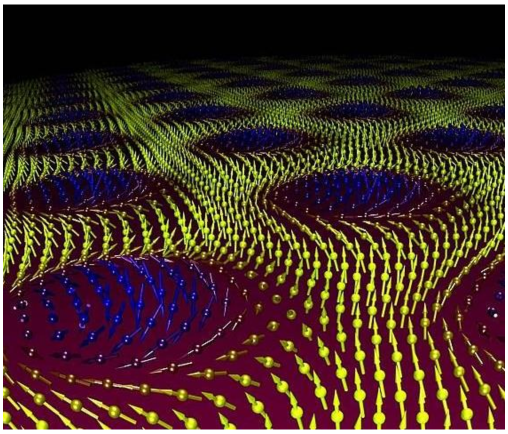
Unité Mixte de Physique CNRS/Thales – Université Paris-Saclay – 1 avenue Fresnel – 91767 Palaiseau- France

MASTER THESIS PROPOSAL (M2) 2016-2017

Interface-engineered topological spin texture in manganese perovskite thin films

In centrosymmetric magnetic materials, one exchange interaction usually dominates, which results in a collinear (antiferromagnetic or ferromagnetic) spin texture. In non-centrosymmetric systems an antisymmetric exchange interaction (Dzyaloshinskii-Moriya interaction or DMI) is allowed and competes with the classical Heisenberg exchange to produce non-collinear spin states. The ground state of the system may correspond to a periodic arrangement of topologically protected spin configurations called skyrmions (see Fig. © TU Munchen). Skyrmions have been first discovered by neutron diffraction in bulk non-centrosymmetric metallic alloys [1], and later imaged in real space by different techniques [2]. However, non-centrosymmetric magnets are rare, and very few order above room temperature.

Interestingly, the spatial symmetry breaking required to achieve DMI and thus skyrmionic states also occur at interfaces in thin film heterostructures [3]. This strategy strongly alleviates the restriction in terms of materials, and skyrmionic states have been engineered and observed in transition metals such as Co or Fe interfaced with heavy metals such as Pt or Ir and/or insulators such as AlO_x or MgO.



In this framework, this internship will aim at the search for possible topological spin configurations akin to skyrmions in perovskite oxide heterostructures [4]. The starting material will be $La_{2/3}Sr_{1/3}MnO_3$ (LSMO), a half-metallic ferromagnet with a T_C=360 K, that will be interfaced with other functional perovskites including heavy elements (a 5d semi-metallic perovskite with large spin-orbit coupling, $SrIrO_3$, and a ferroelectric perovskite, $BiFeO_3$). An asset of epitaxial LSMO single films is that their magnetic properties can be strongly engineered by e.g. epitaxial strain (for instance, compressive strain promotes perpendicular magnetic anisotropy) or doping. In addition, they can be combined with other functional perovskites, with atomically sharp interfaces and controlled atomic stacking sequences. Thus, LSMO-based epitaxial heterostructures look very promising to design unconventional spin textures at room temperature, since at the interface with either $SrIrO_3$ or $BiFeO_3$ one can anticipate strong DMI due to (i) the spatial symmetry breaking inherent to interface formation, (ii) the sizeable spin-orbit interaction of these materials and (iii) the large interfacial electric-field that should be induced in the LSMO by the ferroelectric polarization of the $BiFeO_3$.

Practically, the internship will involve sample growth by pulsed laser deposition, SQUID magnetometry, standard UV lithography to pattern Hall bars and magnetotransport experiments. A key aspect of the work will be the extraction of the different components of the Hall effect (ordinary Hall, anomalous Hall, etc) to identify specific transport signatures of skyrmionic states through the topological Hall effect. In parallel, microscopy techniques (Kerr microscopy, MFM) available at the lab will also be used to image the magnetic states.

[1] S. Mühlbauer et al, Science **323**, 915 (2009). [2] X. Z. Yu et al, Nature **465**, 901 (2010). [3] A. Fert, V. Cros, and J. Sampaio, Nature Nano. **8**, 152 (2013). [4] M. Bibes, J. E. Villegas, and A. Barthélémy, Adv. Phys. **60**, 5 (2011).

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Techniques in use: Pulsed laser deposition, UV lithography, SQUID magnetometry, magnetotransport
Applicant skills: Strong affinity for experimental work, good level in magnetism & condensed-matter physics
Allowance: >400 €/month **Possibility to extend by a PhD thesis:** Yes