Master 2: *International Centre for Fundamental Physics*

PhD PROPOSAL

Laboratory name: Laboratoire de Physique du Solide
CNRS identification code: UMR 8502
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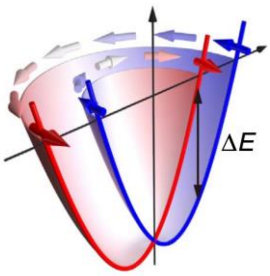
Internship location: Orsay
Thesis possibility after internship: YES
Funding already obtained for a PhD: NO If YES, which type of funding:

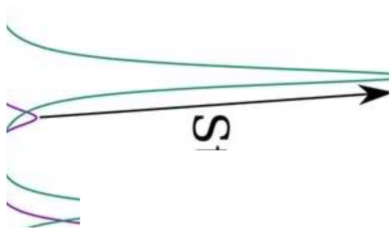
Spin-orbit coupling tuning in two-dimensional systems

Next generation spintronics efficiently targets ultra-low power memories for green electronics and on a longer term full-spin information processing. The spin-orbit coupling (SOC) plays a fundamental role in spintronics as it allows controlling the spin in the conduction channels through an electrostatic manipulation [1-3].

SOC is greatly enhanced at reduced dimensions since the inversion symmetry is broken at surfaces or interfaces, and the resultant electric field couples to the spin of itinerant electrons, a phenomenon known as Rashba effect. Spin-orbit coupling is being intensively studied in two dimensional systems as in transition metal dichalcogenides, hybrid perovskites or in molecular layers on ferromagnetic substrates [4-6].

In this internship, we will tune the SOC in 2D materials by structural modification, for instance by introducing defects in the structure (vacancies or impurities) or by introducing strain in the lattice. The effect of the induced structural modification will be studied by electron diffraction and the impact on the electronic bands will be determined by angle-resolved photoemission (occupied states) and by spin- and angle-resolved inverse photoemission (unoccupied states) [7].





(Left) Spin-orbit splitting of the bands due to Rashba effect. (Right) Strain in 2D materials is a way of tuning the spin-orbit coupling.

Profile: Experimentalist with solid state formation. Experience in surfaces physics, electron spectroscopies, local microscopies or diffraction will be appreciated. Ability to work in a team.

[1] A. Fert, "Nobel Lecture: Origin, development, and future of spintronics", Rev. Mod. Phys. 80, 1517 (2008).
[2] H. C. Koo, J. H. Kwon, J. Eom, J. Chang, S. H. Han, and M. Johnson, "Control of Spin Precession in a Spin-Injected Field Effect Transistor", Science 325, 1515 (2009).

[3] A. Soumyanarayanan, N. Reyren, A. Fert and C. Panagopoulos, “Emergent Phenomena Induced by Spin–Orbit Coupling at Surfaces and Interfaces”. Nature 539, 509 (2016)
[4] D.W. Latzke W. Zhang, A. Suslu, T.-R. Chang, H. Lin, H.-T. Jeng, S. Tongay, J. Wu, A. Bansil, and A. Lanzara, “Electronic structure, spin-orbit coupling, and interlayer interaction in bulk MoS2 and WS2”, Phys. Rev. B 91, 235202 (2015).
[5] J. Even, L. Pedesseau, J.-M. Jancu, and C. Katan, “Importance of Spin−Orbit Coupling in Hybrid Organic/Inorganic Perovskites for Photovoltaic Applications”, J. Phys. Chem. Lett. 4, 2999 (2013).
[6] C. Barraud, P. Seneor, R. Mattana, S. Fusil, K. Bouzehouane, C. Deranlot, P. Graziosi, L. Hueso, I. Bergenti, V. Dediu, F. Petroff and A. Fert., “Unravelling the role of the interface for spin injection into organic semiconductors”, Nature Phys. **6**, 615 (2010).
[7] A. F. Campos, P. Duret, S. Cabaret, T. Duden, A. Tejeda, “Spin- and angle-resolved inverse photoemission setup with spin orientation independent from electron incidence angle”, Rev. Sci. Instrum. 93, 093904 (2022).

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