

MAGIC⁺ WORKSHOP

Magnetism, Interactions and Complexity

Invited

Spin-Orbit Torque Generation and Amplification of Spin-Waves in Garnets Micro-Structures

Abdemadjid Anane

Unité Mixte de Physique, CNRS, Thales, Université Paris-Saclay, 91767, Palaiseau, France

The recent discoveries in the field of insulating spintronic have initiated a surge of interest on ultra-thin insulating thin film based on garnets. The relativistic ultra-fast magnetic domain walls¹ driven by spin-orbit-torques in Bi doped YIG films as well as the coherent emission of spin waves² has made such materials a nesting ground for new physics thanks to their tailored magnetic properties. Even if garnets are investigated since the 60's the emergence of new growth approaches such as Pulsed Laser Deposition (PLD) and off-axis sputtering has proven that garnet ultra-thin films can possess dynamical properties comparable to that of micron-thick films traditionally grown using Liquid Phase Epitaxy (LPE)³. Interface transparency to pure spin currents that take place in adjacent heavy metal layers (most often Pt) has allowed for efficient modulation of the spin-waves' life-time through the Slonczewski-like spin-orbit-torque. For instance, 5 folds modulation of the spin wave attenuation length in 20 nm thick YIG films has been observed⁴ and even auto-oscillation⁵ has been reached. Nevertheless, electrical current flow in Pt induces joule heating in the Pt/YIG bi-layers inducing detrimental effects on the spin-wave spectrum. The reduction of saturation magnetization provokes a self-localisation of the induced magnetization dynamic inhibiting spin-wave emission. A solution to this issue has been proposed using $\text{Bi}_x\text{Y}_{3-x}\text{Fe}_5\text{O}_{12}$ system. Hence, the $\text{Bi}_x\text{Y}_{3-x}\text{Fe}_5\text{O}_{12}$ system seems to reveal itself as the most versatile material platform as it combines tunable magnetic anisotropy and ultra-low magnetic losses. Coherent Spin wave amplification using SOT can now be foreseen.

1. L. Caretta *et al.* Relativistic kinematics of a magnetic soliton, *Science*, 370, 1438-1442 (2020)
2. M. Evelt *et al.* Emission of Coherent Propagating Magnons by Insulator-Based Spin-Orbit-Torque Oscillators. *Phys. Rev. Appl.* 10, 041002 (2018)
3. L. Soumah *et al.*, Ultra-low damping insulating magnetic thin films get perpendicular. *Nature Communications*. 9, 3355 (2018)
4. M. Evelt *et al.*, High-efficiency control of spin-wave propagation in ultra-thin yttrium iron garnet by the spin-orbit torque. *Appl. Phys. Lett.* 108, 172406 (2016).
5. M. Collet *et al.*, Generation of coherent spin-wave modes in yttrium iron garnet microdiscs by spin-orbit torque. *Nat Commun* 7, (2016).