Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Matériaux et Phénomènes Quantiques
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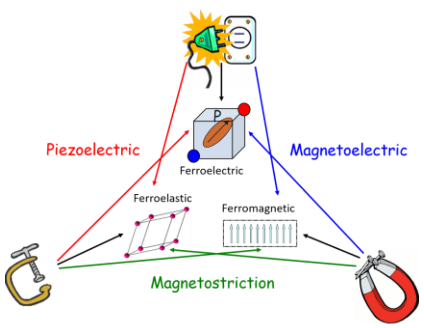
Internship location: Université de Paris – Campus Condorcet, 10 rue Alice Domon et Léonie Duquet 75013 Paris
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: doctoral school

Spin waves dynamics and hybrid excitations in multiferroics



The present project dwells on the recent surge of interest in a family of very attractive materials in which both ferroelectric and magnetic orders are present. These materials, known as multiferroics, have attracted much attention worldwide because they open the possibility of tuning the polarization direction with a magnetic field and/or the change the magnetization direction via an applied voltage. Multiferroic materials are therefore prime candidates for the manipulation of spin states via electric fields and the tuning of dielectric properties via magnetic fields, both very desirable for applications. [1]

Using optical spectroscopies (Raman in our lab, time resolved acoustic at INSP, SU and synchrotron radiations at Soleil) under different conditions (pressure, uniaxial strain, low temperature, under electric and magnetic field), we are able to study the spins excitations, the phonon modes and the hybrid excitations combining spin waves and polar phonons called electromagnons mediated by the Dzyaloshinskii-Moriya interaction. Our work has given major contributions in the field [2,3] to **understand the fundamental properties and interactions of multiferroic materials**.

The aims of this project is to investigate the compound CuO, a multiferroic between 210 and 230K where an electromagnon has been observed by mean of THz time-domain spectroscopy. Pressure has been theoretically proposed to switch the multiferroic phase at room temperature. We wanted to reveal several hitherto unexplored regimes using pressure and studding electromagnons. To do that we are using a uniaxial strain experiment to optically measure the behavior of the spin and lattice excitations as a function of the strain. We also use the IR spectroscopy in the THz range in combination with high-pressure/low-temperature set-up available at Soleil.

To fully understand the coupling between the magnetic and ferrolectric properties in this compound we will collaborate with theoricists. This subject is a premilary work for a thesis in our team.

[1] *Des ondes de spin pour l'électronique*, Maximilien Cazayous, Yann Gallais, et Alain Sacuto, Dossier Pour la Science n°79 - avril - juin 2013.
[2] *Driving spin excitations by hydrostatic pressure in $BiFeO_3$ single crystals*, J. Buhot, et al, Phys. Rev. Lett. 115, 267204 (2015).
[3] *Colossal electromagnon excitation in the non-cycloidal phase of $TbMnO_3$ under pressure*, I. Aupiais, et al, NPJ Quantum Materials 3, 60 (2018).

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