Thesis subject

Name of the laboratory: CINaM (http://www.cinam.univ-mrs.fr/)

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Subject's title: Epitaxial growth and characterizations of chiral antiferromagnetic thin films

Subject description:

The development of new disruptive materials that reduce the environmental footprint of information and communication technologies represents a promising avenue. Among them, antiferromagnetic materials (AFM), thanks to their intrinsic properties, allow the realization of devices that are energy efficient, very stable against external perturbations, compact and faster than their ferromagnetic counterparts. In particular, the peculiar spin texture of Mn_3X materials (where X = Sn, Ge, Ga) [1-2] - chiral in their hexagonal phase - introduces a topological term in the transverse conductivity, at the origin of the anomalous Hall and giant Nernst effects [3-5]. Most of the studies to date have been performed on bulk single crystal samples or on sputtered thin films for which the variable crystalline quality leads to degraded transport properties with respect to the bulk material. With the objective of integrating these AFMs into spintronic devices allowing to manipulate their spin texture, this PhD work aims at synthesizing thin films of Mn_3Sn, Mn_3Ga and Mn_3Ge with a high crystalline quality and to characterize their structural, magnetic and transport properties in order to take advantage of this new non-collinear magnetism.

Objectives:

The candidate will first focus his/her work on the synthesis of the Mn_3X thin films by molecular beam epitaxy and the characterization of their structural properties using techniques such as RHEED, AFM, TEM, DRX, EBSD… The main objectives of the student will be to realize the growth of:

- fully epitaxial Mn_3X thin films with different growth direction on various substrates. We will also consider to growth of the thin films on piezoelectric substrates with the objective of manipulating the spin texture by electrical means [6].
- heterostructures based on this material to exploit the novel transport mechanisms in these chiral antiferromagnets.

The student will also participate to the characterization of the magnetic properties (SQUID, XMCD, XMLD…), electronic properties (XPS, ARPES) and the magnetotransport of the grown structures. Synchrotron runs should be considered.

Environment:

The « Si/Ge Heterostructure team » at the CINaM lab has been working on Mn-based materials over nearly two decades and is a world leader team in the growth of the ferromagnetic $Mn_5Ge_3C_x$- [7] and the antiferromagnetic Mn_5Si_3-based heterostructures [8]. Part of its activity focusses on the investigation of unconventional AFM.

Profile and skills required:

Highly motivated candidates in experimental physics with a Master degree (or equivalent) in condensed matter physics or materials science. A prior experience in physical or chemical vapor deposition growth would be appreciated. A strong involvement in the maintenance of the MBE chamber will be expected. Qualities such as pragmatism, professionalism, taste for teamwork, but also autonomy are expected. A good English level will be appreciated.

References:

[1] *Taylor et al., Phys. Rev. B **101**, 094404 (2020)*
[2] *Liu et al, Scientific Reports **7**, 515 (2017)*
[3] *Nakatsuji et al., Nature **527**, 212 (2015)*
[4] *Ikhlas et al., Nat. Phys. **13**, 1085 (2017)*
[5] *Li et al., Phys. Rev. Lett. **119**, 056601 (2017)*
[6] *Zhao et al., Rare Met **40**, 2862 (2021)*
[7] L. Michez *et al.*, Phys. *Rev. Materials **6**, 074404* (2022)
[8] I. Kounta *et al.*, Phys. *Rev. Materials **7**, 024416* (2023)