Quantum science
& nanomaterials | QMat

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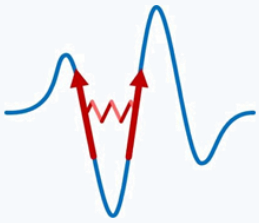

IPCMS Axis 4:
Magnetism

Mini-workshop:

Materials for magnonics

at the IPCMS Auditorium

→ Monday, March 25th :

15:00-16:00: Mairbek Chshiev
Designing spin-orbit and magnetic proximity effects with transition metals, oxides and 2D materials

→ Tuesday, March 26th:

09:15-09:45: Sébastien Petit-Watelot
Anatomy of (Self)Torque in GdFeCo ferrimagnet

09:45-10:15: Laura Thevenard
FeRh: phonons, magnons and their interactions

10:15-10:45: Mohamed Belmeguenai
Interfacial magnetic properties of Ir/Fe- and Pt/Fe-based systems: temperature and capping layers effects

10:45 : coffee break!

This mini-workshop will be followed by the ***PhD Defense of José Solano*** *at* ***14:00 in the IPCMS Auditorium***

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Abstracts

→ Monday, March 25th :

Designing spin-orbit and magnetic proximity effects with transition metals, oxides and 2D materials

Mairbek Chshiev

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A major attention has been recently focused on emerging fields of spin-orbitronics [1] and two-dimensional (2D) spintronics [2,3,4]. The first part of this talk will cover theoretical findings that allow unveiling microscopic mechanisms of perpendicular magnetic anisotropy (PMA) [1,5-11], Dzyaloshinskii-Moriya interaction (DMI) at interfaces comprising oxide (O), ferromagnetic (FM), nonmagnetic (NM) and/or 2D materials. Several approaches for PMA and DMI enhancement at FM/O [5-8], FM/NM, (NM)/FM/O and FM/2D interfaces and their variation under applied electric field (VCMA and VCDMI) [9], via ionic migration [10] or hydrogenation are proposed. DMI mechanisms and possibility of inducing skyrmions in 2D magnetic materials [4] and their chirality control by electric field will be also discussed. In the second part of the talk, the influence of different magnetic insulators on the magnetic proximity effect induced in graphene is investigated using europium chalcogenides (EuO, EuS), yttrium iron garnet (YIG), cobalt ferrite (CFO)) as well as mutliferroic bismuth ferrite (BFO) [26]. Large exchange-splitting values in graphene varying from tens to hundreds of meV depending on substrate are found and explored for introduction of several proximity induced transport phenomena named proximity electro- (PER), magneto- (PMR), and multiferroic (PMER) resistance effects [25,26].

[1] B. Dieny & M. Chshiev, ***Rev. Mod. Phys.*** 89, 025008 (2017)
[2] S. Roche, J. Åkerman, B. Beschoten et al, ***2D Mater.*** 2, 030202 (2015)
[3] H. Yang, S. O. Valenzuela, M. Chshiev, et al, ***Nature*** 606, 663 (2022)
[4] Q. H. Wang, A. Bedoya-Pinto, M. Blei et al, ***ACS Nano*** 16, 6960 (2022)
[5] H.X. Yang. M. Chshiev, A. Manchon et al, ***Phys. Rev. B*** 84, 054401 (2011)
[6] A. Hallal, H. X. Yang, B. Dieny, and M. Chshiev, ***Phys. Rev. B*** 88, 184423 (2013)
[7] A. Hallal, B. Dieny, and M. Chshiev, ***Phys. Rev. B*** 90, 064422 (2014)
[8] L. Vojáček, F. Ibrahim, A. Hallal, B. Dieny and M. Chshiev, ***Phys. Rev. Applied*** **15**, 024017 (2021)
[9] F. Ibrahim, H. X. Yang, A. Hallal, B. Dieny, M. Chshiev, ***Phys. Rev. B*** 93, 014429 (2016).
[10] F. Ibrahim, A. Hallal, B. Dieny, and M. Chshiev, ***Phys. Rev. B*** 98, 214441 (2018).
[11] H.X. Yang, A. Vu, A. Hallal, N. Rougemaille, J. Coraux, G. Chen, A.K. Schmid, M. Chshiev, ***Nano Lett.*** 16, 245 (2016)

Abstracts

→ Tuesday, March 26th :

09:15-09:45

Anatomy of (Self)Torque in GdFeCo ferrimagnet

Sébastien Petit-Watelot

Université de Lorraine, CNRS, Institute Jean Lamour, F-54000 Nancy, France

Spin currents and spin-torques (ST) generated through spin-orbit coupling (SOC) has been widely studied in ferromagnet/heavy metal bilayers [1,2]. The heavy metal is presented as an essential element of the structure since it generates a pure spin current through the Spin Hall Effect (SHE) which induces ST on the neighboring magnetic layer. Similarly, it is generally accepted that in magnetic materials, the spin polarization of the generated spin current is aligned with the direction of the magnetization due to the exchange interaction. The generation of such spin current is referred to as the Spin Anomalous Hall Effect (SAHE) [3]. However, theoretical works [4,5] have shown that the latter description is incomplete for magnetic materials with large spin-orbit coupling. In this case, the spin polarization can be preserved from alignment with the magnetization. The total spin current is therefore the sum of SAHE-like and SHE-like spin currents [3-5]

In this talk, we present a study on the ferrimagnet: GdFeCo, which combine strong SOC through the 5d conduction bands of Gd, and low magnetization. We show that GdFeCo is effectively the source of spin currents with the SAHE-like and SHE-like symmetries using spin-torque Ferromagnetic measurements [6]. We also show that the latter symmetry can induce a torque on the ferrimagnet magnetization, which we called self-torque [7]. To quantify the self-torque, we performed harmonic Hall voltage measurements on GdFeCo interfaced with a light metal. We first focus on the temperature dependence of the effective fields associated with the self-torque. We show that the effective fields are magnified near the magnetic compensation temperature TCM and reverse sign on both sides of it (see Fig. 1) [6,7]. We show that self-torque exhibits different characteristics compared to the external Spin-Orbit Torque.

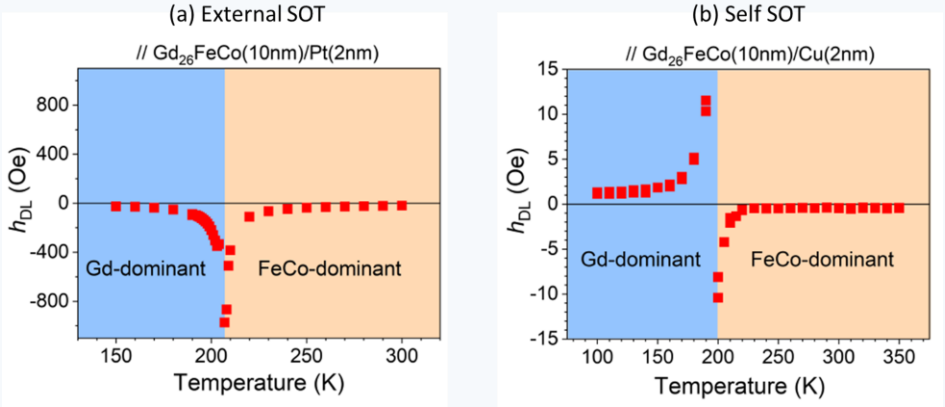

Fig. 1: Temperature dependence of the damping-like effective field h_DL for GdFeCo interfaced with a heavy metal (a) and a light metal (b).

[1] A. Manchon et al., Reviews of Modern Physics, vol. 91, no 3, p. 035004, (2019).
[2] Q. Shao et al., IEEE Transactions on Magnetics (2021).
[3] T. Taniguchi et al., Physical Review Applied, vol. 3, no 4, p. 044001, (2015).
[4] V. P. Amin, et al., Physical Review B, vol. 99, no 22, p. 220405, (2019).
[5] K-W. Kim, et al., Physical Review Letters, vol. 125, no 20, p. 207205, (2020).
[6] H. Damas, et al. Phys. Status Solidi RRL, 2200035, 2022.
[7] D. Céspedes-Berrocal et al., Advanced Materials 33.12: 2007047, 2021.

Abstracts

09:45-10:15

FeRh: phonons, magnons and their interactions

Laura Thevenard

Institut des Nanosciences de Paris, Sorbonne Université

FeRh is a fascinating material, which transitions from an antiferromagnetic phase to a ferromagnetic phase via a 1st order transition during which both phases coexist. I will present different ways of probing phonons and magnons in this material, as well as highlighting their magneto-elastic interaction: thermal studies, ferromagnetic resonance by surface acoustic wave, and inelastic Brillouin scattering.

10:15-10:45

Interfacial magnetic properties of Ir/Fe- and Pt/Fe-based systems: temperature and capping layers effects

Mohamed Belmeguenai

Université Sorbonne Paris Nord, LSPM, CNRS, UPR 3407, F-93430 Villetaneuse, France

Magnetic ultrathin heterostructures with a heavy metal/ferromagnetic film interface are attracting wide interest owing to the several novel phenomena that hosted and could play a crucial role in advancing the next generation of faster, denser and more efficient spintronic devices. Magnetic damping, interfacial Dzyaloshinskii–Moriya interaction (DMI) and perpendicular magnetic anisotropy (PMA) are key parameters for these spintronic devices functionality.

The focus of this presentation is to explore damping, perpendicular magnetic anisotropy (PMA), and interfacial Dzyaloshinskii-Moriya interaction (iDMI) in Ir/Fe- and Pt/Fe-based systems. Special attention is given to the effect of temperature measurement as well as the capping layer. The objective is to employ various materials and different combinations or stacking orders to discern the distinct contributions to PMA, iDMI, and damping. To achieve this, ferromagnetic resonance, Brillouin light scattering coupled with vibrating sample magnetometry techniques were utilized.