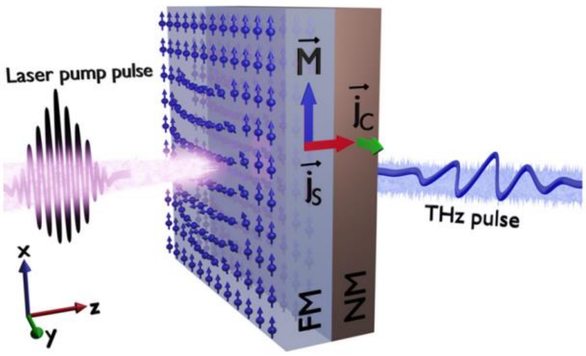
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Terahertz spintronics – Quantum Materials for Ultrafast Spin-to-Charge Conversion

This project will study spin-to-charge conversion (SCC) in novel topological/ferromagnetic materials, bringing a step change in the application and understanding of quantum interfaces for terahertz (THz) spintronic devices.

The excitation of a magnetic material by ultrafast laser pulses has become an active research field in magnetism. Recently, when excited by an ultrashort femtosecond laser pulse, a spintronic element composed of a ferromagnet (FM)/heavy metal (HM) bilayer has shown to emit THz waves via the conversion of the excited spin current into transient dipole charges. This spin-to-charge conversion (SCC) phenomena is made possible owing to the spin-orbit interaction (SOI). This occurs via the inverse spin Hall effect (ISHE), arising in the bulk of heavy metals (like Pt or W), or via the inverse Edelstein-Rashba effect (IEE) at spin-orbit split quantum interfaces in topological insulators. Moreover, ultrafast SCC emitters possess the advantage of phonon-less spectra resulting in no THz spectral dips and extremely large bandwidths (larger than 20THz), compared to other materials and technology. In this case, topological materials are expected to boost the THz performances owing to potentially high SCC, through their topologically protected conductive surface states. These possess the unique property of spin-momentum locking: the spin of the carrier is oriented perpendicular to its momentum direction. This particular spin texture, in momentum space, provides spin accumulation with upon charge current injection.



We will bring i) a full understanding of THz generation via spin currents that remains incomplete, and ii) show highly efficient heterostructures for THz emission using novel quantum materials, taking advantage of their high figure of merit and SCC power.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO