PhD on ultrafast spintronics

Partners involved : SPEC (lead), UMPhy, Soleil This PhD work here aims at assessing the potential of new spintronic components at the picosecond timescale. It will tackle three topics. The first one concerns spintronic THz emitters in which spin current bursts will be studied in detail in order to unveil the relevant physical quantities responsible for an efficient THz emission. The second deals with antiferromagnets and their ability to be applied in new ultra-fast spintronic components. These materials will be manipulated using pure spin currents generated by ultra-fast demagnetization of an adjacent ferromagnetic layer. The last topic deals with time-resolved imaging of non-collinear structures subjected to spin current stimuli. The methodology is based on a set of unique experimental techniques as described below:

- Second harmonic generation has been developed at SPEC and it is at present able to image ferroelectric or antiferromagnetic domains at a 500 nm length scale. It has also been upgraded for pump/probe measurements and it is able to stroboscopically image with a 100 fs time resolution. The newly acquired near field optical imaging setup will be soon upgraded in the frame of the new IMAGeSPIN experimental platform to measure second harmonic signals and later in pump/probe mode.
- The synchrotron based time resolved X-ray magnetic scattering experiment is under development at the SEXTANTS beamline at SOLEIL. A 800 nm/100 fs laser has been purchased in order to pump the sample and we will use the 10 ps long synchrotron pulse (in Low Alpha mode) as the probe. Measurements in reciprocal space as well as imaging using coherent scattering will be available at the start of the SPICY project. It should also be mentioned that an X-ray streak camera is also under development and ultimately should give access to shorter time scales down to 1 ps using the standard operation mode of SOLEIL.
- THz time domain spectroscopy is going to be set up at SPEC. Using a ZnTe crystal, the technique to be implemented is that of electro-optic sampling. Moreover, H. Jaffrès (UMPhy) will provide theoretical support on this part of the work based on a multiband tight-binding formalism.

Lastly, several materials will be synthetized by the relevant partners. UMPhy has a long experience in sputtering deposition of multilayers like Pt/CoFeB/Ru providing non collinear magnetic structures and the synthetic antiferromagnets Pt/CoFeB/Ru/Pt/CoFeB/Ru, as well as oxides including $BiFeO_3$, a multiferroic antiferromagnet and $TmFeO_3$ ideal for optical pumping. Other antiferromagnets including NiO, Cr_2O_3 and Fe_2O_3 will be deposited at SPEC. For the THz-TDS experiments, three classes of materials will be prepared at UMPhy: Bilayers of the 3d/5d transition metal systems for their ISHE properties, the 2D oxide electron gas (NiFe/LAO/STO) due to their strong Rashba properties and interfaces with the quantum topological insulators (like Co/Bi_2Se_3) for spin-charge interconversion at the level of the Dirac cone.