Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Solides
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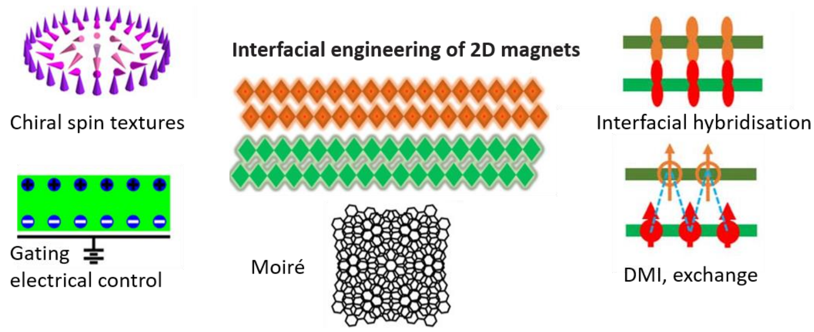
Internship location: LPS, Université Paris Saclay, plateau du Moulon

Thesis possibility after internship: YES
Funding already obtained for a PhD: YES/NO If YES, which type of funding: ANR

Interfacial magnetic interactions in 2D systems

Interfacial magnetic interactions, such as exchange coupling, Dzyaloshinskii-Moriya interaction (DMI) and interfacial perpendicular magnetic anisotropy (PMA), radically change the behaviour of thin-film magnets, of which spin textures are often a manifestation. In metallic thin films, chiral spin textures stabilised by DMI and PMA (e.g. spin spirals, skyrmions) have been intensively studied due to their small size and efficient propagation by current. The exotic properties of van der Waals (vdW) 2D materials, along with the comparatively simple fabrication of atomically-thin but wide heterostructures have set in motion a small revolution in research and opened the way to systems with completely new functionalities. In magnetism, in particular, the discovery of ferromagnetic (FM) order in vdW materials, either in exfoliated single layers or in weakly-coupled multi-layers, allows for the study of purely 2D magnets either in relative isolation or integrated in heterostructures [Fig a]. In vdW materials and heterostructures, due to their thinness and exotic electronic properties, interfacial magnetic effects may be strengthened and modified well beyond what is possible in metals. The atomic control of the thickness of the vdW layers, the electronic properties and symmetry of their interfaces, the diversity of possible stackings and device engineering (proximity effects, contacts for current injection, electric field gating…) constitute tuning parameters to induce new properties at the nanometric scale. Furthermore, vdWs present clean and abrupt interfaces, more suitable for a realistic modelling than metallic systems.
VdW heterostructures constitute a vast class of systems with potentially new functionalities in nanomagnetism that remain essentially uncharted. The goal of the internship is to explore how the interfaces in vdW heterostructures can be engineered to produce magnetic interactions (DMI, PMA, exchange) that enable useful functionalities (e.g. movable skyrmions) and to understand their key ingredients. It will follow our first experiments that demonstrate a large DMI in polycrystalline Co/hBN systems [Fig b] and rely on the use of complementary techniques in magnetism (growth, magneto-optics, imaging, spin waves…).



a)

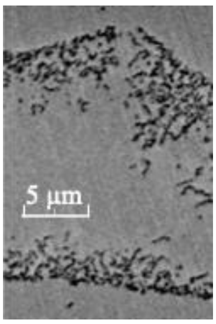
b)


Figure: a) Explored concepts of interfacial engineering in 2D magnets in heterostructures. Adapted from [Gong19, Li22]. b) Preliminary experimental results of Skyrmions in Co/hBN imaged by MFM (LPS).

[Gong19] C. Gong & X. Zhang, Science 363, 706 (2019)
[Li22] Y. Li et al., ACS Appl. Electron. Mater. 4, 3278 (2022)

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