

“SPiCY” project: *Spin in NanoSaclay*

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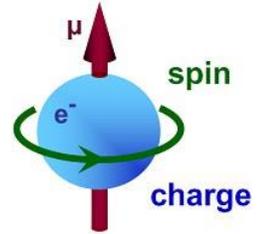
⁶ *Thales Research & Technology (Thales TRT), 1 av. Augustin Fresnel, Palaiseau*



SPINTRONICS : a rich and recent (hi)story

«Conventional electronics has forgotten the spin of the electron »

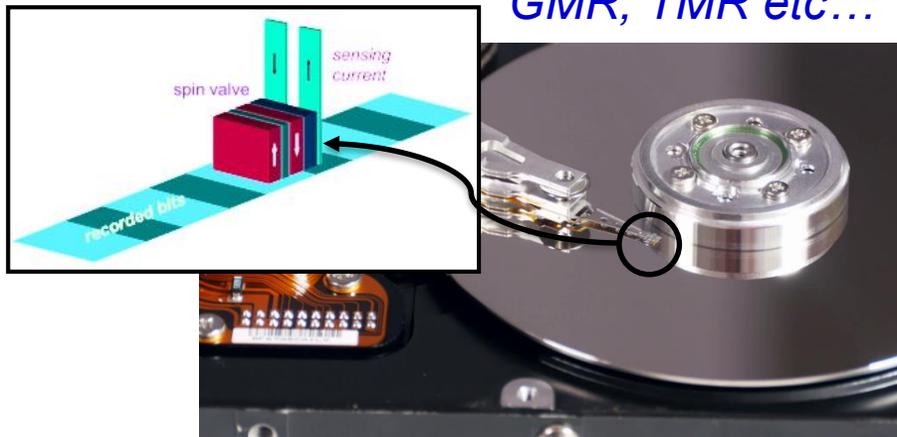
→ **SPINTRONICS**



❖ From fundamental research to applications in record time...

Magneto-resistive effects → Reading

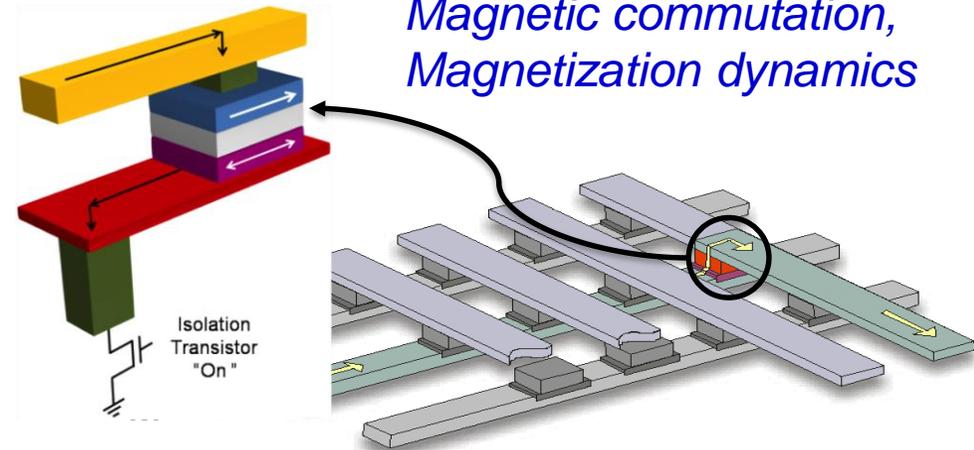
GMR, TMR etc...



Magnetic sensors, HDD read heads

Spin transfer effects → Writing

*Magnetic commutation,
Magnetization dynamics*



Non-volatile memories (STT-MRAM)

→ Toward **new breakthrough applications** in Information & Communication

*Technologies : rf spintronic devices, energy harvesting devices, neuromorphic hardwares
spintronic systems etc...*

New challenges and new paradigms in Spintronics

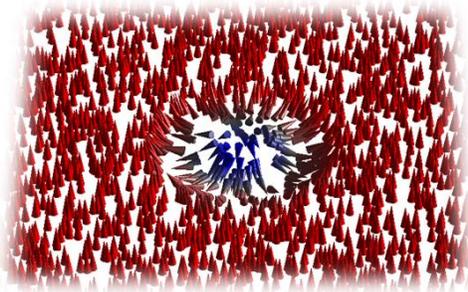
New materials : ferrimagnetic or antiferromagnetic films, 2D and 3D topological materials, magnetic insulator thin films, etc...

New concepts : use of topological spin textures, propagation of magnetic excitations, manipulation of pure spin currents etc...

+ interfacial properties and physical effects at interfaces

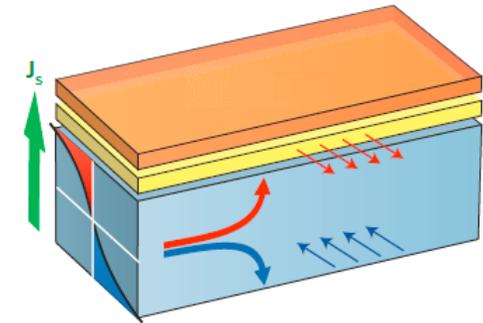
TOPOLOGICAL SPINTRONICS:

Use of the topological charge as a support of information

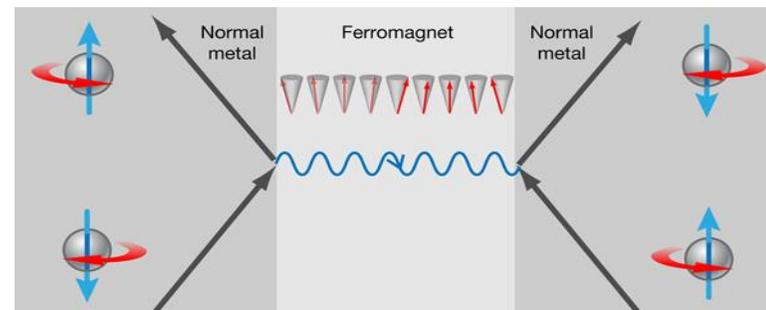
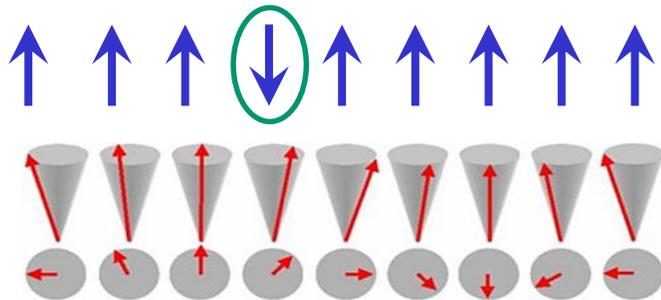


SPIN ORBITRONICS :

Efficient conversion between a charge current and a pure spin current



MAGNONICS : Use of elementary magnetic excitations: the magnons

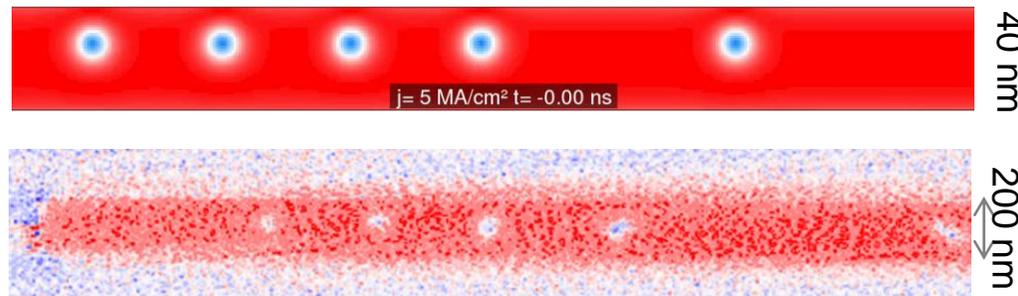


Towards new spintronic devices...

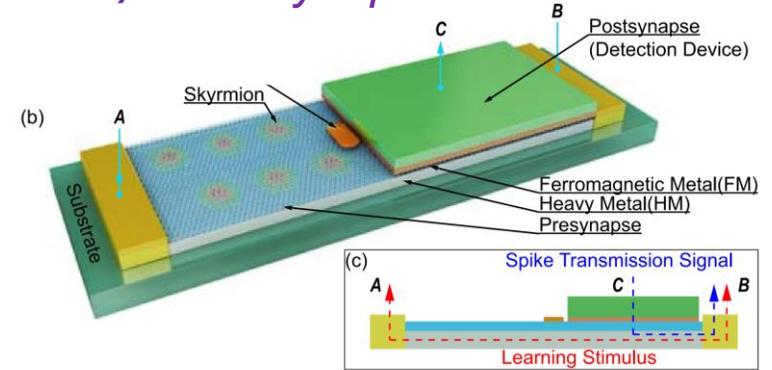
Denser, faster, less energy consuming, multi-functional ...

Skyrmion based devices:

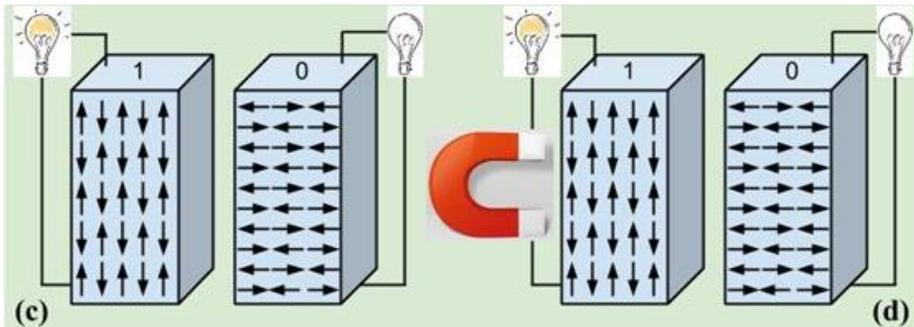
→ Skyrmion Racetrack memory



→ Skyrmion synapses

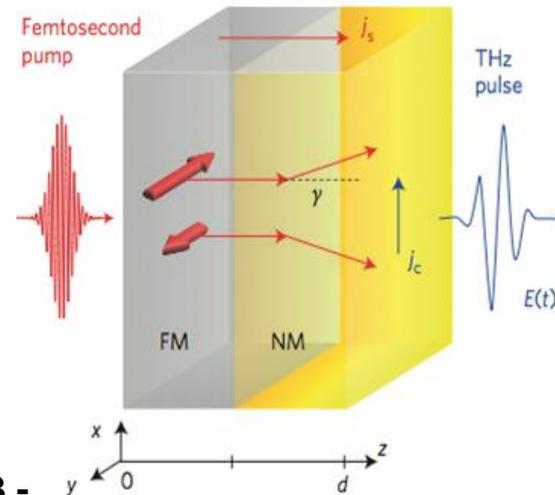


Antiferromagnetic memories :



→ Ultimate density, ultra-fast writing (ps)

THz spintronic emitters



→ Broad band,
large power,
tunable through
magnetoelectric
coupling

Context of the **SPiCY** flagship project

Paris-Saclay, the historical cradle of **Spintronics**, is now one of the 2 or 3 major poles on the international level.

One of the objectives of SPiCY is to strengthen this position but also to better organize the research effort, the training and the related technological developments

- **2017 : « IRS Spintronique » project from the initiative IDEX Paris-Saclay :**

This project is coordinated by D. Ravelosona (C2N) and A. Thiaville (LPS), comprising main spintronic laboratories in Paris-Saclay area and involving more than 100 permanent researchers, has been labelled as a strategic priority (not funded).

- **2018 : « IMAGeSPIN » platform, SESAME calls from Ile de France region**

The IMAGeSPIN project, coordinated by V. Cros (UMPhy), results from a reflection shared by the spintronics community of Paris Saclay on innovative instrumentation.

Scanning NV microscopy (UMPhy), k-resolved Brillouin Light Scattering (LPS), spacially resolved BLS (C2N) and Second Harmonic Generation microscopy (SPEC)

associated to the opportunities from the 3 beamlines from SOLEIL synchrotron i.e. Cassiopee, Sextants and Deimos, the SPiCY project has a set of equipments dedicated to nanomagnetism and spintronics that is unique in Europe and even in the world.

Flagship project SPiCY

→ **Strategic choice** that the support is fully dedicated to hire non permanent researchers : **4 PhD students + 1 postdoc (own funding)**

Topics	Lead partner	Other partners	Candidate + start
PhD on topological insulators/magnetic systems for spin-charge conversion	Unité Mixte de Physique CNRS/Thales (UMPhy), Palaiseau	C2N + SOLEIL	Diana She, 01/10/2020
PhD on ultrafast spintronics	Service de Physique de l'Etat Condensé (SPEC), Saint-Aubin	SOLEIL + UMPhy	Zixin Li, 15/10/2020
PhD on static and dynamic properties of skyrmions in ferrimagnetic systems	Laboratoire de Physique des Solides (LPS), Orsay	UMPhy + SOLEIL	Sujit Kumar Panigrahy, 15/11/2020
PhD on non-linear spin-wave dynamics in non-reciprocal spin-wave bus	Centre de Nanosciences et de Nanotechnologies (C2N), Palaiseau	SPEC + UMPhy	XX, 10/2021
Postdoc on magnetization dynamics in chiral thin films probed by x-ray resonant magnetic resonant scattering	Synchrotron SOLEIL (SOLEIL), Gif-sur-Yvette	UMPhy + SPEC	XX, 2021

Training and innovation in SPiCY

1. Actions for completing the number of PhDs and postdocs

- Secure fundings from other local actors e.g. **Ile de France region, SOLEIL synchrotron, Thales TRT** as well national or european agencies e.g. **ANR, DGA, CNES, CNRS, ITNs** etc.

2. Actions for further structuration

- Foster connections and collaborations with **other themes and communities @ Paris-Saclay** i.e. **Quantum technologies, Artificial Intelligence, energy harvesting, biomedical engineering** etc.

3. Actions for dissemination and communication of SPiCY results

- Publications in scientific journals and presentations at national and international conferences
- Organization of an **international scientific workshop** on topics of **SPiCY** project
- Organization of **one of the annual meetings** of the European network **SpinTronicFactory**

4. Actions for promoting innovation

- **Promoting the maturity of Spintronics by reinforcing the existing links** with the different **industrial partners** from Paris Saclay area e.g. *Thales, Spin-ION technologies, Crivasense, Horiba, Caylar* etc.

5. Actions for training

- **Setup a regular training offer** on spintronics addressed at young scientists, mainly master or PhD students and postdocs, in connection with the GS of Physics and GS of Engineering from Paris-Saclay University : *2 editions of SPiCY school in 2021 and 2023*
- **Setup of specific training modules on spintronics and its technological impact** for the next generation of engineers and technicians.