Highlights

2025

SPINTEC, CEA Grenoble, – 17 rue des Martyrs – GRENOBLE (France)
https://spintec.fr direction.spintec@cea.fr
company/spintec-lab

CONTENTS

FOREWORD

SPINTEC YEAR IN REVIEW: CELEBRATING ACHIEVEMENTS AND EMBRACING NEW HORIZONS

Lucian PREJBEANU
Director

Olivier FRUCHART,
Deputy director

As we conclude a very rich year, we would like to take a moment to express our heartfelt gratitude to each of our colleagues. Your dedication, hard work, and passion have not only made this year a success but have also made it particularly enjoyable. Together, we have overcome challenges and celebrated significant achievements.

2025 was marked by the HCERES SPINTEC evaluation, with many positive outcomes, as well as the continuation of the laboratory's reorganization with new group leaders and an operational manager. In June, we inaugurated the much-anticipated pilot line SPINfab, a significant milestone for our laboratory.

On the projects side, several notable advancements have been made within the framework of the structuring PEPR SPIN program: new projects, the establishment of an industrial board and a scientific committee, new industrial partnerships with Texas Instruments and Vertical Compute, and the creation of a joint lab with the start-up Nellow. We have also launched the AUDACE project on in-situ learning in 3D physical neural networks, coordinated by Philippe Talatchian, as well as the ASPIRE programs with Japan and soon SPIN-CHIP as part of the European Chip Act.

Regarding human resources, we welcome Clarisse Ducruet as a CNRS research engineer in materials and Corentin Bouchard as a UGA engineer in nanofabrication. We also thank Florian Disdier and Nicolas Mollard who have decided to continue their careers at LETI and DSBT, respectively, for their involvement over the past years.

Congratulations to Laura Alvaro-Gomez for her PhD award Claudine Hermann 2025 from the French Physical Society, Libor Vojacek for his C'Nano 2025 PhD award, Johanna Fischer for her EMA Young Scientist award, Bernard for the Legion of Honor and the prize of the French Academy of Sciences. Congratulations also to all the thesis defenses of the year, truly highlight moments in the life of the laboratory!

Consistent with the laboratory's commitment to open science, the research outputs produced by the laboratory is made publicly available through the laboratory's HAL repository. This limited length of the highlights document make it not exhaustive. It could also have mentioned many actions undertaken in the areas of safety, inclusion or well-being at work. All the highlights are definitely linked to the day-to-day efforts carried out by all members of our scientific groups, core facilities, and support services. They are the primary asset of our laboratory, and we would like to warmly commend their dedication and commitment.

2026 brings new challenges, including the establishment of a new management team for SPINTEC in 2027 (thanks to Ricardo Sousa, Liliana Buda-Prejbeanu and Vincent Baltz for their dedication of work for the management of SPINTEC in future years to come and the continuation of the nice lab's story).

Lab days at Château des Chaulnes in Noyarey on March 24, 2026, will allow us to both reflect on the laboratory's reorganization experience and collectively discuss with the new team the challenges and organization of the lab in the years to come.

As we look forward to the new year, let us continue to build on these achievements and strive for even greater success. Thank you for your unwavering commitment and enthusiasm. Together, we will shape the future of SPINTEC and make it a beacon of excellence in the field of spintronics.

Lucian Prejbeanu, Director

Olivier Fruchart, Deputy Director

SPINTEC Highlights – December 2025

Editors: Gregory Di Pendina, Hélène Béa

Directors of publication: Lucian Prejbeanu, Executive Director / Olivier Fruchart, Deputy Director

Modulating terahertz emission using 2D materials and ferroelectricity

The modulation of THz spintronic emitters represents a real challenge nowadays. Here, we consider a THz emitter made of 2D materials grown by molecular beam epitaxy (MBE) on large area and transferred on $LiNbO_3$. The low dimensional character makes this system sensitive to the ferroelectric polarization of $LiNbO_3$. Using this proximity effect, we demonstrate the modulation of spintronic THz emission by the ferroelectric modification of the inverse Rashba Edelstein effect in the 2D materials.

Spintronic THz emitters based on spin-to-charge conversion are promising candidates to build new compact and energy efficient THz technologies. In this prospect, the modulation of THz emission at low energy cost remains challenging today. One possible route consists in using ferroelectricity to modulate spin-orbit coupling. Thanks to their low dimensional character and large spin-orbit coupling, 2D materials such as transition metal dichalcogenides (TMD) coupled to a ferroelectric material represent good candidates. Here, we demonstrate such ferroelectric modulation of THz spintronic emission in the CoFeB/ $PtSe_2/MoSe_2/LiNbO_3$ stack.

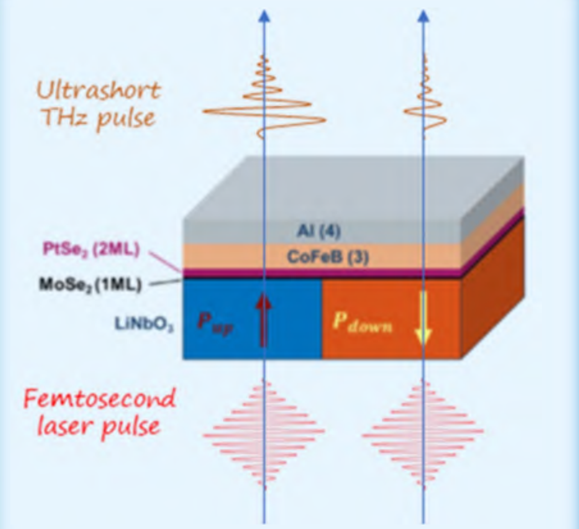


Illustration of THz spintronic emission modulation by ferroelectric polarization.

We use MBE in the van der Waals regime to grow the $PtSe_2/MoSe_2$ bilayer epitaxially on mica. This bilayer is then transferred using a wet method (in deionized water) onto a bidomain $LiNbO_3$ substrate as shown in the Figure. Using several characterization techniques, we confirm that the TMD bilayer structural and electronic properties are preserved after transfer. After thermal surface treatment under ultrahigh vacuum, the $PtSe_2/MoSe_2/LiNbO_3$ stack is covered with 3 nm of CoFeB and 4 nm of Al grown by sputtering. THz time-domain spectroscopy is performed by exciting the stack with 80 fs laser pulses at 800 nm with linear polarization. THz pulses are detected with a 250 µm-thick ZnTe crystal. As sketched in the Figure, a clear difference in amplitude (up to 22 %) between the THz signal for the $LiNbO_3$ polarization up (P_{up}) and polarization down (P_{down}) can be observed demonstrating the ferroelectric modulation of THz spintronic emission. Density Functionnal Theory calculations show that spin-to-charge conversion takes place at the interface between $PtSe_2$ and $MoSe_2$ through the inverse Rashba Edelstein effect. They also show that the ferroelectric modulation comes from the opposite shifts of the TMD bilayer Fermi level induced by the polarization up (P_{up}) and polarization down (P_{down}) of $LiNbO_3$.

Our results open perspectives for the realization of efficient THz modulators based on field effect spin–orbit devices integrating 2D materials.

Team: 2D Spintronics

Collaboration: Laboratoire de Physique de l'ENS (Paris, France), Laboratoire Albert Fert (Palaiseau, France)

Funding: ESR/EQUIPEX2D-MAG projects, PEPR SPIN TOAST &SPINTHEORY

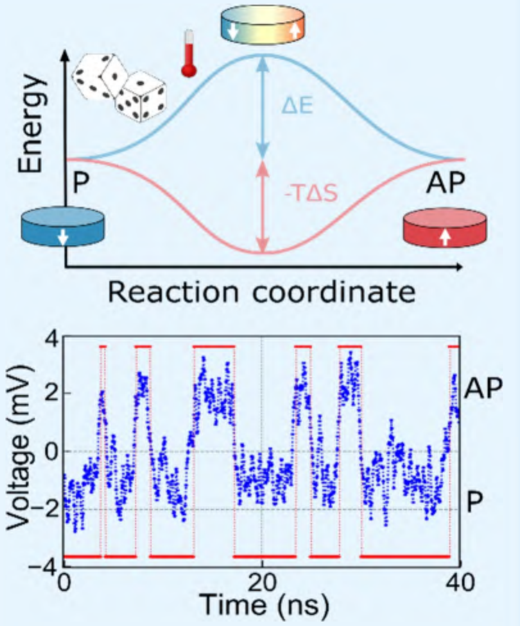
Further reading: *Inverse Rashba Edelstein THz emission modulation induced by ferroelectricity in CoFeB/PtSe2/MoSe2//LiNbO3 systems*, S. Massabeau, O. Paull, A. Pezo, F. Miljevic, M. Micica, A. Grisard, P. Morfin, R. Lebrun, H. Jaffrès, S. Dhillon, J.-M. George, M. Jamet, and M. Bibes, APL Materials 13, 041102 (2025). *Open access: hal-05064688v1*

matthieu.jamet@cea.fr

Nanosecond stochastic operation in perpendicular superparamagnetic tunnel junctions

Superparamagnetic tunnel junctions have emerged as promising stochastic neurons for low-energy cognitive computing. We report, for the first time, nanosecond-scale mean waiting times between magnetization reversals in perpendicularly magnetized tunnel junctions, enabled by a strong entropic contribution to the thermally activated switching dynamics.

Magnetic tunnel junctions (MTJs) consist of a free and a fixed magnetic layer separated by a tunnel barrier. They exhibit two metastable states depending on the relative orientation of the magnetic layers, namely parallel (P) and antiparallel (AP). At finite temperature, the energy barrier between these states can be overcome by thermal fluctuations, causing the magnetization of the free layer to reverse. We focus on the mean waiting times—or mean dwell times—between such reversals.



Top: Schematic of the energy profile along the reaction coordinate for the thermally induced magnetization reversal in an SMTJ, where ΔE and ΔS respectively correspond to the change in internal energy and entropy. Bottom: Corresponding random telegraph noise in the voltage-time trace (in blue). The red curve corresponds to a binarized state.

MTJs are well-established building blocks for non-volatile magnetic memory, where information retention at the scale of years is required. More recently, their low-retention-time (below milliseconds) counterparts, called superparamagnetic tunnel junctions (SMTJs), have emerged as highly appealing for numerous low-energy, unconventional, and bio-inspired computing schemes. In this context, minimizing the mean dwell times improves computational speed and energy efficiency.

We experimentally measured the mean dwell times in perpendicularly magnetized, 50 nm diameter SMTJs, and observed values as low as a few nanoseconds at negligible bias voltage—a timescale previously reported only in in-plane magnetized tunnel junctions. We theoretically explained this observation with a large entropic contribution to the free energy barrier. In perpendicularly magnetized MTJs, magnetization reverses via the nucleation and propagation of a domain wall. The large entropic contribution stems from the existence of low-energy modes that exist in domain walls, but are not present in collinear magnetic states. The transition state with a domain wall is thus favored by the entropy.

Teams: Artificial Intelligence, Theory / Simulation, RF spintronics, MRAM, Materials.

Collaboration: NIST-Gaithersburg, University of Maryland (Maryland, USA)

Funding: ANR (StochNet PRIME SPOT), NSF, the French RENATECH network, the University of Liège (Special Funds for Research, IPD-STEMA Programme).

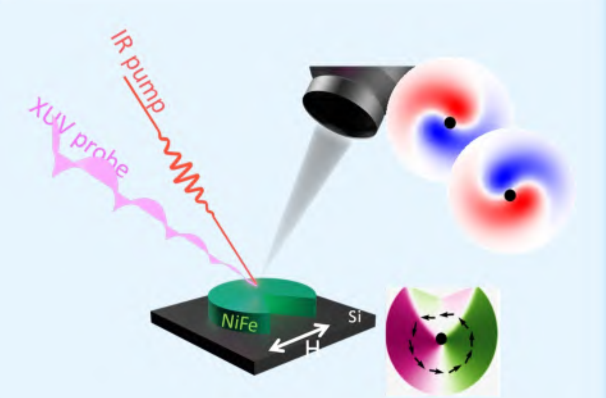
Further reading: *Entropy-assisted nanosecond stochastic operation in perpendicular superparamagnetic tunnel junctions*, L. Soumah, L. Desplat, N.-Tan Phan, A. Sidi El Valli, A. Madhavan, F. Disdier, S. Auffret, R. C. Sousa, U. Ebels, M. D. Stiles, and P. Talatchian, Phys. Rev. Appl. 24, L011002 (2025). *Open access: hal-05149179v1*

@ philippe.talatchian@cea.fr, louise.desplat@cea.fr

Magnetic vortex dynamics probed by time-resolved magnetic helicoidal dichroism

Time-resolved magnetic helicoidal dichroism (MHD) was successfully used to assess the ultra-fast dynamics of magnetization. This first attempt to use an MHD-based technique was demonstrated on a magnetic vortex structure hosted by a permalloy pacman micropillar (diameter ~ 15 µm, thickness ~ 80 nm). Micromagnetic simulations allowed to link the features identified in the MHD signal to a process of regeneration of the internal structure of the vortex following laser induced demagnetization.

While the spin angular momentum of light is widely used in dichroic studies (*e.g.*, X-ray magnetic circular dichroism, magneto-optical Kerr effect), the orbital angular momentum (OAM) degree of freedom has been far less explored. Recently, it was demonstrated that OAM can enhance ptychographic imaging resolution. Besides, by controlling the sign of the incoming OAM, it was also shown that it can reveal the orientation of static magnetic textures, such as the winding direction of a magnetic vortex. Here, we have exploited this technique to track the ultrafast dynamics (~ps) of a magnetic vortex following thermal demagnetization.



Schematic of the experimental setup, the pacman NiFe pillar in which a magnetic vortex is stabilized after applying an in-plane magnetic H field. Some associated experimental MHD maps are shown.

NiFe pillars were microfabricated at the PTA platform with appropiate size and shape to precisely control the stabilisation of a vortex state at remanence. Light-magnetization interaction experiments were carried out at Elettra-Sincrotrone (Trieste). An ultra-short infrared laser pulse was used to heat the pillar and partially demagnetize the permalloy layer from its upper surface (see Figure). Using a pump-probe method, the dynamics of magnetization was probed by time-resolved MHD in resonant scattering in the extreme ultraviolet. MHD describes the change in the optical response of a magnetic sample due to a sign reversal in the orbital angular momentum of light. It has been shown to be sensitive to the spin texture of the sample, especially in vortex confguration. In addition to the well-known laser-induced processes of ultra-rapid demagnetization and re-magnetization, analysis of the MHD signal provided direct evidence of important transient reorganisations of the spin texture. With the help of micromagnetic modeling, several scenarios of demagnetization were investigated to get insights on the dynamics of the spin texture of the permalloy nanostructure. In particular, we found that an ultrafast laser pulse of sufficient intensity can induce a transient magnetic texture characterized by a vortex surface structure of winding direction opposite to that of the bulk.

A key advantage of time-resolved MHD is its ability to operate without the need for scanning, enabling rapid measurements of magnetization dynamics in magnetic microstructures. These results hold great promise not only for monitoring complex magnetic spin textures but also for uncovering new forms of optical spin-orbit interactions mediated by magnetization.

Team: Theory / Simulation, MRAM

Collaborations: Sorbonne Université (Paris, France), INSP (Paris, France), CEA-LIDYL (Gif-sur-Yvette, France), Elettra-Sincrotrone (Trieste, Italy)

Funding: ANR HELIMAG

Further reading: *Magnetic vortex dynamics probed by time-resolved magnetic helicoidal dichroism*, M. Fanciulli, M. Pancaldi, A. E. Stanciu, M. Guer, E. Pedersoli, D. De Angelis, P. Rebernik Ribic, D. Bresteau, M. Luttmann, P. Carrara, A. Ravindran, B. Rosner, C. David, C. Spezzani, M. Manfredda, R. Sousa, L. Vila, I. L. Prejbeanu, L. D. Buda-Prejbeanu, B. Dieny, G. De Ninno, F. Capotondi, T. Ruchon and M. Sacchi, Phys. Rev. Lett. 134, 156701 (2025). *Open access: hal-05127585v1*

liliana.buda@cea.fr, bernard.dieny@cea.fr, lucian.prejbeanu@cea.fr

Monolayer control of spin-charge conversion in van der Waals heterostructures

2D materials and van der Waals (vdW) heterostructures are promising candidates to build efficient THz spintronic emitters. Here, we demonstrate the drastic modification of THz spintronic emission by inserting a single layer of $MoSe_2$ in the $PtSe_2$/graphene vdW heterostructure. *Ab initio* calculations indeed show the emergence of Rashba states due to the electronic hybridization between $MoSe_2$ and $PtSe_2$ giving rise to strong spin-to-charge conversion and THz emission.

Spintronics is being more and more integrated into THz technologies enabling more energy efficient and tunable THz emission. The underlying mechanism of spintronic THz emission is spin-to-charge conversion. In this respect, 2D materials present several key advantages like Rashba or topological spin textures, large spin-orbit coupling, various crystal symmetries and their electronic properties can be easily manipulated with strain, light or electric fields. In this work, we showed that THz spintronic emission can be efficiently manipulated at the atomic scale in vdW heterostructures. For this, we inserted a single layer of $MoSe_2$ in the $PtSe_2$/graphene vdW heterostructure which modifies both the sign and intensity of THz emission owing to the formation of Rashba states at the hybridized interface between $MoSe_2$ and $PtSe_2$.

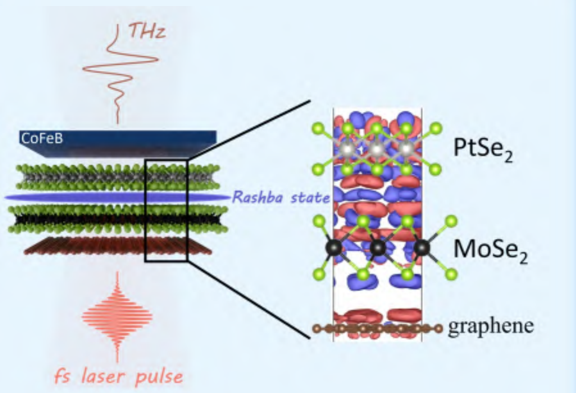


Illustration of the hybridization between $MoSe_2$ and $PtSe_2$ monolayers generating Rashba states at the interface governing THz spintronic emission.

We used molecular beam epitaxy (MBE) in the van der Waals regime to grow $PtSe_2$/graphene and $PtSe_2$/$MoSe_2$/graphene epitaxial vdW heterostructures on SiC substrates. Both stacks were covered with a thin ferromagnetic CoFeB layer serving as the spin source and 4 nm of Al to protect the films against oxidation, both evaporated by sputtering. THz time-domain spectroscopy is performed by exciting the stacks with 80 fs laser pulses at 800 nm with linear polarization. THz pulses are detected with a 250 µm-thick ZnTe crystal. We first observed a weak positive THz emission from $PtSe_2$/graphene. Using ab initio calculations, we could attribute this signal to the Rashba effect at the $PtSe_2$/graphene interface owing to interface charge transfer and the formation of an electric dipole. Surprisingly, by inserting a single layer of $MoSe_2$ between $PtSe_2$ and graphene, we could detect a 3.5 times larger THz emission with opposite sign. To explain this result, we performed spin- angle-resolved photoemission spectroscopy (ARPES) measurements with synchrotron radiation and ab initio calculations to unveil the strong electronic hybridization between $MoSe_2$ and $PtSe_2$ owing to their epitaxial relationship. We thus demonstrated that, despite the vdW gap, electronic hybridization takes place at the interface between 2D semiconductors leading to the formation of Rashba states as illustrated in the Figure. These Rashba states are responsible for spin-to-charge conversion and the enhanced THz emission. Our results open perspectives for the manipulation of THz spintronic emission at the atomic scale using 2D materials vdW heterostructures.

Teams: 2D Spintronics, Theory / Simulation, Materials

Collaboration: Laboratoire de Physique de l'ENS (Paris, France), Laboratoire Albert Fert (Palaiseau, France), IRIG-MEM (Grenoble, France), ELETTRA (Trieste, Italy), CEA LETI (Grenoble, France), C2N (Palaiseau, France)

Funding: ESR/EQUIPEX+, ANR 2D-MAG, PEPR SPIN TOAST & SPINTHEORY

Further reading: *Monolayer control of spin-charge conversion in van der Waals heterostructures*, K. Abdukayumov, O. Paull, M. Mičica, F. Ibrahim, L. Vojáček, A. Wright, S. Massabeau, F. Mazzola, V. Polewczyk, C. Jego, R. Sharma, C. Vergnaud, A. Marty, I. Gomes de Moraes, A. Ouerghi, H. Okuno, A. Jana, I. Kar, J. Fujii, I. Vobornik, L. Melo Costa, O. Renault, J. Li, F. Bonell, M. Chshiev, M. Bibes, J.-M. George, H. Jaffrès, S. Dhillon and M. Jamet, Phys. Rev. Lett. 135, 016702 (2025). *Open access: hal-04940355v1*

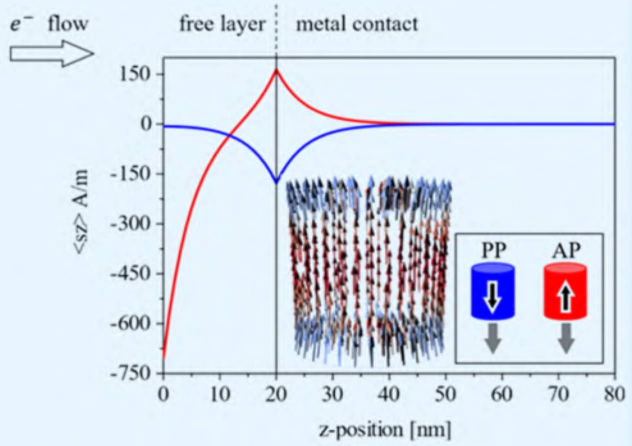
matthieu.jamet@cea.fr, mair.chshiev@cea.fr

Physics of current-induced switching in 3D nanopillars

We simulated the current-induced switching of magnetization of short vertical magnetic nanopillars as the free layer in a magnetic tunnel junction. Considering spin accumulation is crucial in such 3D elements, leading to an enhancement of the field-like torque, and the excitation of non-uniform FMR modes.

3D nanomagnetism is a fast-growing topic, motivated by fundamental physical effects arising from curvature. These are for instance effective anisotropy or Dzyaloshinskii-Moriya interaction, the respective topologies and chiralities of magnetization distributions versus those of the underlying nanostructures, or enhanced magnetostatics. So far, most investigated effects concerned the distribution of magnetization, either in static of dynamic conditions. In contrast, specificity of spintronics effects in 3D nano-elements have rarely been mentioned, while this would be desirable in the context of the push of information / communication technology towards integrated 3D devices to ever improve performances. An example in spintronics is the concept of perpendicular shape anisotropy magnetic random access memory (PSA-MRAM), proposed and demonstrated independently by Tohoku University and SPINTEC. Its storage layer consists of a short pillar, whose vertical aspect ratio is the main source of perpendicular anisotropy, and the much-increased volume allows to sustain thermal stability down to a few nanometers in diameter.

We have considered a cylindrical nanopillar as the free layer of a PSA-MRAM, bounded by the tunnel barrier at one interface and the metal lead at the other interface. We have simulated self-consistently the coupled dynamics of the spin accumulation and the resulting magnetization dynamics. Several specific features were identified. First, the gradual decay of spin accumulation along the depth of the pillar results in a field-like torque equal in magnitude to the damping-like torque. Second, the magnetization canting at the edges of the pillar, in the so-called flower state, induces a sizable torque from the very beginning of the current pulse. This reduces the incubation time and can even lead to a qualitative change of the switching behavior, from the usual macrospin to a curling type, promoted by the emergence of a non-uniform ferromagnetic resonance mode with rotational symmetry.



Spin accumulation in the 3D free layer and in the metal contact for both parallel and antiparallel configurations with respect to the reference layer of the magnetic tunnel junction. The flower state of the 3D free layer is displayed in the inset.

The conducted simulations showed that specific spintronic features are to be expected in 3D nanosystems. First, it may be crucial to compute explicitly spin accumulation and derive the resulting components of the spin-transfer torque, while the consideration of effective torques and neglecting the field-like torque such as usually done in flat magnetic cells may be erroneous. Besides, specific modes of magnetization switching may arise, promoted by the enhanced 3D magnetostatic effects. Both may provide opportunities to optimize the emerging 3D spintronics devices in terms of speed and power consumption.

Teams: Spin textures, MRAM, Theory / Simulation

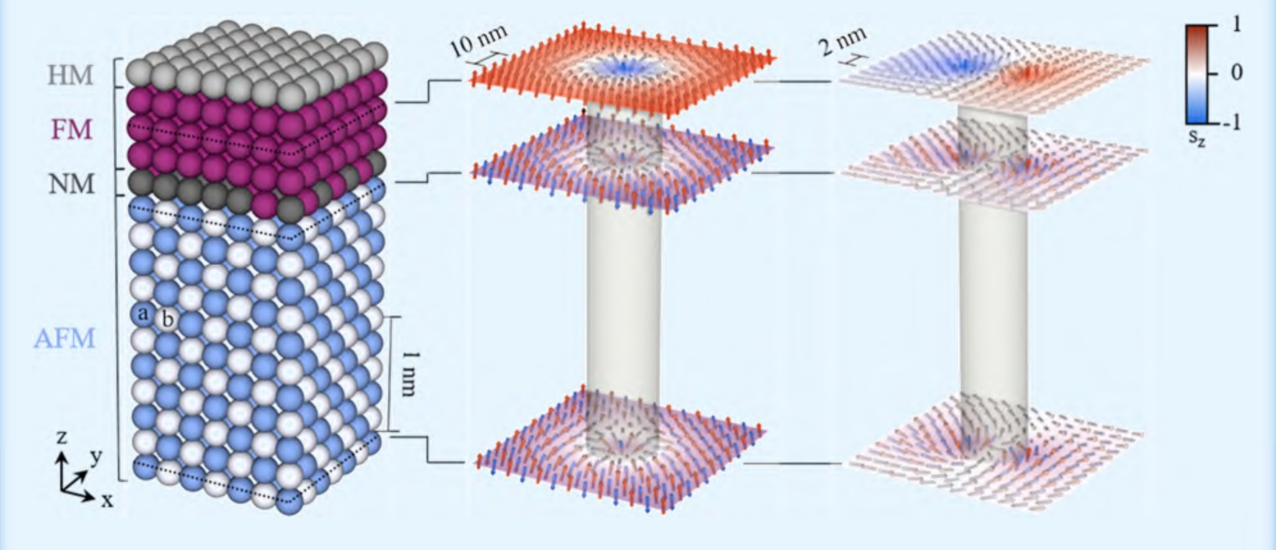
Collaboration: Institut NEEL (Grenoble)

Further reading: *Simulation of current-driven magnetization switching in nanopillars with perpendicular shape anisotropyipole-coupled core-shell perpendicular-shape-anisotropy magnetic tunnel junction with enhanced write speed and reduced crosstalk*, N. Boscolo Meneguolo, O. Fruchart, J.C. Toussaint, M. Fattouhi, L. Buda-Prejbeanu, I.L. Prejbeanu, D. Gusakova, Phys. Rev. B 112, 014448 (2025). *Open access: hal-04999028*

@ daria.gusakova@cea.fr, olivier.fruchart@cea.fr

Imprinting of skyrmions and bimerons in an antiferromagnet

In this work, a consortium of physicists from SPINTEC and York addressed the challenge of nucleating quantitatively proven topological magnetic textures in compensated magnets with zero net magnetization. It paves the way for extending the study of topological spin textures beyond ferromagnets, into materials with intriguing electrodynamic properties, such as antiferromagnets and altermagnets.



A topological texture, either a skyrmion (middle) or a bimeron (right), formed in the HM/FM/NM ferromagnetic heterostructure (left) is employed as a template and replicated in the prototypical AFM layer through a thermal cycling procedure.

Topologically protected magnetic states in condensed matter physics, particularly antiferromagnetic (AFM) skyrmions (Sks) and bimerons (Bms), offer promising prospects for terahertz dynamics and sustained current-induced motion, thanks to their compensating multiple sub-lattice structure. However, nucleating AFM Sks and Bms is challenging due to the lack of net magnetization.

Previous attempts to imprint pre-defined Sks and Bms in a ferromagnet (FM) and transfer them to an AFM using interfacial exchange bias in FM/AFM heterostructures have been hindered by complex multilayers with discontinuities, polycrystallinity, or multipartite chiral AFMs.

Employing atomistic spin simulations, we demonstrated the viability of texture imprinting for nucleating Sks and Bms in AFMs, using a prototypical bipartite AFM layer in a multilayer structure free from discontinuities. This approach has enabled us to calculate the topological parameters of the imprinted spin textures: polarity, vorticity, and helicity, as well as intermerons axis for the case of the Bms, providing quantitative data that was previously inaccessible. Such imprinting is a crucial step towards understanding the static and dynamic properties of natural magnetic compensated textures and their unique spin transport properties.

.

Teams: Antiferromagnetic spintronics, Theory / simulation

Collaboration: University of York (United Kingdom)

Funding: IRP CITRON; EPSRC EP/V007211/1; PEPR-SPIN ALTEROSPIN

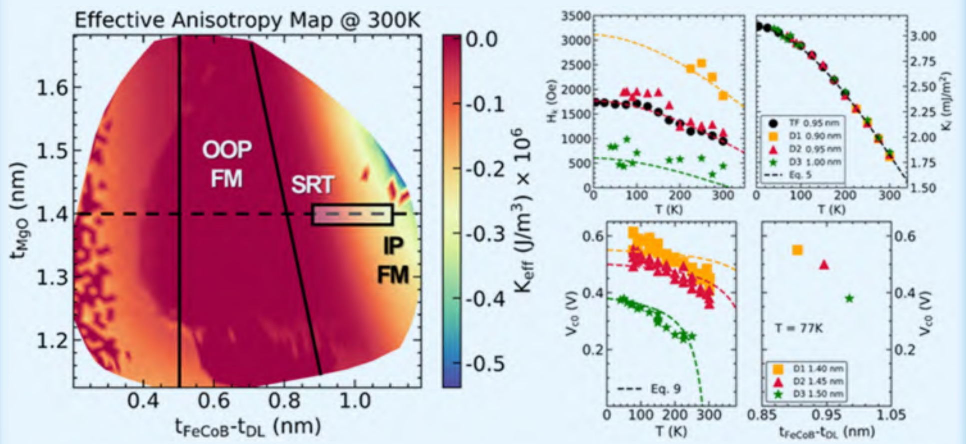
Further reading: *Imprinting of skyrmions and bimerons in an antiferromagnet,* C. Thevenard, M. Leiviskä, R. F. L. Evans, D. Gusakova, V. Baltz, Phys. Rev. B **111**, 224429 (2025). *Open access: hal-04930920v2*

vincent.baltz@cea.fr, daria.gusakova@cea.fr

Controlling effective anisotropy for efficient switching at cryogenic temperature

The field of cryoelectronics holds promise for high-performance computing applications, particularly within the realm of quantum computing. Recent advances in quantum computing systems have spurred the investigation of various technologies suitable for cryogenic environments. Among these technologies, spintronic memory elements have received significant attention due to their potential for minimal energy consumption.

Our research paper focuses on the control of the perpendicular interface anisotropy for cryogenic operation, illustrated in a perpendicular magnetic tunnel junction (pMTJ) cell written by spin transfer torque (STT). These elements achieve the lowest writing energy at time scales around 1 nanosecond pulse widths, thereby significantly reducing total energy dissipation. In cryogenic settings, the thermal stability requirements are substantially relaxed, a reduction of more than 100 times compared to room temperature, shifting the primary challenge to optimizing the energy barrier of the memory cell. For STT-written magnetic memories, this optimization requires precise control of magnetic anisotropy at the specified operating temperature. The novelty of this work lies in the experimental method we have developed to extrapolate thin film magnetic properties measured at room temperature to the electrical device properties at cryogenic temperatures. The method employs magneto-optical Kerr effect (MOKE) magnetometry to calculate the effective anisotropy as a function of the storage layer thickness using wedge depositions, achieving sub-nanometer layer resolutions. Key findings of our study include: confirmation that Bloch and Callen-Callen laws correctly describe the evolution of effective anisotropy in fabricated devices, that these laws can be used to extrapolate low temperature measurements from values obtained at higher temperature, and that the proposed methodology is applicable to any magnetic stack relying on perpendicular interface anisotropy.



Room temperature effective anisotropy and model extrapolation of room temperature results to cryogenic temperature environment.

The Figure presents the effective anisotropy map as a function of the FeCoB layer thickness for different oxidized MgO thicknesses oxidized under identical conditions. As the free layer thickness increases, it becomes possible to reduce the effective anisotropy, transitioning from a perpendicular easy axis (out-of-plane, OOP) to a reorientation (spin reorientation transition, SRT) into an in-plane (IP) anisotropy region. Our measurements demonstrate that the switching voltage amplitude decreases with increasing FeCoB thickness, *i.e.*, the decrease in effective anisotropy. This result underscores the potential of our method to select, from room-temperature measurements, regions of the layer stack space that are suitable for cryogenic memory applications, either by controlling the ferromagnetic layer thickness or the tunnel barrier oxidation state.

Team: MRAM

Collaboration: Institut Néel (Grenoble, France)

Funding: ANR Crymco, PEPR-Quantique PRESQUILE

Further reading: *Optimizing Effective Anisotropy in Magnetic Tunnel Junctions for Operation at Cryogenic Temperatures*, S. Martín Rio, K. S. Senapati, L. Farcis, L. Soumah, P. B. Veiga, K. Garello, R. C. Sousa. Phys. Rev. Appl. 2025, 24 (2), 024016. *Open access: hal-05217689*

ricardo.sousa@cea.fr

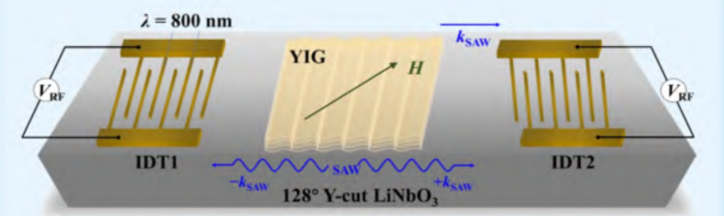
A one-way sound transmitter

Magnetism is known to inherently break time-reversal symmetry. By integrating a magnetic thin film onto a piezoelectric substrate, enabling the phonons to hybridize with the magnons via magneto-elasticity, we show that this intrinsic nonreciprocity can be transferred to surface acoustic waves.

Surface acoustic wave (SAW) filters are key components in modern wireless electronic devices. Their ultra-high selectivity, combined with a slow propagation speed (~ 1000 m/s), enables the design of compact filters for the microwave frequency range. Achieving one-way information transport is essential when the same component is used to selectively route signals from an antenna to either the receiver or the transmitter part of the electronic circuit. Magnetic materials offer a unique way to break time-reversal symmetry. In an out-of-equilibrium state, the magnetization precesses in a single direction (counter-clockwise, as defined by the polarity of the gyromagnetic ratio) around its equilibrium axis.

A collaboration between SPINTEC, RIKEN, and the Institute ISSP at the University of Tokyo has proposed realizing this functionality by integrating a thin film of the ferrimagnetic insulator yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) onto a piezoelectric substrate of lithium niobate as illustrated in the Figure. YIG is particularly attractive due to its low magnetic damping and long magnon relaxation time, making it ideal for enabling strong coupling between acoustic waves and magnetic excitations. The magnetoelastic interaction between YIG magnetization and surface acoustic waves forms here the basis in the development of surface acoustic wave isolators.

While magnetoelastic interactions between YIG and SAWs have been used to implement acoustic isolators, achieving on-chip SAW-driven magnetic resonance has been challenging due to material-device integration constraints. In this work, we demonstrated, at room temperature, nonreciprocal resonant SAW absorption in an on-chip YIG-SAW device fabricated using focused-ion-beam techniques. Multiple absorption peaks are observed, corresponding to perpendicular standing spin wave (PSSW) modes, with higher-order PSSWs exhibiting pronounced nonreciprocity when the SAW propagation direction is reversed. These observations are consistent with theoretical models that account for asymmetric surface conditions and nonreciprocal magnon-SAW coupling.



SAW filter: Two interdigitated transducers (IDT1 and IDT2) generate elastic surface waves in a piezoelectric crystal, which then interact with a YIG thin film deposited on the same surface.

The strong nonreciprocal SAW attenuation observed in YIG provides a promising route toward highly efficient RF signal processing. Our results establish on-chip YIG–SAW devices as a versatile platform for exploring nonreciprocal acoustic transport, magnon–phonon interactions, and next-generation YIG-based magnonic technologies. Future work will target the intrinsic nonlinearities of magnetic materials, opening opportunities to integrate frequency mixing and advanced signal-manipulation functionalities directly into acoustic devices.

Team: Spin Insulatronic

Collaboration: RIKEN (Wakō, Japan), ISSP (Tokyo, Japan)

Funding: Q-SPIN chaire d’excellence LANEF portée avec le Prof. YoshiChika Otani

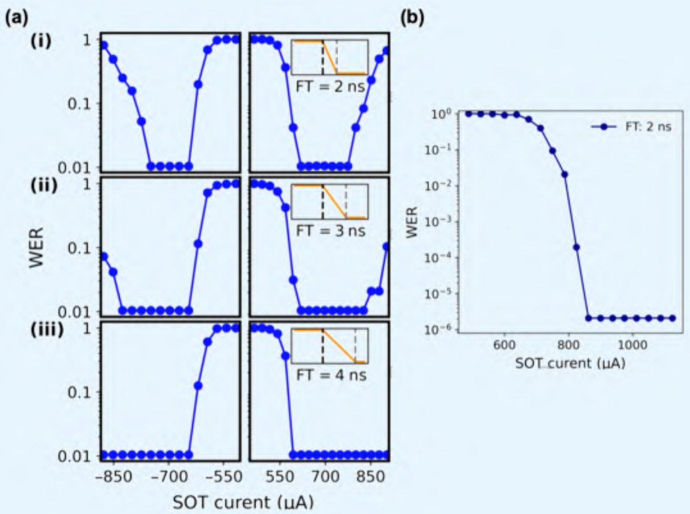
Further reading: *Influence of interlayer coupling on the spin-torque-driven excitations in a spin-torque oscillator,* Y. Ba, J. Puebla, K. Yamamoto, Y. Hwang, L. Liao, S. Maekawa, O. Klein, and Y. Otani, Nonreciprocal Resonant Surface Acoustic Wave Absorption in \({Y}{$_3$}{Fe}$_5$O$_{12}$\), Physical Review B 111, 104401 (2025). *Open access: hal-01578636*

oklein@cea.fr

Pulse shaping suppresses intrinsic back-switching in SOT-MRAM

Spin–orbit-torque (SOT) magnetic random access memories (MRAM) writing exhibits an unusual current dependence: at high current amplitudes, the write probability can drop to zero or even oscillate as the current increases. In collaboration with Antaios, we showed that this behavior originates from an intrinsic, largely deterministic back-switching mechanism, and we demonstrated that tailoring the pulse fall time significantly widens the reliable write window.

SOT-MRAM is particularly attractive for replacing the memories closest to processing units, as it combines high endurance with sub-nanosecond switching times. Reliable writing is therefore essential for this technology to scale and mature. However, perpendicularly magnetized SOT-MRAM devices may enter a back-switching regime in which increasing the current causes the bit to relax back to its initial state. We studied ~60-nm CoFeB pillars on β-W Hall crosses and mapped the write-error rate (WER) as a function of nanosecond SOT-pulse amplitude under magnetic fields applied along x, y, and z. These WER maps consistently reveal three regions: no switching, deterministic forward switching (low WER), and a high-WER zone where the magnetization returns to the starting state. This provides clear evidence that back-switching is a systematic dynamical outcome rather than random noise. Importantly, the effect is observed with practical nanosecond-scales write pulses and is reproduced across device configurations, from 100-nm pillars on β-W Hall crosses to a full SOT-MRAM single cell (a magnetic tunnel (MTJ) on a W SOT track), highlighting its relevance for circuit-level operation.



*Experimental WER versus SOT write current for 10-ns pulses. **(a)** 100-nm CoFeB (0.9 nm) pillars on β-W Hall crosses, measured at H_x = 950 Oe for pulse fall times of 2, 3, and 4 ns. **(b)** 75-nm MTJ dot on a 130-nm-wide β-W (4 nm) SOT track, measured at H_x = 800 Oe with a 2-ns fall time.*

Realistic macrospin simulations reproduced the maps and clarify the mechanism: at large currents, spin-orbit torques drive the magnetization close to an energetically unstable in-plane equilibrium; after the pulse, small thermal fluctuations during relaxation can send it back to the original state, depending on the torque balance. Guided by this picture, we mitigate back-switching without changing materials by shaping the write pulse. Lengthening the fall time keeps the torques active during relaxation and steers the magnetization away from the unstable point. Experimentally, increasing the fall time (2→4 ns) suppresses back-switching and widens the forward-switching window; on a complete SOT-MRAM single cell, this approach achieved WER < 2×10^{-6}, improving write margins. Beyond performance gains, these macrospin simulations also pave the way for compact device models that explicitly capture back-switching, enabling more predictive design of write drivers and error budgets.

Team: Spinorbitronics

Collaboration: Antaios (Meylan, France)

Funding: EU Horizon 2020 MSCA ITN SPEAR, Région Auvergne-Rhône-Alpes Pack Ambition Recherche, and RENATECH/PTA support

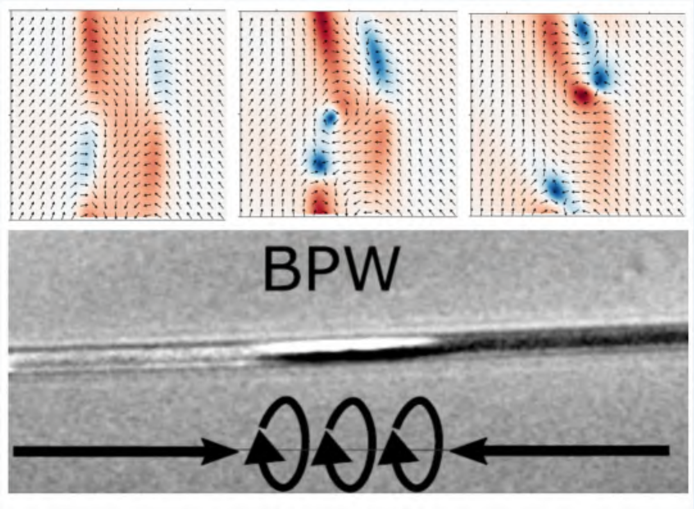
Further reading: *Intrinsic back-switching phenomenon in spin-orbit torque MRAM devices*, K. Ray, J. Vigier, P. Usé, S. Martin, N. Lefoulon, C. Bouard, M. Drouard, G. Gaudin, Phys. Rev. Appl. 24, 064038 (2025). Open access: hal-05411536

gilles.gaudin@cea.fr

Topological analysis and experimental control of DW transformations in cylindrical wires

Topology is a powerful tool for categorizing magnetization textures by defining a topological index in both two-dimensional (2D) systems, such as thin films or curved surfaces, and in 3D bulk systems. In the emerging field of 3D nanomagnetism, both volume and surface topological numbers must be considered, requiring the identification of a proper global topological invariant to support categorization.

Here we considered domain walls (DWs) in cylindrical nanowires as an excellent playground for 3D nanomagnetic systems, excited by a charge current, that generates an Œrsted field. We first provide experimental evidence of previously unreported domain-wall transformations of topology occurring at the nanosecond timescale.



Snapshots of magnetic textures on the unrolled surface of the cylindrical wire and XMCD image of the Bloch point domain wall.

DWs in cylindrical nanowires made of magnetically soft materials represent a textbook case for investigating 3D nanomagnetism in finite-size systems. When nanowire diameter exceeds approximately seven times the dipolar exchange length (i.e., up to a few tens of nanometers), complex 3D magnetization textures may develop, involving 3D nanostructure features. The moderate dimensions of these structures allow for accurate micromagnetic simulations, and experiments are feasible using electrodeposition as a versatile growth method for high quality nanomaterials.

Two types of DWs topologies exist in such wires, both energetically metastable and with very similar energy: the Bloch-point wall and the transverse vortex wall. Experimental observations have demonstrated that these DWs can dynamically change topology under the application of a sufficiently large stimulus of charge current inducing an Œrsted field.

We investigated these transformations with micromagnetic simulations, tracking both bulk and surface topological signatures. We demonstrated a topological invariant combining both signatures, while the topological charge varies from bulk to surface during the dynamics. The experimental change of topology is reproduced when the pulse duration matches the timescale of the internal transformations of the wall, and the current is switched off before the transformation is complete. We expect that the topological categorization and dynamical exploitation apply to any 3D nanomagnetic system.

Teams: Spin Textures, Theory / Simulation

Collaboration: Institut NEEL (Grenoble, France), IMDEA (Madrid, Spain), ALBA (Barcelona, Spain), Max Planck Institute (Dresden, Germany)

Funding: ANRs MATEMAC-3D, DIWINA

Further reading: *Topological analysis and experimental control of transformations of domain walls in magnetic cylindrical nanowire*, L. Álvaro-Gómez, J. Hurst, S. Hegde, S. Ruiz-Gómez, E. Pereiro, L. Aballe, J. C Toussaint, L. Pérez, A. Masseboeuf, C. Thirion, O. Fruchart, and D. Gusakova, Phys. Rev. Research 7(2), 023092 (2025). *Open access: hal-04558642v1*

daria.gusakova@cea.fr, olivier.fruchart@cea.fr

Inauguration of the pilot line SPIN*fab*

On June 25, 2025, the SPINTEC laboratory inaugurated SPIN*fab*, a pilot line dedicated to the fabrication of spintronic materials. This new facility, unique in France, represents a strategic step in strengthening Europe's technological capabilities by bridging cutting-edge research and industrialization in a key area of future electronics. The discovery and integration of spintronic features in devices require the development of new materials, performance improvements, and industrial compatibility.

The inauguration took place with participation of major institutional and scientific representatives. Notably present were Yassine Lakhnech, President of Université Grenoble Alpes (UGA), Pascale Bayle-Guillemaud, Director of IRIG (CEA), Thierry Dauxois, Director of the CNRS Institute of Physics, and Catherine Staron, Vice-President of the Auvergne-Rhône-Alpes Region in charge of research. All the guests emphasized the strategic importance of this large-scale facility, at the intersection of fundamental research and industrial innovation. The collective commitment of the CNRS, CEA, UGA, as well as public partners such as the European Union, the State, the Region, and the Grenoble Métropole, was praised as a model of co-construction around a common scientific and technological objective.

Singulus cluster deposition tool, key tool of the pilot line

At the heart of SPIN*fab*, this pilot line aims to accelerate the maturation of spintronic innovations and includes two flagship equipment: a unique thin film deposition system in France, capable of stacking several dozen complex materials necessary for spintronic devices and a custom plasma etching tool, specifically developed for magnetic materials at the origin of spintronic phenomena.

These facilities enable the production, under near-industrial conditions, of the basic elements of a new electronics—faster, less energy-intensive, and paving the way for applications ranging from ultra-dense data storage to embedded artificial intelligence. To achieve this, SPIN*fab* benefits from €11.5 million in funding from CPER and FEDER Auvergne-Rhône-Alpes, as well as from the EQUIPEX Nanofutur and the research programs Électronique and SPIN, demonstrating the strong support from the research community—primarily CNRS, CEA, and UGA—and local authorities—Europe, the State, the Auvergne-Rhône-Alpes Region, and Grenoble Alpes Métropole—for this project.

Its integration into national and European networks like Renatech and Infrachip further consolidates its role as an open platform, capable of initiating structuring collaborations on a larger scale. It is also a timely moment, as numerous spintronics-based application developments are underway, driven by growing industrial interest, particularly in the fields of high-performance computing (HPC), radiation-hardened circuits, and the Internet of Things (IoT). The project will also have a strong impact on education, giving students and engineers access to state-of-the-art equipment. It will continue to contribute to making the region a recognized hub of expertise in the jobs of tomorrow, in line with the objectives of France 2030.

Teams: Materials, Nanofabrication, MRAM, RF Spintronics, Magnetic sensors

Collaboration: LETI (Grenoble)

Funding: ECPER SPIN*fab*, FEDER SPIN*fab*, EQUIPEX Nanofutur, PEPR électronique, PEPR SPIN

jerome.faure-vincent@cea.fr, miguel.rubio-roy@cea.fr, florian.disdier@cea.fr, lucian.prejbeanu@cea.fr

Kick-off of the ASPIRE Top Scientists project Q-SPIN

On March 3 and 4, 2025, Grenoble hosted the launch of a major collaboration between France and Japan in the field of quantum spintronics. Led by SPINTEC and University of Tokyo and funded by the ASPIRE program of the Japan Science and Technology Agency (JST), this initiative brought together around a hundred participants at the Minatec center, with 70 attending in person. The event featured presentations on the latest scientific advances, as well as stimulating exchanges between established researchers and young scientists. The event concluded with laboratory tours at the Néel Institute and SPINTEC.

The event was inaugurated by the project coordinators, YoshiChika Otani for Japan and Lucian Prejbeanu for France, in the presence of several representatives from partner institutions. Among them were Zenji Hiroi, Director of the Institute for Solid State Physics (ISSP), Norio Kawakami, JST Manager, Catalin Miron, Director of Research Infrastructures, European and International Affairs at CEA-DRF, Pascale Bayle Guillemaud, Director of CEA-Irig, Frédéric Petroff, Scientific Director of Physics at CNRS, Caroline Bertoneche, Vice-President for International Affairs at Université Grenoble Alpes, Lorena Anghel, and Vice-President for Research at Grenoble INP – UGA. Bringing together a hundred participants, including seventy in person, the event highlighted recent advances in quantum spintronics and fostered discussions between renowned scientists and the new generation of researchers.

Quantum spintronics is emerging as a new scientific frontier, at the intersection of spintronics, quantum mechanics, and materials science. This collaborative project aims to exploit the quantum degrees of freedom associated with charge, spin, orbital, phonon, and magnon currents to develop new functionalities and reveal unprecedented physical phenomena.

By integrating advanced nanofabrication techniques and cutting-edge analysis, this Franco-Japanese collaboration aspires to lay the foundations for a revolutionary quantum spintronics, with potential applications in spintronics and quantum computing.

By fostering exchanges between young researchers and doctoral students from Japan and France, this initiative strengthens the circulation of knowledge and encourages the emergence of new ideas. The partnership between PEPR SPIN and Japanese institutions is part of a broader vision of cutting-edge research, opening new perspectives for quantum spintronics.

This event marks the formalization of the collaboration between the University of Tokyo – RIKEN – Osaka University and PEPR SPIN, including the hubs of Grenoble, Paris Saclay, and Marseille. It marks the beginning of an ambitious scientific endeavor, positioning France and Japan at the forefront of tomorrow's technological advances.

Teams: Spin insulatronics, Theory / Simulation

Funding: ASPIRE Q-SPIN, PEPR-SPIN

lucian.prejbeanu@cea.fr, olivier.klein@cea.fr

SPINTEC in the press

Accueil // Spintronique : une ligne pilote « unique en France » ; lancement du 2^e AAP du PEPR Spin en janvier 2026

Spintronique : une ligne pilote « unique en France » ; lancement du 2^e AAP du PEPR Spin en janvier 2026

news tank éducation & recherche Paris - Actualité n°407654 - Publié le 27/08/2025 à 11:07

« Au sein de notre laboratoire, nous avons déjà donné naissance à plusieurs start-up ces dernières années et nous travaillons avec des industriels. Mais il manquait une brique essentielle pour franchir une étape supplémentaire de maturité : une ligne pilote permettant de réaliser des démonstrateurs fonctionnels. Spinfab vient précisément...

Un équipement de la ligne pilote Spinfab - © Spintec (CEA)

Isère

Physique : à Grenoble, une figure montante de la spintronique récompensée

En cette fin août, l'association européenne du magnétisme remet son prix du jeune scientifique à Johanna Fischer. Cette Allemande de 32 ans, chercheuse CNRS au sein du laboratoire grenoblois Spintec, « est déjà une des figures montantes de la spintronique ».

L'USINENOUVELLE

Accueil > Industrie & Technologies > Technologies numériques

Spintronique : la ligne-pilote Spinfab se déploie à Grenoble pour faire progresser la recherche et les applications industrielles

La ligne-pilote Spinfab a été inaugurée à Grenoble ce mercredi 25 juin en présence d'officiels du CEA, du CNRS et de l'université Grenoble Alpes. Installée dans le laboratoire Spintec, elle héberge deux machines, pour le dépôt de couches minces et la gravure. Ces équipements devront aider la spintronique à gagner en maturité et à conquérir de nouvelle applications industrielles, pour une électronique plus verte.

Frédéric Monflier

Publié le 26 juin 2025 à 09h48

● **Réservé aux abonnés**

Partager

© Frédéric Monflier

Jérôme Faure-Vincent (à gauche) et Lucian Prejbeanu (à droite) posent devant le nouveau système d dépôt de couches minces, appartenant à la ligne-pilote Spinfab. L'inauguration a eu lieu le 25 juin au laboratoire Spintec, à Grenoble.

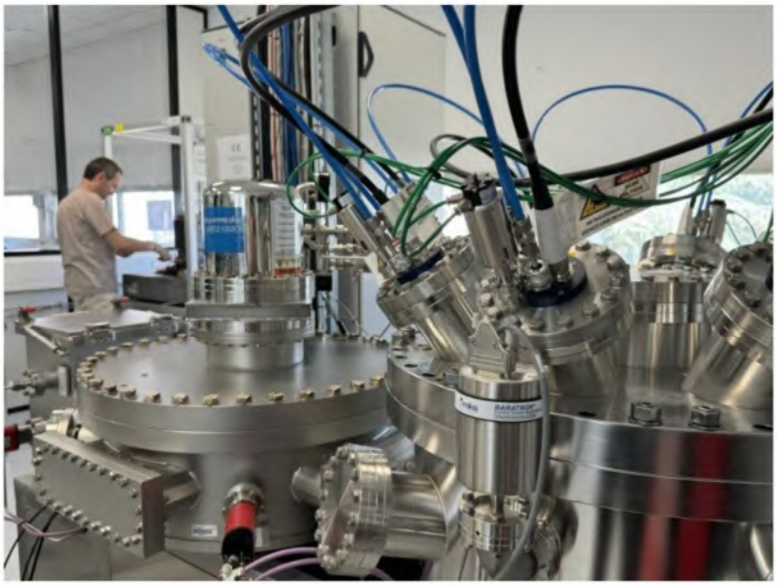
« C'est une ligne pilote unique en Europe dans le secteur académique », sourit Lucian Prejbeanu, directeur du laboratoire Spintec, situé à Grenoble, et codirecteur du grand programme de recherche national (PEPR) consacré à la spintronique, lancé officiellement début 2024. Car il est question de spintronique, cette « cousine » de l'électronique qui exploite le spin de l'électron (son moment magnétique intrinsèque), en plus de sa charge, pour traiter et stocker de l'information.

LE DAUPHINÉ libéré

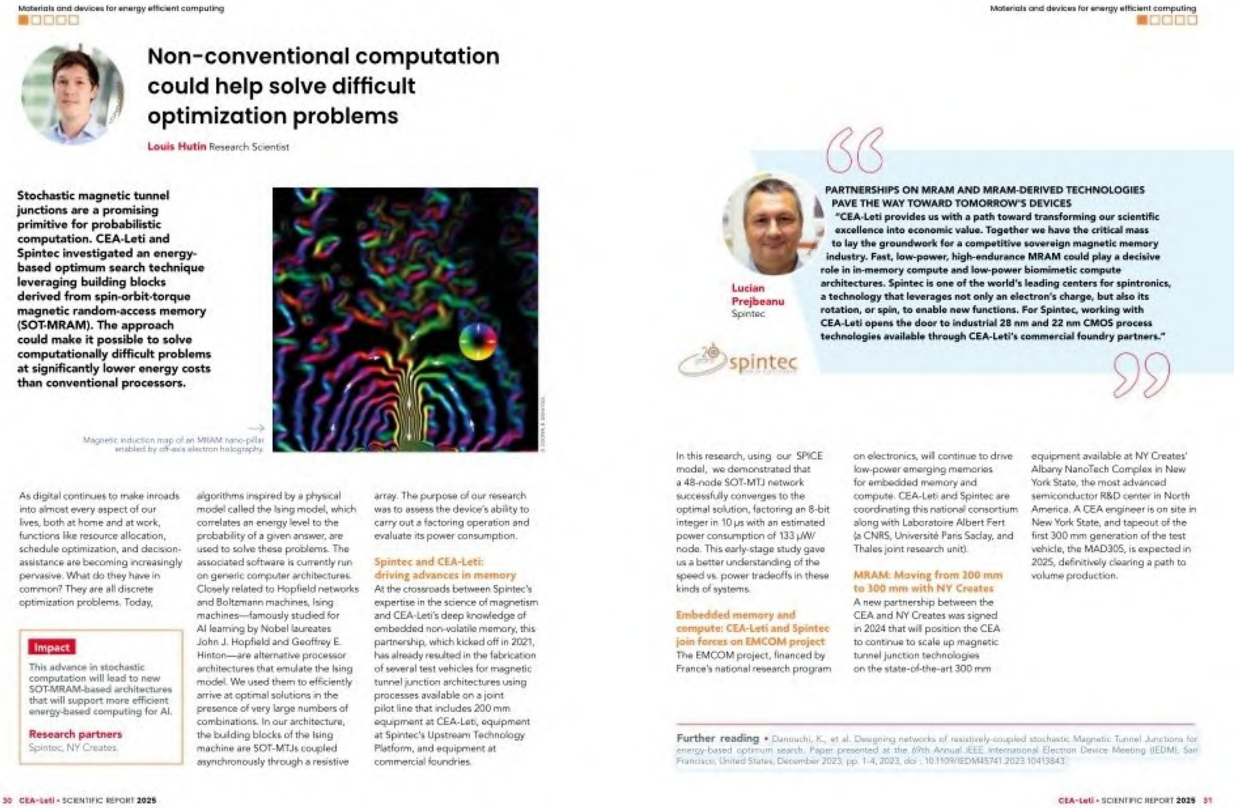
Grenoble

Avec SPINfab, l'électronique de demain se rêve « plus verte »

Le laboratoire Spintec dispose officiellement depuis ce mercredi 25 juin d'une ligne pilote académique. Baptisé SPINfab, cet équipement unique en Europe doit permettre aux scientifiques d'accélérer l'émergence d'innovations pour une électronique « plus verte ».



La l



Non-conventional computation could help solve difficult optimization problems

Louis Hutin Research Scientist

Stochastic magnetic tunnel junctions are a promising primitive for probabilistic computation. CEA-Leti and Spintec investigated an energy-based optimum search technique leveraging building blocks derived from spin-orbit-torque magnetic random-access memory (SOT-MRAM). The approach could make it possible to solve computationally difficult problems at significantly lower energy costs than conventional processors.

Magnetic induction map of an MRAM nano-pillar enabled by off-axis electron holography.

As digital continues to make inroads into almost every aspect of our lives, both at home and at work, functions like resource allocation, schedule optimization, and decision-assistance are becoming increasingly pervasive. What do they have in common? They are all discrete optimization problems. Today, algorithms inspired by a physical model called the Ising model, which correlates an energy level to the probability of a given answer, are used to solve these problems. The associated software is currently run on generic computer architectures. Closely related to Hopfield networks and Boltzmann machines, Ising machines—famously studied for AI learning by Nobel laureates John J. Hopfield and Geoffrey E. Hinton—are alternative processor architectures that emulate the Ising model. We used them to efficiently arrive at optimal solutions in the presence of very large numbers of combinations. In our architecture, the building blocks of the Ising machine are SOT-MTJs coupled asynchronously through a resistive array. The purpose of our research was to assess the device's ability to carry out a factoring operation and evaluate its power consumption.

Impact

This advance in stochastic computation will lead to new SOT-MRAM-based architectures that will support more efficient energy-based computing for AI.

Research partners

Spintec, NY Creates.

Spintec and CEA-Leti: driving advances in memory

At the crossroads between Spintec's expertise in the science of magnetism and CEA-Leti's deep knowledge of embedded non-volatile memory, this partnership, which kicked off in 2021, has already resulted in the fabrication of several test vehicles for magnetic tunnel junction architectures using processes available on a joint pilot line that includes 200 mm equipment at CEA-Leti, equipment at Spintec's Upstream Technology Platform, and equipment at commercial foundries.

PARTNERSHIPS ON MRAM AND MRAM-DERIVED TECHNOLOGIES PAVE THE WAY TOWARD TOMORROW'S DEVICES

> **"CEA-Leti provides us with a path toward transforming our scientific excellence into economic value. Together we have the critical mass to lay the groundwork for a competitive sovereign magnetic memory industry. Fast, low-power, high-endurance MRAM could play a decisive role in in-memory compute and low-power biomimetic compute architectures. Spintec is one of the world's leading centers for spintronics, a technology that leverages not only an electron's charge, but also its rotation, or spin, to enable new functions. For Spintec, working with CEA-Leti opens the door to industrial 28 nm and 22 nm CMOS process technologies available through CEA-Leti's commercial foundry partners."**

Lucian Prejbeanu
Spintec

spintec

In this research, using our SPICE model, we demonstrated that a 48-node SOT-MTJ network successfully converges to the optimal solution, factoring an 8-bit integer in 10 µs with an estimated power consumption of 133 µW/node. This early-stage study gave us a better understanding of the speed vs. power tradeoffs in these kinds of systems.

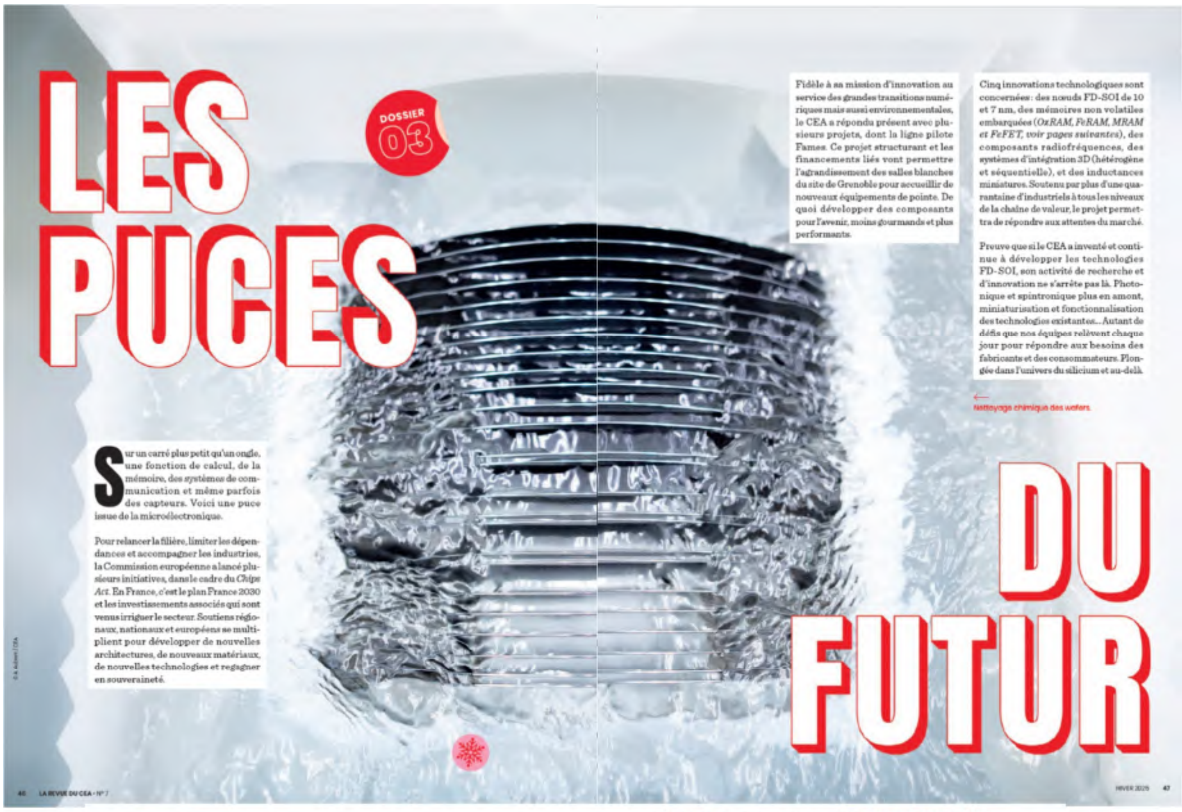
Embedded memory and compute: CEA-Leti and Spintec join forces on EMCOM project

The EMCOM project, financed by France's national research program on electronics, will continue to drive low-power emerging memories for embedded memory and compute. CEA-Leti and Spintec are coordinating this national consortium along with Laboratoire Albert Fert (a CNRS, Université Paris Saclay, and Thales joint research unit).

MRAM: Moving from 200 mm to 300 mm with NY Creates

A new partnership between the CEA and NY Creates was signed in 2024 that will position the CEA to continue to scale up magnetic tunnel junction technologies on the state-of-the-art 300 mm equipment available at NY Creates' Albany NanoTech Complex in New York State, the most advanced semiconductor R&D center in North America. A CEA engineer is on site in New York State, and tapeout of the first 300 mm generation of the test vehicle, the MAD305, is expected in 2025, definitively clearing a path to volume production.

Further reading • Danouchi, K., et al. Designing networks of resistively-coupled stochastic Magnetic Tunnel Junctions for energy-based optimum search. Paper presented at the 69th Annual IEEE International Electron Device Meeting (IEDM), San Francisco, United States, December 2023, pp. 1-4, 2023, doi : 10.1109/IEDM45741.2023.10413843.



LES PUCES DU FUTUR

Sur un carré plus petit qu'un ongle, une fonction de calcul, de la mémoire, des systèmes de communication et même parfois des capteurs. Voici une puce issue de la microélectronique.

Pour relancer la filière, limiter les dépendances et accompagner les industries, la Commission européenne a lancé plusieurs initiatives, dans le cadre du *Chips Act*. En France, c'est le plan France 2030 et les investissements associés qui sont venus irriguer le secteur. Soutiens régionaux, nationaux et européens se multiplient pour développer de nouvelles architectures, de nouveaux matériaux, de nouvelles technologies et regagner en souveraineté.

Fidèle à sa mission d'innovation au service des grandes transitions numériques mais aussi environnementales, le CEA a répondu présent avec plusieurs projets, dont la ligne pilote Fames. Ce projet structurant et les financements liés vont permettre l'agrandissement des salles blanches du site de Grenoble pour accueillir de nouveaux équipements de pointe. De quoi développer des composants pour l'avenir, moins gourmands et plus performants.

Cinq innovations technologiques sont concernées : des nœuds FD-SOI de 10 et 7 nm, des mémoires non volatiles embarquées (*OxRAM, FeRAM, MRAM et FeFET, voir pages suivantes*), des composants radiofréquences, des systèmes d'intégration 3D (hétérogène et séquentielle), et des inductances miniatures. Soutenu par plus d'une quarantaine d'industriels à tous les niveaux de la chaîne de valeur, le projet permettra de répondre aux attentes du marché.

Preuve que si le CEA a inventé et continue à développer les technologies FD-SOI, son activité de recherche et d'innovation ne s'arrête pas là. Photonique et spintronique plus en amont, miniaturisation et fonctionnalisation des technologies existantes... Autant de défis que nos équipes relèvent chaque jour pour répondre aux besoins des fabricants et des consommateurs. Plongée dans l'univers du silicium et au-delà.

←
Nettoyage chimique des wafers.

1. Ingénieure d'affaires en technologies innovantes, **Florine Varin** est responsable des partenariats dans les secteurs de l'agriculture et de l'agroalimentaire pour l'ensemble du CEA. Sa connaissance de leurs problématiques a été précieuse pour bâtir un dossier le plus complet possible sur la gestion de l'eau.
© Carla Pellicola

2. Chef du programme SMR, **Pierre Gavoille** est quasi incollable sur les différentes technologies de réacteurs nucléaires, petits ou grands, et sur les manières de les coupler à toutes sortes de procédés industriels. Pour l'avenir, il est convaincu que l'énergie nucléaire aidera à décarboner bon nombre de nos usages.
© L. Godart

Les invités de la revue

6. Directeur des énergies, **Philippe Stohr** mobilise ses équipes autour d'une vision intégrée du système énergétique, avec un objectif: contribuer à l'atteinte par la France de la neutralité carbone en 2050. Une approche désormais partagée par de nombreux acteurs de l'énergie.
© Y.Audic/CEA

5. **Thomas Ernst** est directeur scientifique à l'Institut de microélectronique et des technologies de l'information du CEA, le Leti, où il supervise les stratégies de recherche à long terme et les partenariats scientifiques. Si vous vous demandez ce que peut bien vouloir dire GaaFET, il a la réponse !
© UtopikPhoto/CEA

SEMICONDUCTOR DIGEST
NEWS AND INDUSTRY TRENDS

The 2025 MRAM Global Innovation Forum to Showcase MRAM Technology Innovations, Advance...

The 2025 MRAM Global Innovation Forum to Showcase MRAM Technology Innovations, Advances, & Research from Industry Experts

SHANNON DAVIS - 1 MONTH AGO 0

The MRAM Global Innovation Forum is the industry's premier platform for Magnetoresistive Random Access Memory (MRAM) technology, bringing together leading magnetics experts and researchers from industry and academia to share the latest MRAM advancements. Now in its 13th year, the annual one-day conference will be held the day after the IEEE International Electron Devices Meeting (IEDM) on December 11, 2025 from 8:45am to 6pm at the Hilton San Francisco Union Square Hotel's Imperial Ballroom A/B.

"The STT-MRAM market is growing rapidly now, especially with use of embedded STT-MRAM in next-generation automotive microcontroller units," said Kevin Garello, MRAM Forum co-chair (since 2021) and senior researcher engineer at SPINTEC. "I expect edge AI applications to be the next big market for STT-MRAM."

"I am pleased to see that over the years, the MRAM Forum series has grown into a landmark event within the MRAM industrial ecosystem," said Bernard Dieny, former MRAM Forum co-chair (2017–2023), and director of research at SPINTEC. "We are witnessing a steady increase in the adoption of this technology across the microelectronics industry, and the initial concerns associated with this new technology are steadily fading away."

Awards

Johanna Fischer – Young scientist award of EMA (The European Magnetism Association)

Recognition of her contributions to the field of multiferroics and magnetic skyrmions

Bernard Dieny – Knight of the Legion of Honor and Clément Codron Prize from the Academy of Sciences

Bernard DIENY
Directeur de recherche CEA, laboratoire Spintronique et technologies des composants, Grenoble

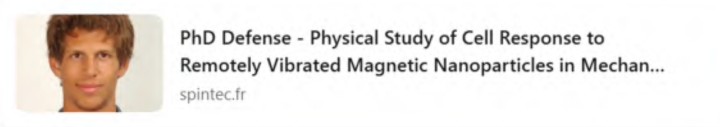
Laura-Alvaro- Gomez – *PhD award Claudine Hermann 2025 from the French Physical Society*

Libor Vojacek – *PhD award C'NANO 2025*

PhD defenses

Congratulations to all our new PhD colleagues!

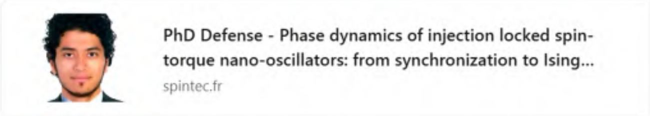
On Thursday January 30th, **Andrea Visonà** will defend his PhD thesis on the interaction between cells and remotely vibrated magnetic nanoparticles in mechano-mimetic environments, co-supervised by **Alice Nicolas** and Robert Morel at **S** ...more

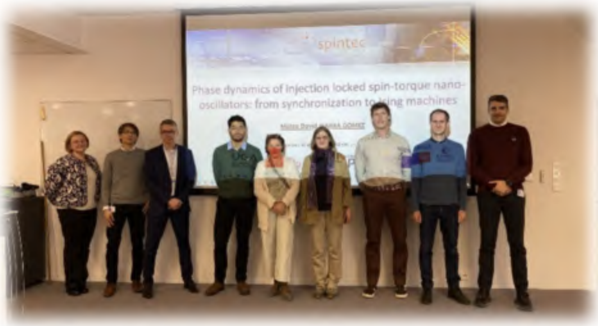

PhD Defense - Physical Study of Cell Response to Remotely Vibrated Magnetic Nanoparticles in Mechan...
spintec.fr

On Tuesday February 4th, **Nhat-Tan PHAN** will defend his PhD thesis on exploring the potential of spin-torque nano-oscillators and superparamagnetic tunnel junctions as stochastic building blocks for unconventional computing, ...more


PhD Defense - Leveraging Stochastic properties of Spintronic Nanodevices for Unconventional Computin...
spintec.fr

On Tuesday April 1st **Mateo David Ibarra Gomez** will defend his PhD thesis on on the physical understanding of injection locking properties of spin-torque nano-oscillators, co-supervised by **Liliana Buda-Prejbeanu** and Ursula Ebels at **SPII** ...more

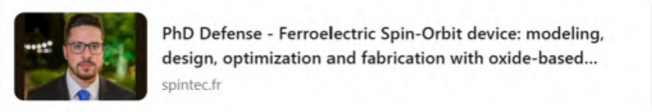

PhD Defense - Phase dynamics of injection locked spin-torque nano-oscillators: from synchronization to Ising...
spintec.fr



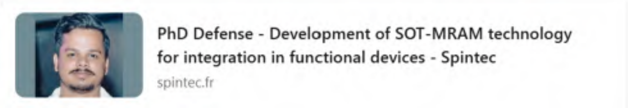
On Wednesday April 9th, **Michael Wißmann** will defend his PhD thesis on the classical and quantum coherent transport properties of intrinsic magnetic topological insulators, co-supervised by **Romain Giraud** and **Bernd Büchner** ...more

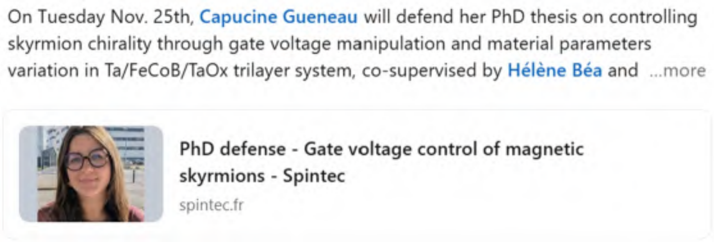

PhD defense : Quantum Transport in Intrinsic Magnetic Topological Insulators - Spintec
spintec.fr

On Tuesday May 6th, Paolo Sgarro will defend his PhD thesis on the study of the possibilities for the implementation, optimization and application of the Ferroelectric Spin-Orbit (FESO) device, co-advised by **Jean-Philippe Attané** and **Guillaume** ...more


PhD Defense - Ferroelectric Spin-Orbit device: modeling, design, optimization and fabrication with oxide-based...
spintec.fr

On Friday October 10th, **Kuldeep Ray** will defend his PhD thesis on development of SOT-MRAM technology for integration in functional devices, co-advised by Gilles Gaudin and **Marc Drouard** at **SPINTEC Université Grenoble Alpes CNRS CEA** ...more


PhD Defense - Development of SOT-MRAM technology for integration in functional devices - Spintec
spintec.fr

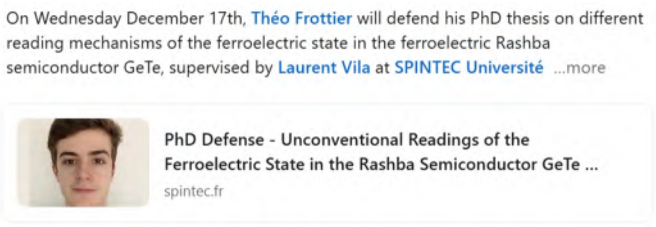

On Tuesday Nov. 25th, **Capucine Gueneau** will defend her PhD thesis on controlling skyrmion chirality through gate voltage manipulation and material parameters variation in Ta/FeCoB/TaOx trilayer system, co-supervised by **Hélène Béa** and ...more

PhD defense - Gate voltage control of magnetic skyrmions - Spintec
spintec.fr

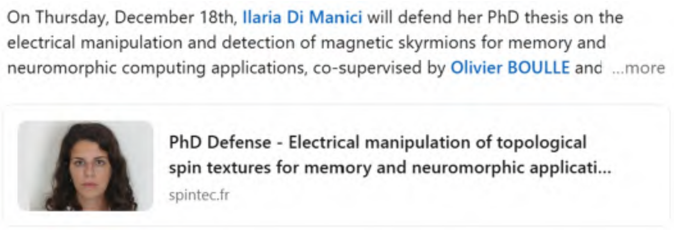

Jeudi 4 décembre 2025, @Augustin Nogier soutiendra sa thèse sur une imagerie operando des dynamiques magnétiques en jeu lors de l'écriture et de la lecture dans les mémoires magnétiques, co-dirigé par **Aurélien Masseboeuf** et **Kevin** ...more

Show translation

PhD Defense - Microscopie électronique operando pour l'étude de mémoires magnétiques - Spintec
spintec.fr


On Wednesday December 17th, **Théo Frottier** will defend his PhD thesis on different reading mechanisms of the ferroelectric state in the ferroelectric Rashba semiconductor GeTe, supervised by **Laurent Vila** at **SPINTEC Université** ...more

PhD Defense - Unconventional Readings of the Ferroelectric State in the Rashba Semiconductor GeTe ...
spintec.fr


On Thursday, December 18th, **Ilaria Di Manici** will defend her PhD thesis on the electrical manipulation and detection of magnetic skyrmions for memory and neuromorphic computing applications, co-supervised by **Olivier BOULLE** and ...more

PhD Defense - Electrical manipulation of topological spin textures for memory and neuromorphic applicati...
spintec.fr

2025 in pictures – Science

January: yearly webinar of PEPR SPIN

February: Kaleidoscope visit of students from UGA-Grenoble INP

Ma

February: participation to Tech&Fest, with dedicated booths for Nellow, Golana Computing and the PTA cleanroom platform

February: participation of the PEPR SPIN directors (Lucian Prejbeanu and Vincent Cros) to a one-day colloquium dedicated to innovation and exploitation of exploratory PEPRs, organized by the SGPI (Secrétariat Général pour l'Investissement)

February: Nellow is laureate of the EIC transition call with the project UPSPRING

March: kick-off of the project Q-SPIN led by Yoshichika Otani and Lucian Prejbeanu organized in Grenoble in the framework of the ASPIRE Top scientist Japanese program

JST ASPIRE Project Kickoff meeting

"Joint Franco-Japanese Initiative for Establishing Foundations for Human Resource Development and Quantum Spintronics Technology"

3-4 March 2025

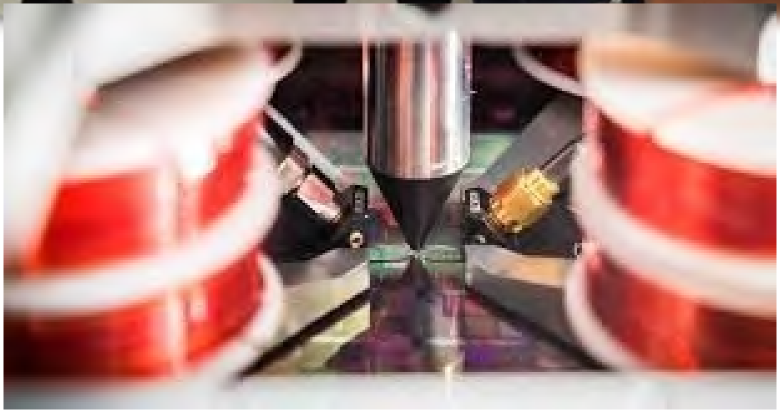
@Grenoble MINATEC

3rd Mar. 9:00 -
Introductions of Projects and Institutions
Session on Topic1 : ***Orbital currents***
Session on Topic2 : ***Quantum Transport***
Summary of the day / possible collaborations
Cocktail / networking

4th Mar. 9:00 -
Session on Topic3 :
Chimera Quasi Particles
Lab tour SPINTEC and Institut Néel

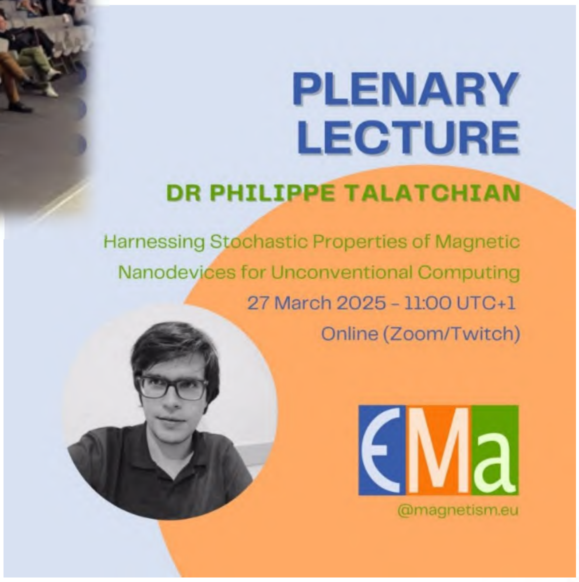
March: Launch of the 3D-Learn project led by Philippe Talatchian in the framework of the AUDACE Recherche à risque program led by CEA

March: Our former start-up Hprobe joins the Mycronic group, a leading provider of turnkey semiconductor Automatic Test Equipment



March: Participation of the PEPR SPIN directors to the annual day of PEPR electronics

March: General assembly of IRIG, with the active participation of several SPINTEC colleagues & EMA plenary lecture by Philippe Talatchian



April: Installing and aligning a new section of the Mecatrans Magnetic Transfer tunnel with the existing 2D cluster. Isabelle de Moraes finalizing the work with the engineers from VINCI & finalizing the factory reception for the SCIA IBE-IBD tool, part of the SPIN*fab* pilot line, monitored by Florian Disdier.

April: kick-off of the new projects of the open call of PEPR SPIN, with SPINTEC involved in the 7 of them, of which 3 in coordination

May: visit of the General Administrator of CEA, François Jacq

June: Bernard Dieny is awarded Chevalier de la Legion d'Honneur

June: Colloque Louis Néel and PEPR SPIN day in Ardèche

June: Inauguration of SPIN*fab* pilot line

August: participation of SPINTEC colleagues at the JEMS conference in Frankfurt

September: master internship booklet

spintec
SPIN IN ELECTRONICS

SPINTRONIQUE et TECHNOLOGIE des COMPOSANTS

Master Internship Booklet

2026

www.spintec.fr

List of proposals

1. Atomistic spin dynamics modelling of novel magnetic topological objects
2. A new altermagnetic material with remarkable properties for spintronics
3. Spin textures of magnetotactic bacterias with Electron Microscopy
4. Experimental search for spinwave non-reciprocity in nanowires & nanotubes
5. Characterization of orbital and spin-orbital torques for MRAM applications
6. Orbital Angular Momentum of Magnons
7. Memristor arrays based on ferroelectric devices
8. Ferroelectric control of spin-charge interconversion
9. Digital circuit design based on ferroelectric spin-orbit devices
10. Selective destruction of pancreatic cancer cells by magneto-mechanical stimulation
11. Physics and functionalities of nanopillars for 3D spintronic devices
12. High efficiency STT-MRAM for femtosecond pulse laser writing
13. Manipulation of magnetic skyrmions for neuromorphic computing
14. Orbitronic effects in heterostructures with two-dimensional materials
15. Out-of-equilibrium thermally activated magnetization reversals in magnetic tunnel junctions
16. Characterization of a spin-torque nano-oscillator network for Ising-spin analog computing

The laboratory is constantly seeking undergraduate and summer students with high potential and a taste for research at the frontier between fundamental physics and technology. Individuals with cutting edge scientific skills, strong motivation, the taste for teamwork and a good sense of humor are welcome.

Below is the list and description of projects that are proposed for the Master-2 level, most of them are intended to continue to a PhD, and several are also open to Master-1 level students. In the framework of French universities the typical period for M2 internships is from March to June / July, but we welcome equally students from foreign universities and different timeframes for carrying out their internship.

Please do not hesitate to contact us any time if you are a student and wish to join, either through the lab directors or directly through the permanent staff whose e-mail you find at the end of the corresponding description of the research projects.

direction.spintec@cea.fr
Lucian PREJBEANU, Director / +33(0)4 38 78 91 43
Olivier FRUCHART, Deputy Director / +33(0)4 38 78 31 62

September: participation of several SPINTEC colleagues at the French-Taiwanese workshop

October: participation at the Fête de la Science by several colleagues from SPINTEC, led by Aurélien Masseboeuf and Isabelle de Moraes

October : welcoming M2 students

November : HCERES committee visit at SPINTEC

2025 in pictures – Social events

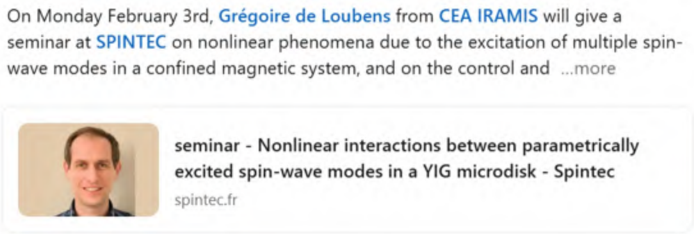
March: Macaron contest

October: Cake contest

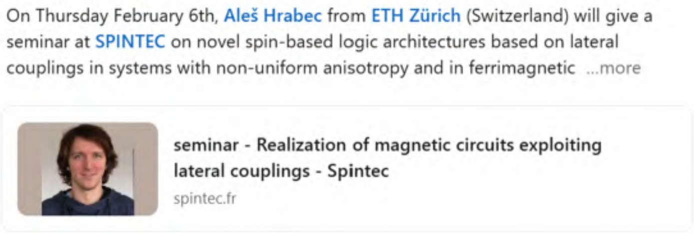
November: winter is coming in Grenoble

December: Gift exchange and end-of-year party

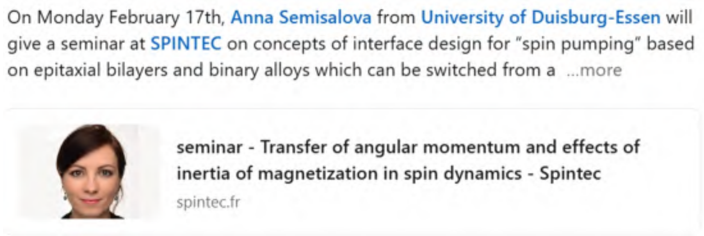
Invited seminars at SPINTEC


On Monday February 3rd, Grégoire de Loubens from CEA IRAMIS will give a seminar at SPINTEC on nonlinear phenomena due to the excitation of multiple spin-wave modes in a confined magnetic system, and on the control and ...more

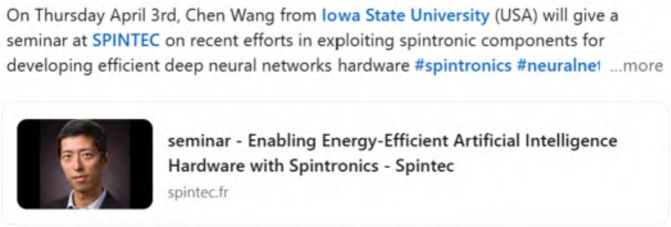
seminar - Nonlinear interactions between parametrically excited spin-wave modes in a YIG microdisk - Spintec
spintec.fr


On Thursday February 6th, Aleš Hrabec from ETH Zürich (Switzerland) will give a seminar at SPINTEC on novel spin-based logic architectures based on lateral couplings in systems with non-uniform anisotropy and in ferrimagnetic ...more

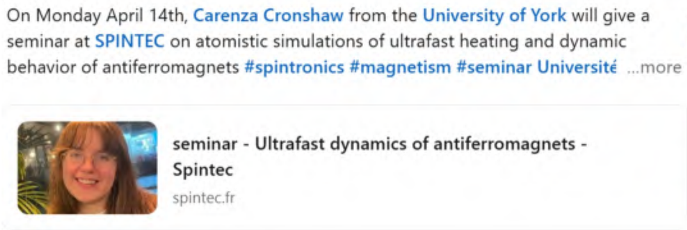
seminar - Realization of magnetic circuits exploiting lateral couplings - Spintec
spintec.fr


On Monday February 17th, Anna Semisalova from University of Duisburg-Essen will give a seminar at SPINTEC on concepts of interface design for "spin pumping" based on epitaxial bilayers and binary alloys which can be switched from a ...more

seminar - Transfer of angular momentum and effects of inertia of magnetization in spin dynamics - Spintec
spintec.fr


On Thursday April 3rd, Chen Wang from Iowa State University (USA) will give a seminar at SPINTEC on recent efforts in exploiting spintronic components for developing efficient deep neural networks hardware #spintronics #neuralnet ...more

seminar - Enabling Energy-Efficient Artificial Intelligence Hardware with Spintronics - Spintec
spintec.fr


On Monday April 14th, Carenza Cronshaw from the University of York will give a seminar at SPINTEC on atomistic simulations of ultrafast heating and dynamic behavior of antiferromagnets #spintronics #magnetism #seminar Université ...more

seminar - Ultrafast dynamics of antiferromagnets - Spintec
spintec.fr


On Wednesday June 11th, Luis Avilés Félix from CNEA-CONICET and Instituto Balseiro (Argentina) will give a seminar at SPINTEC on the magnetotransport and spin dynamics in CoFe layers Université Grenoble Alpes Grenoble INP - UGA ...more

Seminar - Spin dynamics and magnetotransport in ultra-low damping Co100-xFex layers - Spintec
spintec.fr


On Thursday June 26th, Kazuma Ogawa from the The University of Tokyo will give a seminar at SPINTEC on spin texture manipulation by current and light probed via magneto-optical microscopy #spintronics #magnetism #seminar Université ...more

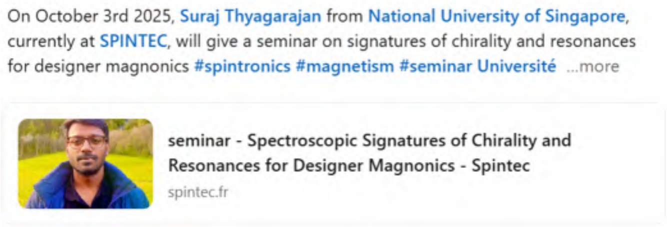
seminar - Spin Texture Manipulation by Current and Light probed via Magneto-Optical Microscopy - Spintec
spintec.fr


On Monday June 30, 2025 Sergey A. NIKOLAEV from Osaka University will give online seminar on the description of antiferromagnetic systems from the group-theoretical perspective and on realistic models for altermagnets establishing ...more

Seminar - Symmetry aspects of antiferromagnets and altermagnets - Spintec
spintec.fr


On Wed. Oct. 1st 2025, Aurélien Lagarrigue from Tohoku University will give a seminar at SPINTEC on analog control of magnetization via spin-orbit torque for neuromorphic computing #spintronics #magnetism #seminar Université ...more

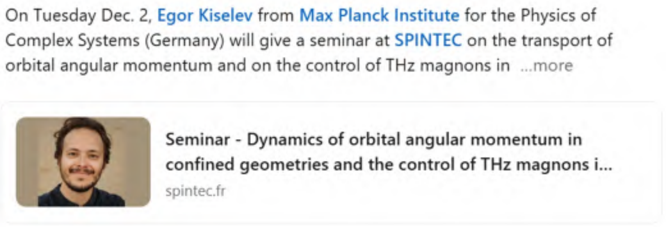
seminar - Analog Control of Ferromagnetic Magnetization Through Spin-Orbit Torque for...
spintec.fr


On October 3rd 2025, Suraj Thyagarajan from National University of Singapore, currently at SPINTEC, will give a seminar on signatures of chirality and resonances for designer magnonics #spintronics #magnetism #seminar Université ...more

seminar - Spectroscopic Signatures of Chirality and Resonances for Designer Magnonics - Spintec
spintec.fr


On Wed. Nov. 12th, Lucas Perez from Universidad Complutense de Madrid and IMDEA Nanociencia will give a seminar at SPINTEC on the in vitro detection of neuronal activity emerging from spinal cord slices under physiological ...more

seminar - Magnetic recording of neural activity using spintronics-based sensors - Spintec
spintec.fr


On Tuesday Dec. 2, Egor Kiselev from Max Planck Institute for the Physics of Complex Systems (Germany) will give a seminar at SPINTEC on the transport of orbital angular momentum and on the control of THz magnons in ...more

Seminar - Dynamics of orbital angular momentum in confined geometries and the control of THz magnons i...
spintec.fr

On Mon. Dec. 8th at 11am CET, Chih-Huang Lai from National Tsing Hua University (Taiwan) will present a seminar at SPINTEC on the potential of using spin-orbit torque devices as building blocks for neuromorphic computing #spintronics ...more

seminar - Spin-orbit torque devices and their applications for neuromorphic computing - Spintec

spintec.fr

On Monday, Dec. 8th at 2pm CET, Vincent Polewczyk from GEMaC - UMR8635 (Versailles) will give a seminar at SPINTEC on the strain-tailored properties of antiferromagnetic/ferromagnetic oxide thin films #spintronics #magnetism ...more

seminar - Epitaxial strain tailoring of the antiferromagnetic/ferromagnetic oxide thin film...

spintec.fr

On Tue. Dec. 16th 2025, Helena Reichlova from FZU - Institute of Physics of the Czech Academy of Sciences (Prague) will give a seminar at SPINTEC on spin transport experiments in altermagnetic metals, semiconductors and ...more

seminar - Spin transport experiments in altermagnets - Spintec

spintec.fr

Obituary

In memoriam professor Anatoly Vedyaev

from Lomonosov Moscow State University

Our laboratory, SPINTEC - and previously the Nanostructure and Magnetism Laboratory - collaborated with Anatoly and his team for over 25 years (since 1992).

International collaborations

International collaborations are more than ever a crucial aspect of scientific research and innovation.

They allow benefiting from **expertise and ideas complementary to our known**, enabling us to achieve **broader objectives**; they provide opportunities to access European and bilateral funding, contributing to accelerate our research; they foster **staff exchange**, outwards to provide career-development secondments for our PhDs, inwards to establish contact with early-career scientist to fuel our positions.

Collaborations may take a variety of forms, from large structured networks to focused collaborations, considering research, innovation, education and outreach.

The list below provides a list of our recent network of collaborations.

EUROPE

- **Austria** (Universität Wien, Vienna)
- **Belgium** (Université Catholique de Louvain La Neuve; IMEC, Leuven)
- **Czech Republic** (Charles University, Prague)
- **Estonia** (MPhysX, Tallinn)
- **Germany** (Forschung Zentrum Jülich; Paul Drude Institute, Freie Universität, Berlin ; Technical University Dortmund ; IFW, Dresden; Martin Luther Universität, Halle; University of Erlangen-Nürnberg; RPTU, Kaiserslautern; JGU, Mainz; Universität München; Karlsruhe Institute of Technology)
- **Greece** (FORTH, Heraklion)
- **Italy** (University of Ancona; Politecnico di Milano; University Sapienza, Roma)
- **Netherlands** (University of Groningen; Radboud University, Nijmegen)
- **Portugal** (INL, Braga, INESC, Lisbon)
- **Romania** (IMT, Bucharest; National Institute for Materials Physics, Bucharest; Babes-Bolyai University, Cluj-Napoca, Transilvania University, Brasov, Technical University, Cluj-Napoca)
- **Spain** (Universitat Autònoma de Barcelona, Catalan Institute of Nanotechnology ICN2, Barcelona; ICMM-CSIC, IMDEA, Complutense University, Madrid; Nanogune, San Sebastian)
- **Switzerland** (ETH, Zürich)
- **Turkey** (Ankara University, METU, ODTU-MEMS, Ankara)
- **United Kingdom** (University of Cambridge; University of York)

ASIA

- **Saudi Arabia** (King Abdullah University of Science and Technology, Thuwal)
- **China** (Zhejiang University, Hangzhou)
- **India** (SN Bose National Centre for Basic Sciences, Kolkata)
- **Japan** (Osaka University; JAEA, Tokai; ISSP, Tokyo; NIMS, University of Tsukuba; AIST, Tsukuba; RIKEN CEMS, Wako, Tohoku University)

AMERICAS

- **Argentina** (Centro Atómico Bariloche CNEA)
- **Chile** (USACH, Santiago)
- **USA** (Argonne National Labs, Chicago; University of Maryland, College Park; NIST, Gaithersburg; NIST, Boulder; University of Nebraska, Lincoln; Western Digital Corporation, San Jose; University of G. Washington, Washington D.C.; Purdue University, West Lafayette; Applied Materials, Silicon Products Group, Sunnyvale; NY Creates, New-York)

SPINTEC research topics

SPIN ORBITRONICS

The team covers new concepts to devices: exploring new concepts in spintronics based on spin-dependent transport with various systems: structure inversion asymmetry (spin orbit torques, Rashba effect, Spin Hall Effect, Topological Insulators), and alternative geometries in order to develop innovative architectures of devices.

TOPOLOGICAL SPINTRONICS

The team aims at manipulating spins currents in nanostructures of novel quantum materials (Dirac/Weyl matter, topological states at interfaces/edges, van der Waals heterostructures, oxides). Some important aspects of future spintronics devices, such as the efficient spin-charge interconversion at interfaces controlled by ferroelectricity or the ballistic transport of spin states for quantum metrology or topological devices, are studied by magneto-transport measurements.

2D SPINTRONICS

The team deals with spin-dependent phenomena in several important classes of materials: Si and Ge, which are the materials of today’s microelectronics, and transition metal dichalcogenides and surfaces of topological insulators, which are emerging 2D materials with exceptional optical and spin-orbit properties. We are studying model systems grown by molecular beam epitaxy and their spin properties.

ANTIFERROMAGNETIC SPINTRONICS

The team explores the spin-dependent properties of compensated magnets such as antiferromagnets and altermagnets. These materials possess unrivalled properties in terms of spin physics, putting them in a good position to integrate spin active parts of future generations of memories, sensors and transceivers for applications in sectors such as automotive, classical and quantum information, and artificial intelligence.

SPIN TEXTURES

The team investigates novel spin textures and their magnetization dynamics, especially in curvilinear systems such as wires and core-shell tubular structures. This involves the three components of magnetization and their three-dimensional distributions, with topology specific to these 3D phase spaces. The team designs the systems, images the spin textures with advanced techniques, and addresses these with spin-polarized current. The applied background are concepts for 3D magnetic memories and sensors.

SPIN INSULATRONICS

The team aims at understanding and controlling microwave oscillations of magnetization around its equilibrium, which are the natural dynamical response to external perturbations (*e.g.*, thermal fluctuations, microwave fields). This offers the promise for a new class of microwave devices based on magnetic insulators, benefiting from their small footprint, their ability to be controlled electrically, and their integrability with CMOS technology to design local oscillators, microwave filters, detectors, and non-reciprocal devices.

RF SPINTRONICS

The aim of the team is to provide a fundamental understanding and control of the excitation, manipulation and detection of the linear, non-linear and complex magnetization dynamics in single and coupled magnetic nanostructures such as magnetic tunnel junctions. Potential applications lie within smart sensor networks and unconventional computing.

MAGNETIC SENSORS

The team explores and develops new concepts for magnetic sensors and covers the entire value chain, from fundamental studies to industry support. The team i) explores the effect of gate voltage on interfacial magnetic properties for new concepts of controllable sensors; ii) develops proofs of concept for ultra-low field sensors; and iii) valorizes its expertise by supporting industrial R&D. The research is essentially experimental, based on material expertise of active stacks and magnetic flux guides, on design and microfabrication of complex devices in clean-room and on magnetic (VSM, MOKE) and electric (magnetotransport and noise) characterization. In addition, micromagnetic simulations and analytical macrospin modeling are used both to deepen our understanding of experimental observations and to further optimize our devices.

MRAM

The team develops memory concepts with improved thermal stability, low power consumption and/or ultrafast writing. The targeted applications range from standalone to embedded memories, for various usages ranging from in-memory computing to artificial intelligence. Electric-field control of magnetization, possibly in combination with spin-charge interconversion, as well as optical switching of magnetization, are studied as further extension of spintronic memories beyond-CMOS technologies.

SPINTRONICS COMPUTING & ARCHITECTURES

The team is dedicated to the evaluation of the benefits of using magnetic devices in Integrated Circuits (ICs). It is expected that integrating non-volatility in ICs could contribute to push forward the incoming limits in the microelectronics scaling. This work includes integrating the magnetic devices in standard design tools, design hybrid circuits and evaluate their performance for various applications, *i.e.*, low power, neuromorphic, security, radiation hardening.

MAGNETIC BIOTECHNOLOGIES

The team’s research deals with mechanobiology i.e. the study of the physiological reactions of living cells to mechanical stresses. These stresses are applied by dispersing anisotropic magnetic particles among the cells and actuating the particles by external varying magnetic fields. We already demonstrated that the magneto-mechanical stimulation of cancer cells can trigger their apoptosis (spontaneous death) or can produce insulin release from pancreatic cells. Further work is in progress on magnetically assisted neuroregeneration. Our team contributions consist in fabricating the engineered magnetic mesoparticles, providing the magnetic field sources adapted to the biology experiments and leading the collaborations with our biology and medical partners.

ARTIFICIAL INTELLIGENCE

The team brings together various expertise of SPINTEC in spintronic devices: nanofabrication, characterization, circuit integration, architecture, and algorithm techniques, to implement hardware solutions for artificial intelligence (AI) and unconventional computing. Spintronic devices provide substantial opportunities to improve the energy efficiency of next-generation computing hardware. The team also takes advantage of brain-inspired computing models to deploy cutting-edge neuromorphic algorithms, closing the gap between current hardware AI implementations and exceptional brain computing ability.

THEORY / SIMULATION

The team covers all aspects of fundamental and applied physics related to spin electronics by employing a wide range of theoretical approaches including ab initio, tight-binding, free electron and diffusive methods, combined with micromagnetic and atomistic simulation approaches. This allows explaining experimental observations, providing solutions for specific problems and predicting novel properties and phenomena guiding the experimental work to optimize spintronic nanostructures.

About SPINTEC

Positioned at the crossroad of science and technology, SPINTEC (SPINtronique et TEchnologie des Composants) is one of the leading spintronics research laboratories worldwide, ideally located on the *MINATEC* campus in Grenoble. The laboratory was created in 2002 and rapidly expanded to now exceed 120 persons of which 53 Permanent staff and almost 70 interns, Ph.D. students, post-docs and international visitors. **The scientific institutions taking part in the lab are**: *CEA*, *CNRS*, and the *University of Grenoble Alpes* including the *Grenoble Institute of Technology*.

SPINTEC's objective is to **bridge fundamental research and innovative devices in the fast-growing field of spin electronics** (spintronics). Indeed, the *international technology roadmap for semiconductors (ITRS)* now reckons that spintronics devices will play a major role in tomorrow's semiconductor chips, with high potential for fast and low-power stand-alone (e.g. DRAM) and embedded memories, magnetic field sensors, hardware components for artificial intelligence and bio-applications. **In this context, SPINTEC brings together top-level scientists and applicative engineers** who work in close collaboration, to ensure that discoveries at the forefront of research can be swiftly translated into technological proofs of concepts and functional devices. As such, **the outcome of the laboratory is not only scientific publications and communications at international conferences**, but also a **coherent patents portfolio**, implementation of **relevant functional demonstrators**, and partnerships for technology transfer. Our large scale provides the critical mass to master all required steps ranging from materials, nanofabrication, electrical and magnetic characterization, condensed-matter theory, simulation and the design of dedicated integrated circuits.

Whereas our fundamental research is mostly operated through collaborative grants with other research laboratories, **applied research is often carried out in partnership with private actors**. These can be large corporations (Applied Materials, Samsung, Seagate, INTEL, Texas Instruments, Allegro Microsystems), SME's (Singulus, Spin Ion) or **start-up companies spun-off from SPINTEC**: Crocus Technology in 2006, eVaderis in 2014, HProbe in 2016, Antaïos in 2017, Golana Computing in 2023 and Nellow in 2024.

SPINTEC plays also a major role in higher education in magnetism and nanotechnology, through chairing or steering four highly-visible international schools: *the European School on Nanosciences and Nanotechnology* ESONN, the *European School on Magnetism* ESM, the school on applied spintronics InMRAM, and the school *Quantitative Electron Microscopy* QEM.

© C. Comoy / CEA

SPINTEC, CEA Grenoble, − 17 rue des Martyrs − GRENOBLE (France)
https://spintec.fr
direction.spintec@cea.fr
company/spintec-lab