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Scientific Newsletter

Winter 2025

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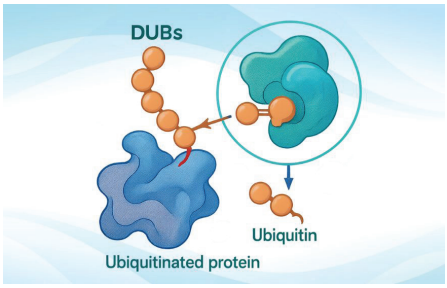
Summary

Highlights

cea cnrs Inserm UGA Université Grenoble Alpes INRAE

The USP36 enzyme: a deubiquitinase with two modes of action

Emmanuel Taillebourg
Biology and Biotechnology for Health Laboratory



The **CEA-Irig/BGE** team has shown in Drosophila that the enzymatic activity of the deubiquitinase USP36 is essential for spermatogenesis but not for cell growth, revealing a novel dual mode of action in this enzyme family.

Deubiquitinases (DUBs) are enzymes that remove **ubiquitin*** from ubiquitinated proteins and thus participate in the regulation of numerous cellular processes. Among them, USP36 plays a central role in stabilizing several proteins such as the MYC oncogene, a major regulator of cell growth and proliferation whose deregulation is at the root of many cancers. Using the Drosophila fly as a genetic model, the **CEA-Irig/Gen&Chem team** explored the mechanisms of action of this enzyme in order to distinguish between functions that are dependent or independent of its catalytic activity.

Using genome editing via the innovative **CRISPR/Cas9*** technique, researchers produced flies expressing a mutated version of USP36 lacking enzymatic activity. While mutants that no longer express the USP36 protein die early during development with severe growth defects (see **Figure**) catalytic mutants of USP36 survive and develop normally (see **Figure**). However, males carrying this mutation are sterile and have spermatogenesis defects. This contrast reveals that the presence of the USP36 protein is necessary for growth, but that its catalytic activity is not. On the other hand, the enzymatic activity of this protein is crucial for sperm formation.

This study shows that the deubiquitinase USP36 has a novel dual mode of action, acting either as a structural protein or as an active enzyme, depending on the context. This opens up new perspectives on the non-enzymatic roles of deubiquitinases in cell development and physiology.

Ubiquitin* is a small, highly conserved protein that covalently binds to other proteins to modulate their stability, localization, or activity.

CRISPR/Cas9* is a genome editing technique that uses an enzyme (Cas9) guided by RNA to cut DNA at a specific site, allowing a gene to be inactivated or a specific modification to be introduced.

On the left: normal Drosophila. **In between:** mutant no longer producing USP36 protein. **On the right:** catalytic mutant of USP36. © CEA

Fundings
- IDEX Université Grenoble Alpes
- GRAL PhD Program

REFERENCE
Coirry C, Manessier J, Clot C, Mortier M, Fauvarque M-O, and Taillebourg E.
The deubiquitinase USP36 functions through catalytic-dependent and catalytic-independent mechanisms in Drosophila
Genetics 2025

Aging of plastics: what about their degradation?

Thierry Douki
Molecular Systems and nanoMaterials for Energy and Health laboratory

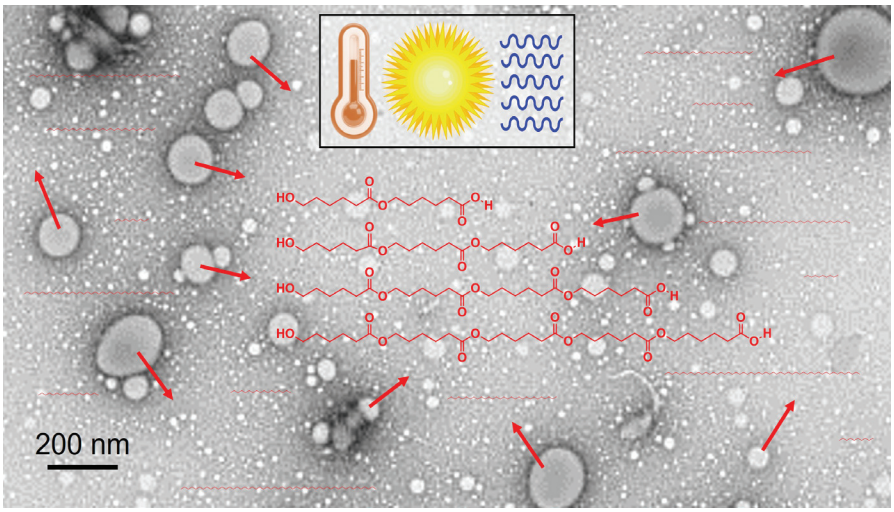
To prevent the accumulation of micro- and nanoplastics in the environment, some industries are turning to biodegradable plastics that can break down in the environment.

But what by-products are produced during this degradation process, and how toxic are they?A team of researchers from **CEA-Irig/SyMMES** has attempted to answer these questions.

Plastics are everywhere: packaging, textiles, toys, medicine, etc., and their consumption continues to grow. More than 80% of these plastics consist of highly stable polymers, mainly derived from fossil fuels, which accumulate in soil and seas. They release micro- and nanoplastics, which raises concerns about human and environmental toxicity.

To mitigate this accumulation, some industries are turning to biodegradable plastics that can break down in the environment. These properties are made possible by their polyester chemical structure, which differs from that of conventional plastics exhibiting only stable C-C bonds.

In 2024, biodegradable plastics represented less than 1% of total plastic production. In order to encourage this strategy as an alternative to plastics that accumulate in the environment, it is necessary to ensure that the degradation products are non-toxic. To this end, a mandatory task is to identify and characterize the degradation products, then quantify them in order to assess the associated risks.



Under the combined action of heat, light and water, particles of biodegradable plastics release small soluble molecules, the oligomers.
© CEA/SyMMES/CIBEST/T. Douki

The **CEA-Irig/SyMMES** team studied several "*pure*" biodegradable plastics in the form of sub-micrometric beads (<1 mm) that had been artificially aged. To do this, particle suspensions were placed at 40° C under light exposure mimicking the equatorial sun for a period of 96 hours. Analysis by mass spectrometry coupled with high-performance liquid chromatography (HPLC) made possible to separate and precisely characterize the degradation products contained in the liquid phase of the suspension, and shows that the particles are hydrolysed into oligomers.

Among plastics previously studied, SyMMES researchers have expanded their investigation to include polycaprolactone (PCL), a biodegradable plastic used in certain types of packaging and in numerous medical applications. Through the chemical synthesis of PCL oligomers, they were able to collect quantitative data under several conditions on the different oligomers released during the hydrolysis of PCL particles. They were thus able to show that PCL hydrolysis was independent of particle size and that the distribution of oligomers present in suspensions after aging depended on temperature (faster at 60° C than at 40° C) and the composition of the medium (three times higher efficiency in seawater than in pure water).

Research on biodegradable polymers conducted by the SyMMES team has therefore led to progress in identifying compounds generated during their degradation. The use of sensitive and specific analytical chemistry tools, usually used for biomarker testing, has shown the predominance of hydrolysis reactions during particle aging. These data will complement the ongoing in vitro toxicology studies. They should confirm the safety of biodegradable plastics and validate their use as an alternative to conventional materials that are responsible for current plastic pollution.

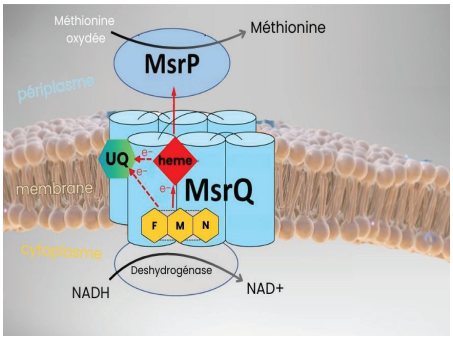
Fundings

- European project PlasticHeal
- ANR project PLASTOX
- ANSES project EXAMINA
- Agence de la Transition Ecologique

REFERENCE
Maëva Boulée, Marie Carrière, Thierry Douki
Quantitative HPLC–mass spectrometry analysis shows the drastic impact of the composition of aqueous and biochemical media on the release of soluble hydrolysis products from submicron polycaprolactone
Polymer 2025

Bacteria resistant to hypochlorous acid

Vincent Nivière
Chemistry and Biology of Metals Laboratory



In the context of the antibiotic resistance, a new MsrPQ enzyme system could explain some of the mechanisms of bacterial virulence. Researchers at **CEA-Irig/LCBM** are therefore studying this system in order to develop new types of antibiotics.

Understanding the mechanisms behind the resistance of pathogenic microorganisms is essential for developing new types of antibiotics. Researchers at **CEA-Irig/LCBM/BioCat** are analyzing the MsrPQ enzyme system, which could enable these bacteria to resist our immune system.

A few years ago, researchers discovered a new enzyme system called methionine sulfoxide reductase (MsrPQ) in certain pathogenic bacteria that enables them to resist hypochlorous acid (HOCl), which is produced by cells of the innate immune system such as macrophages and neutrophils.

Hypochlorous acid specifically causes oxidation of methionines in bacterial proteins, which leads to the loss of their structure and activity, and ultimately to the death of the pathogen. However, as a defense mechanism, these bacteria have developed the MsrPQ system, which repairs these oxidized methionines.

Using complementary approaches (directed mutagenesis, electron paramagnetic resonance spectroscopy, electrochemistry, high-performance liquid chromatography coupled with mass spectrometry, and AlphaFold), researchers at **CEA-Irig/LCBM/BioCat** were able to study the mechanism of MsrPQ in detail, particularly the central role of its membrane component MsrQ, which catalyzes a specific electron transfer reaction from the cytoplasmic space to the periplasm. In addition, they identified that MsrQ contains, in addition to **heme*** two new redox cofactors: a **flavin*** and a **ubiquinone*** (see **Figure**).

Beyond these fundamental aspects studied here, understanding how this new system works will enable us to better characterize bacterial virulence mechanisms and develop new types of antibiotics.

* **Hems** and **flavins** are biological redox cofactors which, when associated with enzymes, enable them to catalyze reactions involving electron transfers.

* **Ubiquinone** also fulfills this function, but is more commonly found in cell membranes.

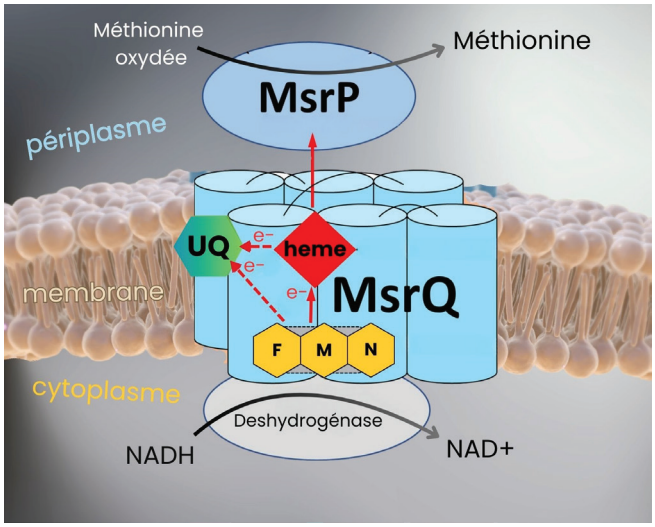
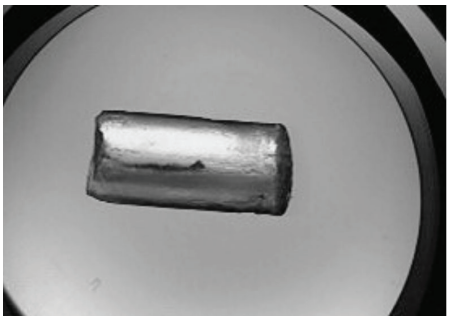


Figure: MsrPQ system repairs periplasmic methionines oxidized by HOCl. The membrane component MsrQ contains three redox cofactors (heme type b, flavin FMN, and ubiquinone UQ), two of which enable electrons to be specifically transported from the cytoplasm to the periplasm for the regeneration of oxidized methionines. © CEA

REFERENCE
Philippe Carpentier et al.
Studies of the membrane-bound flavocytochrome MsrQ flavin mononucleotide (FMN)-binding site reveal an unexpected ubiquinone cofactor
The FEBS Journal 2025

Solid cryogenic hydrogen pellet impact measurements at 500 m/s

Jordan Berton
Low Temperature Systems Department



Researchers at **CEA-Irig/DSBT** have designed a test bench to characterize the impact of cryogenic solids. Physical tests combined with numerical calculations make it possible to predict impact force and fracturing under conditions similar to those anticipated for the Disruption Mitigation System (DMS) of the ITER tokamak.

The Transverse Skills Program "*Dynamic Fragmentation of Ice*" (PTC DeFI) consists of studying the fragmentation of cryogenic solids intended to mitigate plasma disruptions in the ITER reactor. In this context, a preliminary study was conducted using water ice pellets impacting a rigid target. The results of this work, conducted jointly with the Institute of Geosciences and the Environment (CNRS) and the Soils, Solids, Structures, Risks Laboratory at the University of Grenoble Alpes (UGA) have just been published in the International Journal of Impact Engineering [**1**].

The first step of the PTC was to study, under the same experimental conditions as cryogenic solids, a material that is better known in the literature, namely water ice. Ice cubes similar in size to those required for ITER (Ø = 28.5 mm and L = 57 mm) were produced at the IGE and then tested at the 3SR laboratory. In addition, simulations were carried out using the DFH-KST code, which already existed for other fragile materials such as concrete and ceramics.

The water ice pellet manufacturing process developed by IGE allows for control of grain size and porosity. The structure produced was verified by X-ray tomography. Direct impact tests conducted at 3SR used the Hopkinson bar method, which is based on the propagation of elastic waves in solid materials. Using a gas gun, the water ice pellets are projected at 30 m/s onto an aluminum bar. The impact produces an elastic strain wave in the bar, which is measured over time using strain gauges. Simultaneously, the propagation of cracks in the water ice pellets is captured using a high-speed camera with an acquisition frequency of 200 kHz.

The DFH-KST model was implemented in the CEA's EUROPLEXUS software and made it possible to predict the temporal evolution of the impact force of water ice pellets as a function of their impact angle and velocity. These experimental and numerical results were detailed in the reference journal on impact loadings [**1**].

This work experimentally validated the use of a damage model for brittle materials under test conditions similar to those present in ITER.

The next step for PTC-DeFI was to measure the impact force of cryogenic solids made of hydrogen, neon, deuterium, or a mixture of these materials. The **CEA-Irig/DSBT** test bench was specially designed to produce these solids by in-situ desublimation, then propel them with a gas gun at velocities around 500 m/s. To characterize the impact of these cryogenic solids, researchers have developed an acquisition system capable of recording strain data up to 1 MHz and filming the impact up to 1 million frames per second.

Such a system for measuring the impact force of cryogenic solids is unprecedented. Experimental campaigns were conducted using the formation and acceleration parameters required for ITER. A reproducibility study involving 18 solid hydrogen shots, formed and accelerated according to the same parameters using a control system developed by DSBT, yielded promising results for the study of cryogenic solid impacts. These initial results highlight important parameters that need to be controlled, both in terms of the experimental setup (bar diameter, acquisition system) and the manufacturing parameters of cryogenic solids (temperature, pressure, and injection flow rate). We have already demonstrated the ability to film the impact of solid hydrogen pellets launched at 500 m/s (**Figure 1**) and to measure the temporal evolution of their impact force (**Figure 2**).

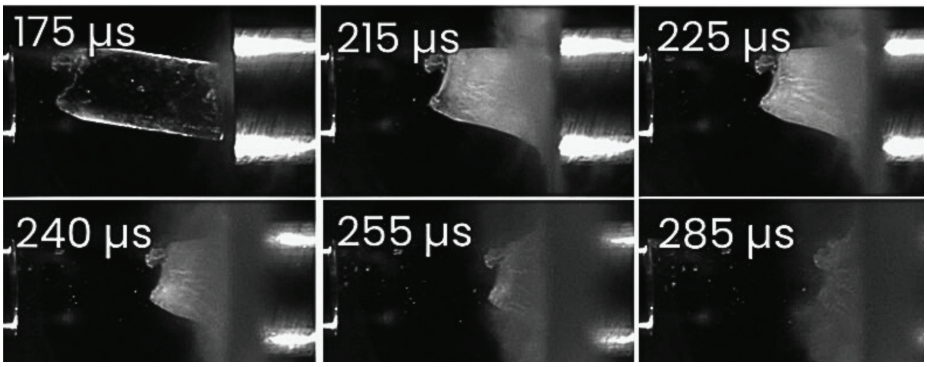


Figure 1: Sequential images of the impact of a solid hydrogen pellet at 500 m/s © CEA

The results are currently being analyzed, and this experimental campaign will be the subject of a new publication. These promising initial results have led to the award of a European EUROfusion Engineering Grant to extend the PTC's work and expand the predictions of current models on inclined plates, thus approximating the actual geometries present in ice injection systems in magnetic confinement fusion reactors such as ITER or the future EU-DEMO demonstrator.

This work has led to the development of instrumental devices and numerical models specifically dedicated to the fragmentation of cryogenic solids injected into fusion reactors. More generally, a better understanding of the mechanical properties of cryogenic solids will make it possible to predict their behavior during impacts and slides that occur during injection. Looking ahead, plans are in place to study the fragmentation process of cryogenic solids as a function of the angle of impact and manufacturing parameters.

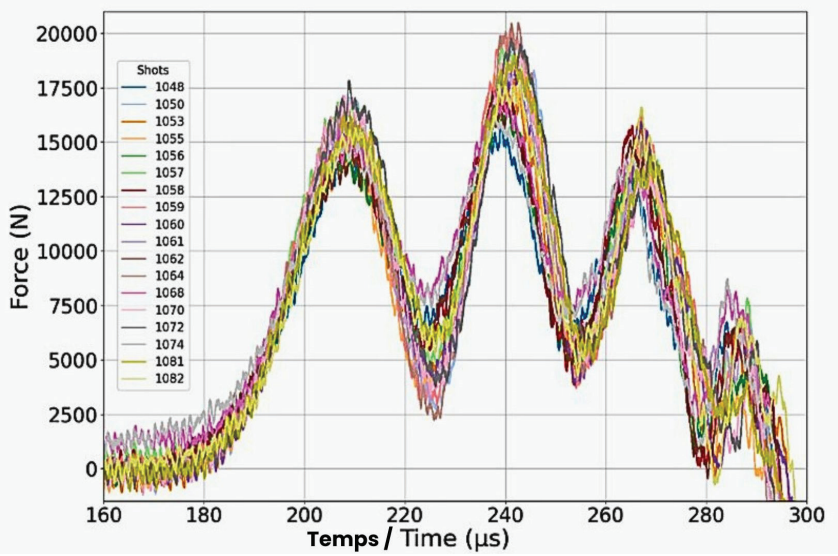


Figure 2: impact force evolution over time for a series of 18 solid hydrogen shots at 500 m/

Collaboration

- Institut Géosciences et de l'Environnement, CNRS
- Laboratoire Sols, Solides, Structures et Risques, UGA

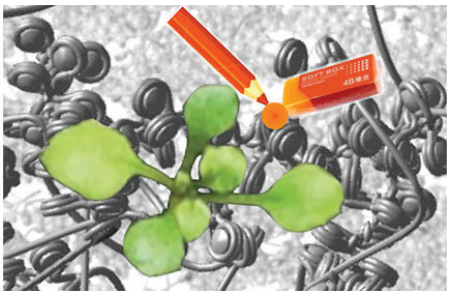
Fundings

- PTC ID
- EEG 2024.

REFERENCE
[1] J. Berton et al.
Experimental and numerical investigation of the impact force generated by cylindrical ice water pellets
International Journal of Impact Engineering 2025

Proof of concept for epigenetic editing in plants

Christel Carles
Cell & Plant Physiology Laboratory



Researchers at CEA-Irig/LPCV report, for the first time in plants, proof of concept for an epigenetic editing* tool that removes a chromatin mark*, with effects ranging from the molecular to the developmental scale.

© CEA-Irig/LPCV/ChromDev/C. Carles

Conventional genetic approaches, although effective in characterizing factors involved in changes in gene activity, reach their limits when it deals with the direct impact of **epigenetic marks*** on transcription and plant development; this is due, among other things, to factors with redundant and multivalent activities. In an attempt to circumvent this limitation, researchers from the Chromatin Dynamics and Developmental Transitions (**ChromDev**) team at **CEA-Irig/LPCV** used a new epigenetic editing approach based on the **dCas9** (dead Cas9) **technology***, allowing to reveal the direct and real functions of epigenetic marks.

The epigenetic mark H3K27me3, a chromatin modification conserved in multicellular eukaryotes, is strongly associated with the repression of developmental genes. The study demonstrates its exact function in plants for the targeted recruitment, via dCas9, of enzymatic activity on the developmental gene CUP SHAPED COTYLEDON 3 (CUC3) in Arabidopsis thaliana, using an epigenetic editing tool. Removal of the H3K27me3 mark induces more extensive transcription of CUC3 in plant tissues, leading to altered leaf morphology and the production of bifid inflorescences.

Epigenetic editing promises to be a powerful approach for dissecting the functional impacts of epigenetic marks on transcription and morphogenesis. The implementation of inducible editing systems will make it possible to monitor their effects in real time.

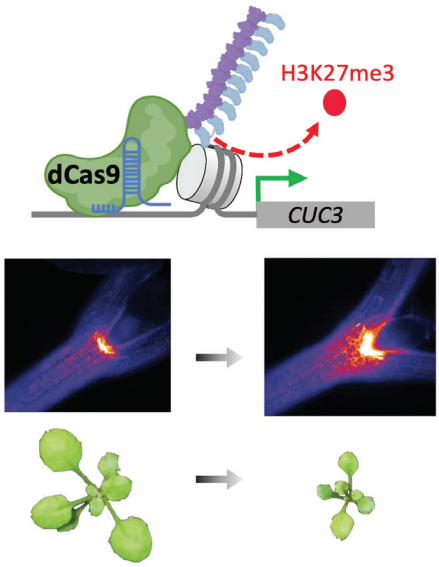


Figure : Démonstration de l'efficacité d'un outil d'édition épigénétique sur une cible spécifique : le gène frontière CUC3 d'*Arabidopsis thaliana*, pour lequel le retrait de la marque H3K27me3 entraîne l'extension de son domaine d'expression, suivie de changements développementaux chez la plante (*e.g.* la taille et la forme des feuilles de rosette, comme illustré ici).
© CEA-Irig/LPCV/C. Carles

Fundings

- Agence Nationale de la Recherche (ANR-18-CE20-0011-01, PRC projet REWIRE), Labex Gral (Grenoble Alliance for Cell and Structural Biology, ANR-10-LABX-49-01), et Graduate School CBH de l'UGA (ANR-17-EURE-0003).

Collaboration

IBMP (Institut de Biologie Moléculaire des Plantes), Dr. Alexandre Berr.

Epigenetic editing*: targeted molecular modification by the action of an enzyme that alters an epigenetic mark, without changing the DNA sequence. This editing aims to reprogram the activity of the targeted gene or genomic region.

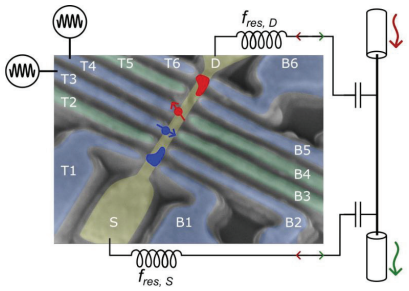
Epigenetic/chromatin mark*: chemical group attached to DNA or to the histone proteins associated with it. This mark can influence gene accessibility and modulate gene transcription. The chromatin mark edited in this study is trimethylation of lysine at position 27 of histone H3 (H3K27me3); with our work, we observe its repressive role on transcription.

dCas9 technology*: a variant of the CRISPR-Cas9 technology. The latter uses a short RNA (guide RNA) to bring the Cas9 enzyme to a specific DNA sequence to make a cut, triggering a repair mechanism and thus modifying the corresponding gene. dCas9 (dead Cas9) is rendered inactive for cutting, but can still bind to a specific location in the DNA thanks to the guide RNA. When coupled with an enzyme that modifies an epigenetic mark, dCas9 brings it to a specific region of DNA to change that mark (here, to remove H3K27me3).

REFERENCE
K. Fal, S. El Khoury, M. Le Masson, A. Berr and C. Carles
CRISPR/dCas9-targeted H3K27me3 demethylation at the CUC3 boundary gene triggers ectopic transcription and impacts plant development
iScience 2025

Optimal operation of hole spin qubits

Vivien Schmitt
Quantum Photonics, Electronics and Engineering laboratory
& Modeling and Exploration of Materials laboratory



By studying the properties of a hole spin qubit in a silicon device fabricated by the CEA-Leti, **PHELIQS** and **MEM**, two joint research units from **CEA-Irig** demonstrated the existence of optimal operation conditions, under which control speed and coherence times are simultaneously maximized – two key metrics usually antagonistic.

Hole spin qubits in silicon and germanium are among the promising candidates for future large scale quantum processor. They offer high performances while being compatible with microelectronics fabrication technologies. Their strong intrinsic spin-orbit coupling enables fast electric drive, but also makes them more sensitive to charge noise, limiting their coherence times.

We have demonstrated that the alignment of the external magnetic field plays a key role in the performance of hole spin qubits. Our experiment shows that the qubit sensitivity to charge noise coming from its environment depends significantly on the magnetic field orientation. In particular, there exists regions where the qubit is effectively decoupled this noise.

Control efficiency also varies with the direction of the field.Notably, the maximum control efficiency occurs precisely where the qubit is least sensitive to noise, and thus most coherent (see **Figure**). These ideal operation points are not fixed: they can be tuned by changing the voltages on the gates controlling the qubit confinement. We have demonstrated that such an electrical tuning allows ideal operation points on multiple qubits to aligned to the same magnetic field orientation. Single qubit gate fidelities on multiple qubits being simultaneously maximized. These results are supported by theoretical models demonstrating the general existence of operating points where noise resilience and control efficiency are simultaneously optimized.

This proof of concept opens the path for multi-qubit architectures more robust and more scalable. The same conclusions would also apply to other material hosting hole spin qubits, such as Ge/SiGe heterostructures.

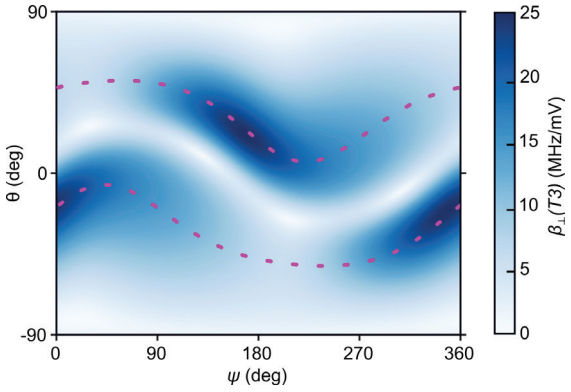
Supervisory Authority of the Joint Research Unit (UMR)

- **Pheliqs**: CEA, UGA, et Grenoble INP-UGA
- **MEM**: CEA et UGA

Fundings

- PEPR Presquile
- projet européen QuCube,
- projet européen QLSI/QLSI2
- LaBEx LANEF

REFERENCE
Bassi M. *et al.*
Optimal operation of hole spin spin Qubits
Nature Physics 2025



Regions of optimal operation: The map shows the control efficiency as a function of polar and azimuthal angle of the applied magnetic field. Regions of maximum efficiency (dark blue) lie where the qubit is insensitive to charge noise (dashed lines) which provide experimental evidence of optimal operation conditions.

Bioethanol production in an industrial bacterium passes through an enzyme

Tristan Wagner
Institute of Structural Biology

Researchers from the Institut de Biologie Structurale, the Max Planck Institute for Marine Microbiology, and the Max Planck Institute of Molecular Cell Biology and Genetics have unraveled a key step in the conversion of the toxic carbon monoxide into ethanol performed by the bacterium Clostridium autoethanogenum.

The study, published in Nature Chemical Biology, reveals the key role of a tungsten-containing enzyme in this remarkable process, bringing new insight into the sustainable production of biofuels from industrial gases.

Converting a toxic waste gas into an energetic resource: a solved mystery

Clostridium autoethanogenum is a fascinating microbe capable of surviving on pure carbon monoxide (CO), a gas deadly to most living organisms, including human beings. The gas is mainly converted into ethanol, making the microbe a promising actor in the synthesis of biofuels. Yet, despite its industrial relevance, the exact mechanism by which this organism converts CO into alcohol has remained poorly understood until now. Notably, one of the steps proposed in the process, the conversion of acetate into acetaldehyde, was questioned within the scientific community

In this work, the researchers demonstrated that aldehyde:-ferredoxin oxidoreductase (AFOR) is responsible for the key step in cellular ethanol production. AFOR is notable for containing tungsten, the heaviest element used in biological systems. The scientists succeeded in purifying the enzyme and resolved its three-dimensional structure at atomic resolution using X-ray crystallography, thus allowing them to describe the precise organization of the tungsten-based catalytic site and its surroundings.

After extensive experimentation, the researchers also found a way to reactivate the enzyme, which was initially inactive after purification. They were then able to demonstrate the enzyme's ability to reduce a wide range of substrates, paving the way for the production of alcohols other than ethanol.

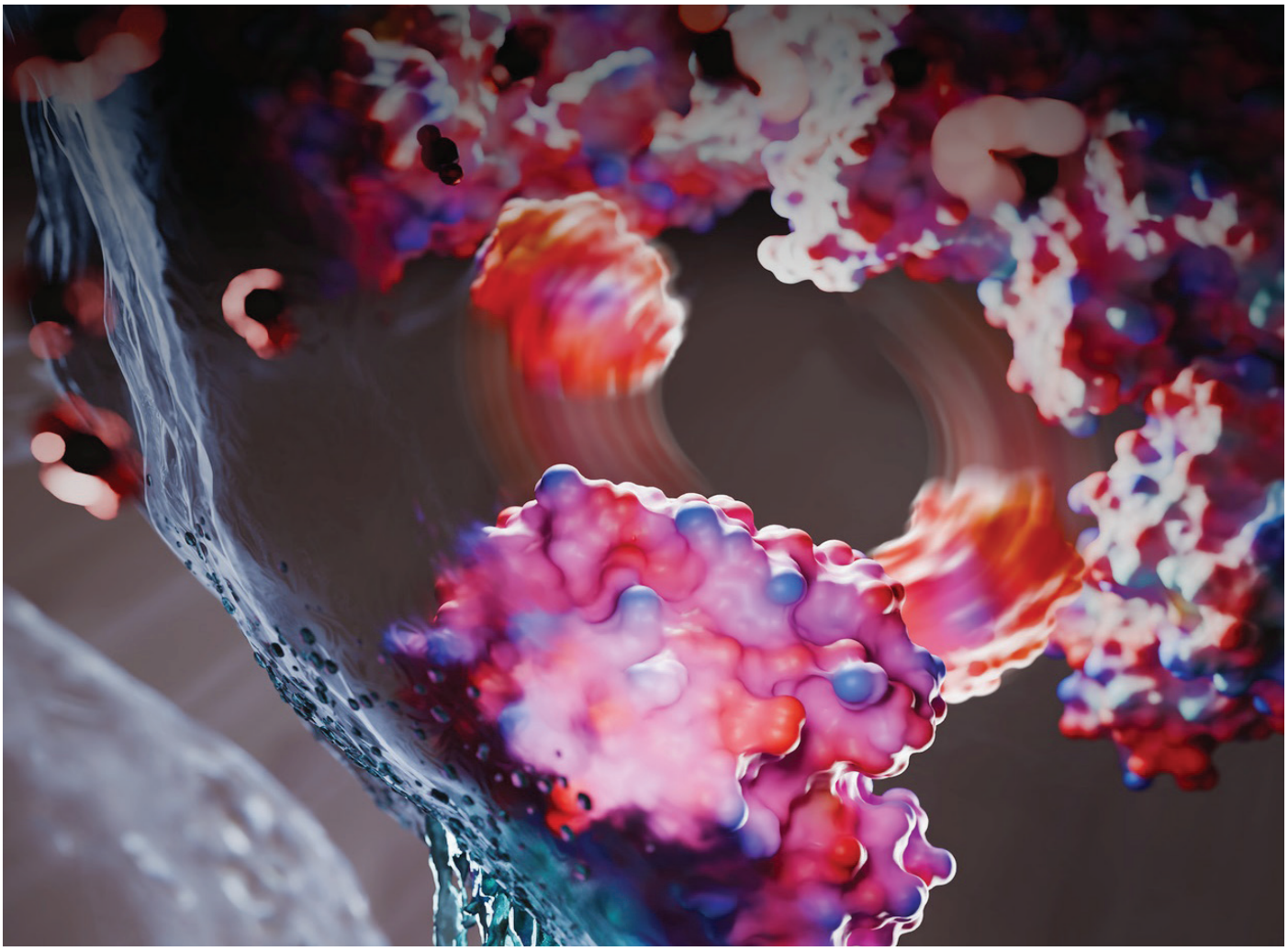
To confirm that the reaction could indeed take place in living cells, the researchers reconstituted an artificial enzymatic pathway in vitro. By recreating the enzymatic coupling occurring in the cell, they demonstrated that the conversion of acetate to ethanol is biologically achievable under physiological conditions.

An unfavorable reaction is enabled through enzymatic cooperation

These results fill a gap in our understanding of the metabolism of C. autoethanogenum and pave the way for new metabolic engineering strategies for the production of biofuels and molecules of interest from industrial gases.

This breakthrough represents a further step towards a circular carbon economy, where waste gases could become renewable energy resources.

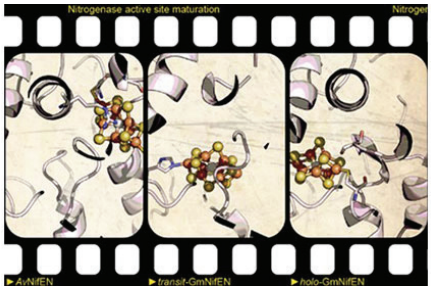
REFERENCE
Olivier N. Lemaire, Mélissa Belhamri, Anna Shevchenko, Tristan Wagner.
Carbon monoxide-driven bioethanol production operates via a tungsten-dependent catalyst.
Nature Chemical Biology 2025



Proposed cover for the Nature Chemical Biology journal inspired by this work.
CO_2 and CO molecules diffuse into *C. autoethanogenum* cells toward the CODH/ACS complex, where their conversion via the ferredoxin cycle drives the AFOR enzyme—key to ethanol production and biofuel formation.
© Benjamin Large (scEYEnce illustrations)

A dynamic molecular structure paves the way for sustainable crops capable of fixing their own nitrogen

Yvain Nicollet
Institute of Structural Biology



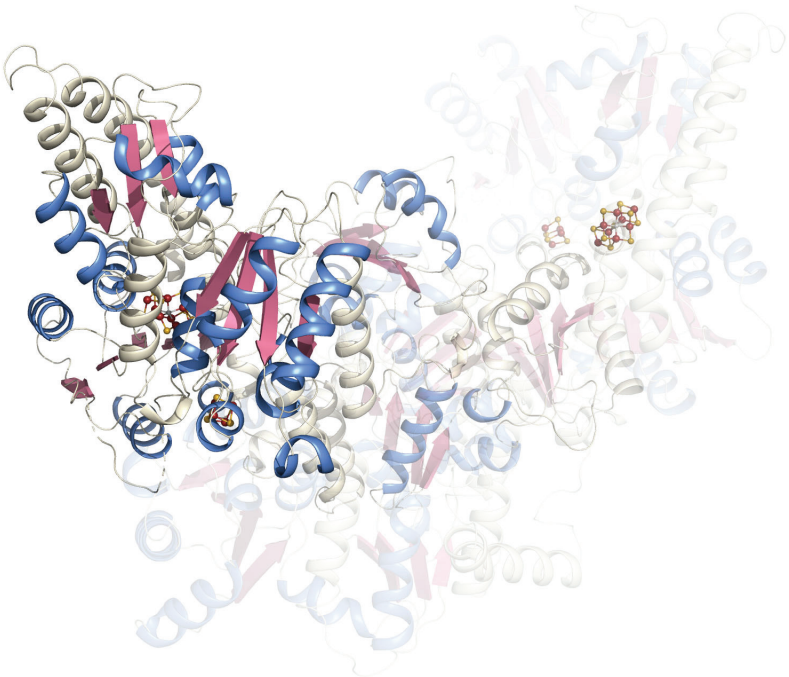
© CEA-Irig/IBS/Y. Nicolet

Nitrogenase is an enzyme complex which enables biological nitrogen fixation thanks to **metallocofactors***. In a recent study published in *Nature Chemical Biology*, researchers from **CEA-Irig/IBS**, in collaboration with CBGP (Centro de Biotecnología y Genómica de Plantas, Spain) reveal the essential dynamic nature of one of the key players involved in nitrogenase activation, ensuring both protection and efficient transfer during the biosynthesis of its cofactor.

Atmospheric nitrogen (N_2) is, for the most part, an inert gas for living beings on Earth. That is, we cannot directly utilize this vital compound. Therefore, the biochemical nitrogen cycle, and especially the role played by bacteria and plants, is essential to sustaining life on our planet. In some microorganisms, a process known as biological nitrogen fixation occurs, in which nitrogenases, oxygen-sensitive proteins, transform atmospheric nitrogen into forms usable for life.

To function, nitrogenases depend on a metal cofactor, a complex molecular component that must be carefully constructed through a series of steps involving numerous proteins. One of the key players in this process is the protein NifEN, which acts as a scaffold to complete the final stages of cofactor assembly before incorporation into nitrogenase, or NifDK.

Until now, the structural basis that allows this protein to fulfill its key role in biological nitrogen fixation was unknown.



Cartoon representation of the structure of NifEN determined by cryo-electron microscopy. © CEA

In this study, published in Nature Chemical Biology, researchers reveal how the NifEN protein performs this function. The researchers used cryo-electron microscopy (cryo-EM) to perform a high-resolution structural analysis of the protein. This cutting-edge technique allowed them to capture unprecedented images of the nitrogenase cofactor assembly. These images revealed a surprisingly dynamic process in which the scaffolding protein NifEN opens and closes like a gate, with parts of the protein moving and rearranging to facilitate the movement of a precursor from the surface to its internal cavity. The researchers were able to draw this conclusion thanks to the crucial discovery of intermediates that show the precursor cofactor in transit between both locations. These findings reveal that the transformation of the precursor may not occur on the surface of the protein, as previously suggested, but within its internal cavity. This discovery not only changes our understanding of nitrogenase cofactor biosynthesis but also sheds light on the evolutionary split between NifEN, which specializes in cofactor construction, and NifDK, which performs nitrogen fixation.

Understanding this process is a key step toward reproducing it in non-native systems, such as eukaryotic cells. Achieving cofactor biosynthesis in these hosts could ultimately enable the assembly of fully functional nitrogenase in plant cells, paving the way for crops capable of fixing their own nitrogen and, consequently, more sustainable agriculture with less reliance on synthetic fertilizers.

Metallocofactor: molecule that contains at least one metal ion, necessary for an enzyme to catalyze a given reaction.*

Fundings

- *Agence Nationale de la Recherche : ANR-15-IDEX-02, ANR-10-INBS-05-02, ANR-17-EURE-0003, ANR-17-EURE-0003,*
- *EXC2008-390540038*
- *PRE2018-084951*
- *RD 289/2021*

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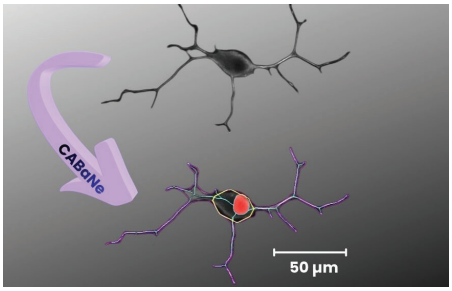
Payá Tormo L et al.
Dynamics driving the precursor in NifEN scaffold during nitrogenase FeMo-cofactor assembly
Nature Chemical Biology 2025

Automated tools transform how neurites are measured

Elisa Miglioni
Biology and Biotechnology for Health Laboratory



BRM team at **CEA-Irig/Biosanté** has developed a new open-source tool CABaNe which automates neurite measurement, turning a slow manual task into fast, reliable analysis. It brings true high-throughput capability to the neurobiology community.

To understand how neurons grow, connect or respond to treatments, researchers measure the length of their extensions, the neurites. This key step is still often performed by hand, image by image, slowing down studies that increasingly require large datasets. CABaNe offers a simple and free solution that fully automates this measurement, making high-throughput neuronal analysis accessible to any laboratory.

CABaNe automatically analyses neuronal images by detecting nuclei, cell bodies and, crucially, neurites, which it measures without human intervention. It runs on any standard computer using ImageJ and requires no technical expertise. Compared with manual measurements and some machine-learning tools, CABaNe is far faster while maintaining high accuracy. It democratizes high-throughput neuronal analysis and allows researchers to process in minutes datasets that were previously difficult to handle.

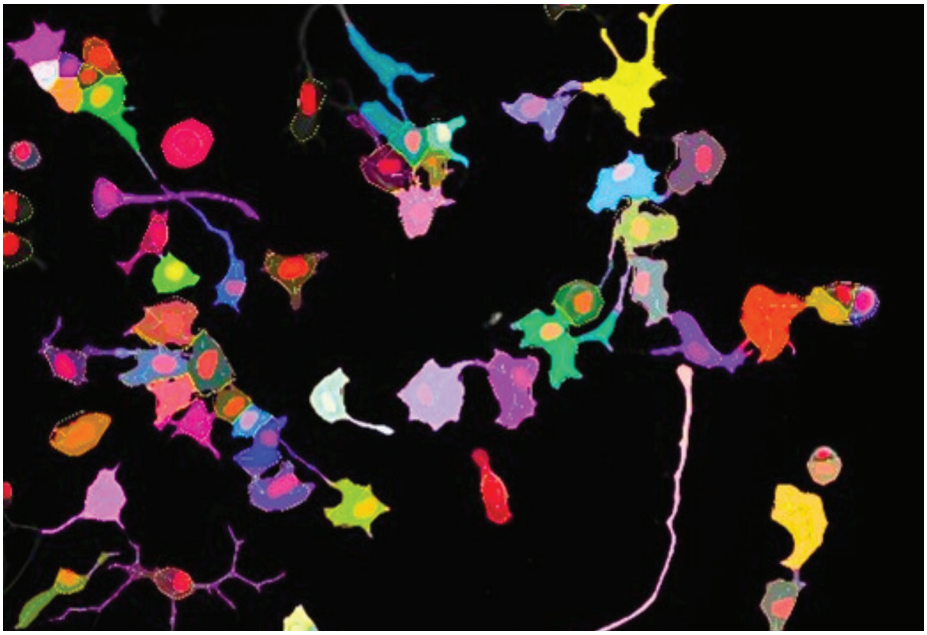
CABaNe simplifies and accelerates neuronal analysis by making high-throughput workflows accessible and reliable. It paves the way for future tools and broader applications to other cell types.

Fundings

- Pfizer, Inserm
- GRAL,Graduate School CBH-EUR-GS
- ANR GlyCON
- Programme "*Investissements d'Avenir*" Glyco@Alps

Collaboration

- Bordeaux Imaging Center, CNRS, France

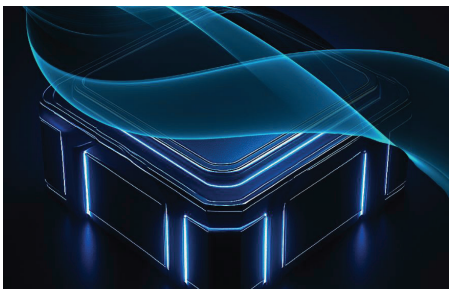


Example of differentiated neurons. CABaNe automatically segments nuclei, cell bodies and neurites, illustrating how the tool identifies and measures neuronal extensions without human intervention.

REFERENCE
Thibieroz N, Cordelières F, Machillot P, Singh A, Marchadier L, Picart C and Migliorini E.
CABaNe, an automated, high throughput ImageJ macro for cell and neurite analysis
eNeuro 2025

A one-way sound transmitter

Olivier Klein
Spintronics and Technology of Components laboratory



A team from CEA-Irig/SPINTEC participated in the development of a new unidirectional surface acoustic wave component for wireless telecommunications. Its principle is based on the integration of thin magnetic films capable of coupling, through magnetoelasticity, to the non-reciprocity inherent in magnetization dynamics. These devices pave the way for a new generation of materials combining piezoelectricity and magnetism.

In the field of wireless communication technologies, front-end filters are placed between the antenna and the signal processing circuit to determine the operating spectral band. These filters exploit the slow propagation of sound waves in a crystal to achieve this function in a compact design. Achieving unidirectional propagation within these devices would open up new functional possibilities, such as selective signal routing. It is well established that magnetic materials intrinsically break time reversal symmetry. One solution being studied by researchers would be to integrate a thin magnetic film onto a piezoelectric substrate. The ensuing magneto-elastic coupling that is created at the interface between the two materials allows to transfer the non-reciprocity of the magnetization dynamics to the surface acoustic waves.

In this work, a team from **CEA-Irig/SPINTEC** participated in the development of a surface acoustic wave (SAW) acoustic isolator operating at room temperature, integrating a thin film of ferrimagnetic yttrium iron garnet ($Y_3Fe_5O_{12}$ YIG) on a piezoelectric lithium niobate substrate (see **Figure**). The choice of YIG, a material with very low magnetic and acoustic damping, allows for strong coupling between magnetic and sound waves.

Analysis of the absorption spectra shows several absorption peaks corresponding to stationary perpendicular spin wave modes. These modes exhibit the strong non-reciprocity sought when the direction of propagation of the acoustic wave is reversed.

Our results demonstrate that integrated YIG–SAW devices are an effective platform for nonreciprocal acoustic transport. They thus pave the way for a new generation of hybrid dielectric materials combining piezoelectricity and ferromagnetism.

Financements

- Q-SPIN chaire d'excellence LANEF portée avec le Prof. YoshiChika Otani

Collaboration

- RIKEN et Institute for Solid State Physics (ISSP) Université de Tokyo (Japon)

REFERENCE
Y. Ba, J. Puebla, K. Yamamoto, Y. Hwang, L. Liao, S. Maekawa, O. Klein, and Y. Otani
Nonreciprocal Resonant Surface Acoustic Wave Absorption in $Y_3Fe_5O_{12}$
Physical Review B 2025

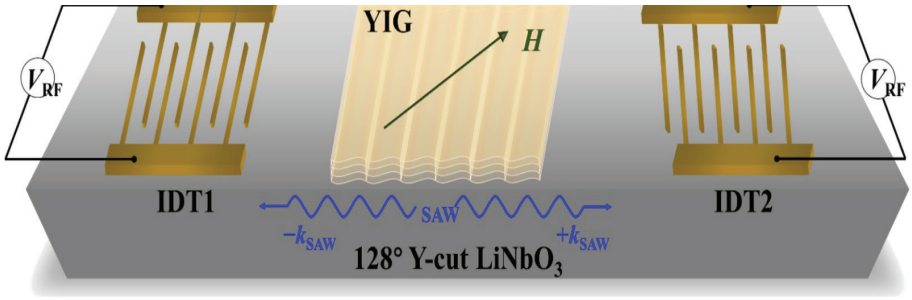


Figure: Surface acoustic wave (SAW) transmitter. Two interdigitated transducers (IDT1 and IDT2) generate elastic surface waves in a piezoelectric crystal, which then interact with a magnetic garnet thin film deposited on the same surface. © CEA

Press releases - Prizes- Media

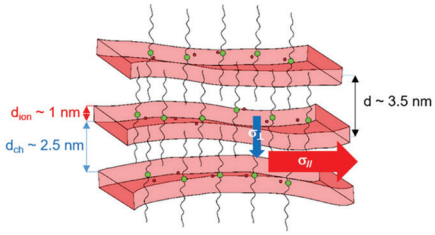
Geneviève Blondin head of the Physicochemistry of Metals in Biology (**PMB**) team at the **CEA-Irig**/Laboratory of Chemistry and Biology of Metals (**LCBM**) has been awarded the prestigious **Luigi Sacconi Medal** by the foundation of the same name and by the Inorganic Chemistry Division of the Italian Chemical Society. This award recognizes her outstanding career and significant contributions to the field of inorganic chemistry. ***Read more***

Christophe Marcenat at **CEA-Irig/Pheliqs/Lateqs** was honored with the 2025 **International Prize in Natural Sciences** from the Slovak Academy of Sciences (SAS). This prize recognizes not only an exceptional scientific career, but also a great success in European scientific cooperation. ***Read more***

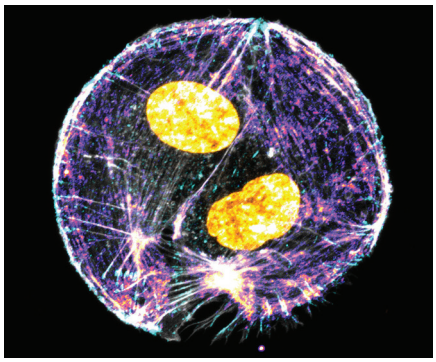
Bernard DIENY Research Director at the **CEA-Irig/SPINTEC** laboratory was awarded the **Prix Clément Codron** by the Académie des Sciences for his work on the fundamental aspects of spin electronics and its applications to ultra-low-power electronic and magnetic devices. He is also exploring the magnetism-biology interface for innovative treatments of cancer and diabetes. ***Read more***

Dynamic mosaicity, key to ion transport in functional soft matter

While liquid crystal batteries appear to be a promising alternative to lithium-ion technologies, their performance remains limited, particularly by our understanding of ion transport mechanisms. A consortium of scientists, including researchers from CEA-Irig/SyMMES, has demonstrated for the first time the decisive role of dynamic mosaicity in the ionic conduction of soft matter. ***Read more***



Other scientific results from the laboratories



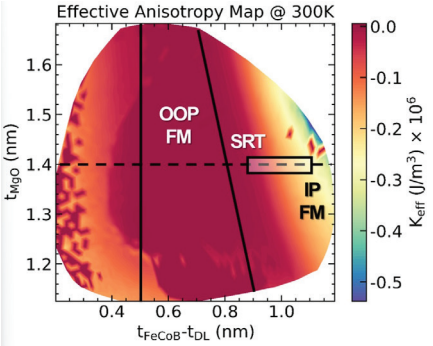
Waltz of the cells: the strongest leads the dance

Cells, when interacting with one another within a group, can adopt a collective behavior. We showed that a pair of cells can spontaneously start rotating in a preferred direction. Our work demonstrates that the level of force produced by the cell pair on their adhesion surface controls the direction of this rotation.

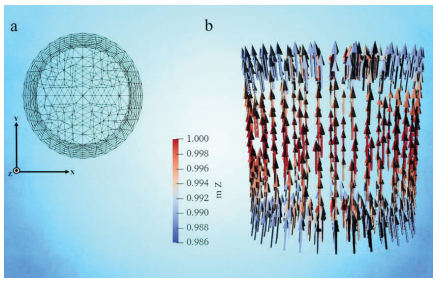
LPCV

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. Specifically, 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 spin transfer torque (STT) written magnetic memories, this optimization requires precise control of magnetic anisotropy at the specified operating temperature.



SPINTEC



SPINTEC

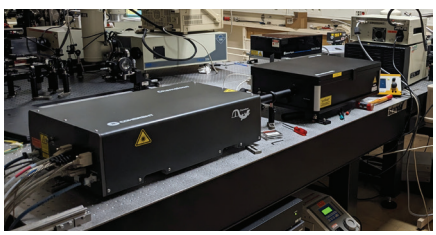
Physics of current-induced switching in 3D nanopillars

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.

A new ultraviolet laser source @ NPSC

A 195 nm new laser source complements our previous UV light source emitting at 244 nm. This source is still quite rare in optical spectroscopy labs!

PHELIQS



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www.Pheliqs.fr

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www.Spintec.fr

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www.IBS.fr

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www.CBM-lab.fr

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www.LPCV.fr

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www.Symmes.fr

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