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Scientific Newsletter

Spring 2026

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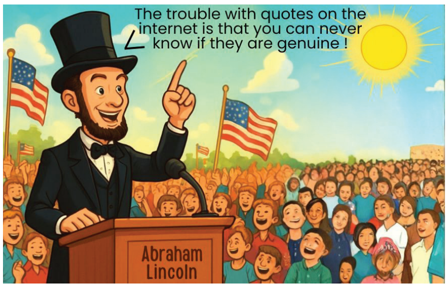
Anticipating hallucinated scientific discoveries in biology

Thomas Burger
Biology and Biotechnology for Health Laboratory



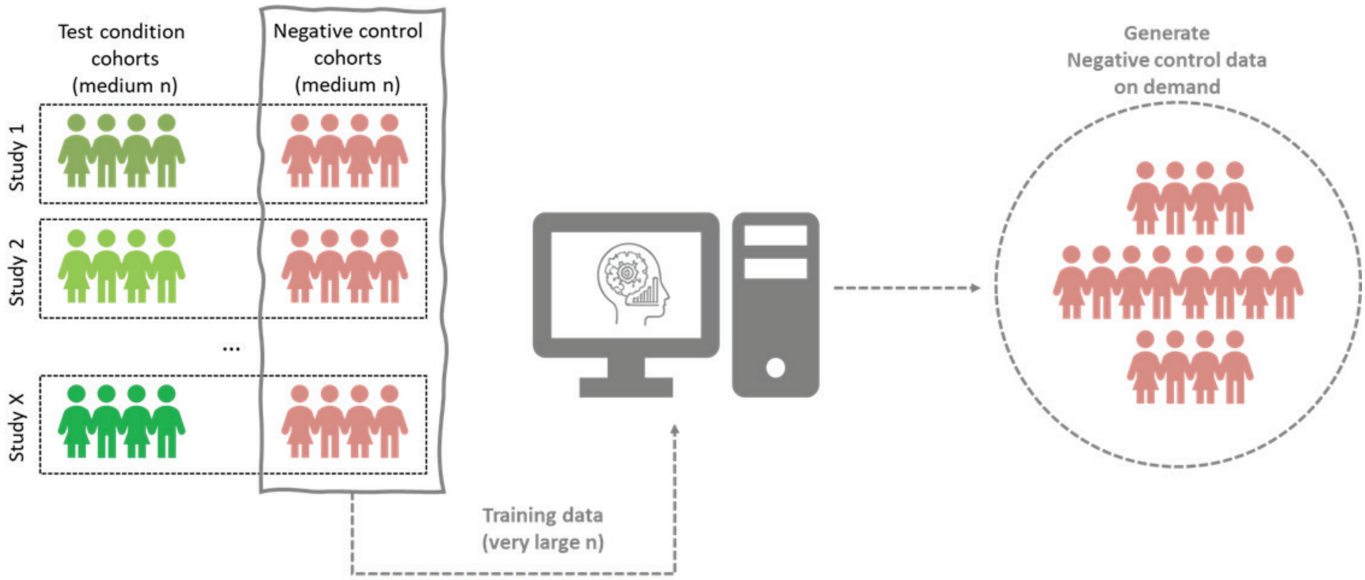
AI generated image

Generative Artificial Intelligence is increasingly used in research, but it can produce hallucinations. Then, how can we prevent scientific discoveries from hallucination-induced corruption?

The recent advent of **generative Artificial Intelligence*** (genAI) has already revolutionized our lives and societies, by means of tools like Chat-GPT or Gemini. For now, genAI is essentially used to generate multimedia data (text editing, summarization, photoshopping, video generation, etc.). However, in the near future, genAI capabilities will be extended to more technical data generation, as produced in academic research labs. This will have unprecedented consequences in scientific knowledge production that must be anticipated–notably because genAI can **hallucinate***.

In the complex landscape of molecular biology, tiny hallucinated details could go unnoticed in large datasets, leading to erroneous conclusions (e.g. a fantasized biomarker) with devastating consequences, from scientific literature corruption to wasted clinical trials. However, prohibiting genAI in scientific research would deprive research and medical communities of powerful tools.

To cope for this dilemma, researchers from Irig proposed to list various uses-cases where genAI can be safely used thanks to a well-chosen risk-mitigation policy. Their article presents a tenth of use-cases, and classify them in three categories: hypothesis generation, data generation and computational biology software improvement.



Exemplified illustration of one of the proposed use-cases. © CEA

Completing a cohort by generating data about additional patients in the disease group (in green), would be highly risky—as any undetected hallucination would lead to a biased representation of the disease. Opposedly, complementing the healthy group (in red) which serves as a control in the study can be compliant with a risk-mitigation policy: First, because undetected hallucinations here would yield to an increased diversity within the control group, which is known as an efficient way to limit false discovery risks. Second, because healthy patients have admittedly been more frequently incorporated in cohort studies, so that the potentially available data to train the genAI tool are larger, more robust and more consistent. This example illustrates how a given genAI algorithm suited to a given task can be used in different ways, with different exposure to hallucination-induced risks.

Though not exhaustive, these uses-cases provide a first basis for the correct integration of genAI into the scientific approach, as it incentivizes researchers to adopt a critical eye on its use.

*Generative Artificial Intelligence refers to algorithms that are not only able to analyse data and make decision or prediction, like classical Artificial Intelligence (AI) tools, but which can also generate new data.

*Hallucinations occur when a genAI tool answer to a request (also known as prompt) by generating details that seem plausible with some respects, but which are either wrong (e.g. a reference to a non-existing article), or impossible according to real-world constraints that are ignored by the genAI model (e.g. US President Abraham Lincoln commenting about the internet, as in heading figure).

BGE is a Joint Research Unit (**UMR**): UGA, CEA, CNRS and INSERM

Fundings: The author's research was supported by grants from the French National Research Agency: ProFI project (ANR-10INBS-0008), GRAL CBH project (ANR-17-EURE-0003), France 2030 program (ANR-19-P3IA-0003), PeptidOMS project (ANR-24-CE45-3296), and ProteoVir project (ANR-24-RRII-0001).

REFERENCE
BURGER T.
Keeping generative artificial intelligence reliable in omics biology
Patterns 2026

Nafion recycling: a sustainable approach for fuel cells

Hakima Mendil-Jakani
Molecular Systems and nanoMaterials for Energy and Health laboratory

In light of current climate challenges, decarbonizing energy systems is a major challenge. In this context **fuel cells*** represent a promising technology, particularly for mobility and low-local-emission electricity generation. The deployment of this technology relies on proton exchange membranes, such as **Nafion***.

By combining **swelling kinetics*** neutron and X-ray scattering, researchers at **CEA-Irig** (**SyMMES**, **MEM**) and CEA-Liten (DTNM) have elucidated the mechanisms governing Nafion dispersion. This breakthrough opens up new prospects for the sustainable recycling of fuel cell membranes.

Nafion membranes are central to fuel cell technology, yet their production remains costly. Furthermore, the use of fluorinated polymers raises environmental and health concerns, and no industrial recycling process currently exists, which constitutes a major challenge. This study proposes an innovative approach using ionic liquids (non-volatile liquid salts, composed entirely of ions, whose properties can be tuned for specific application) to disperse and subsequently recover the membranes. A multi-scale analysis, including macroscopic swelling kinetics, neutron and X-ray scattering, allowed us to decipher the swelling mechanisms driving membrane dispersion and to identify the most promising candidates for sustainable recycling.

We show that Nafion membranes can be dispersed in ionic liquids and subsequently recovered by precipitation and washing. The membranes are restored to their solid form, providing a first proof of concept for closed-loop recycling using ionic liquids as solvents. A multi-scale approach, combining swelling kinetics, light, neutron and X-ray scattering enabled us to elucidate the nature and sequence of interactions from the early stages of swelling to complete dispersion—including swelling of ionic domains, dilution of polymer aggregates and plasticization — and to identify the most promising families of ionic liquids for recycling.

This study establishes a proof of concept for recycling Nafion in an ionic liquid environment and complements recent work on novel recycling methods for membrane-electrode assemblies from fuel cells. Future work will aim to extend this process to aged membranes or alternatives to Nafion.

SyMMES is a joint research unit (UMR): Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP - UGA

Fundings : PTC MP

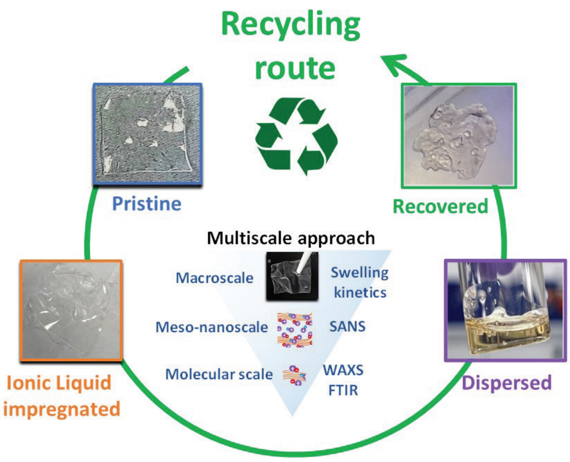
Collaborations:

- Univ. Grenoble Alpes, CEA, LITEN, DTNM, 38000 Grenoble, France
- Univ. Grenoble Alpes, CEA, IRIG, MEM, 38000 Grenoble, France
- Institut Laue-Langevin, 38000 Grenoble, France
- ICGM, University of Montpellier, CNRS, ENSCM, Montpellier, France

***fuel cell:** electrochemical device that produces electricity by converting chemical energy from a fuel into electrical energy, through reactions occurring at the electrodes and the movement of protons across an electrolyte (the membrane).

***Nafion:** fluorinated polymer used as a proton exchange membrane in fuel cells, widely used for its electrochemical performance.

***swelling kinetics:** measurement of the variation in mass and volume of a material over time due to liquid absorption.



A new route for recycling Nafion in an ionic liquid medium

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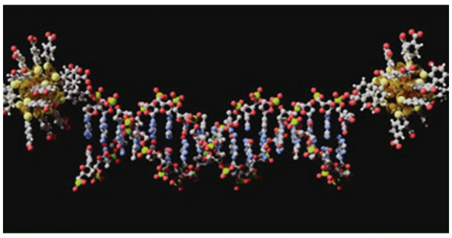
FERNÁNDEZ RODAS A. C, PILUSO P, POUGET S, DEMÉ B, AMEDURI B, GEBEL G and MENDIL-JAKANI H.
Ionic Liquids: A Novel Route for Sustainable Recycling of Nafion from Proton Exchange Membrane Fuel Cells
ACS Sustainable Chemistry & Engineering 2025

Towards the design of DNA-directed self-assembled materials

Didier Gasparutto
Molecular Systems and nanoMaterials for Energy and Health laboratory



Photonic nanomaterials* are attracting growing interest in biology and medicine due to their potential in biosensing and bioimaging, in implantable devices or as therapeutic agents. With this in mind, a consortium of researchers from **CEA-Irig** and the Grenoble Institute for Advanced Biosciences (IAB) has developed photonic nano-architectures based on functionalised gold nanoclusters self-assembled by DNA.

The design of optically active architectures based on gold nanoclusters (AuNCs) has gained considerable popularity in recent years. These architectures constitute a new class of ultra-small particles (<3 nm) known for their photoluminescence, photostability and high biocompatibility.

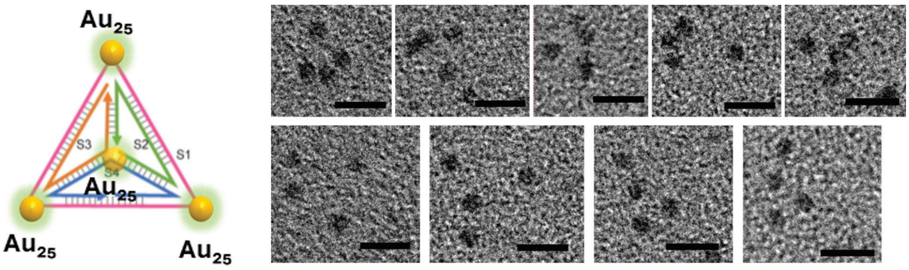
DNA engineering uses self-assembly processes to create perfectly defined architectures with sub-nanometre precision, which are excellent scaffolds for the construction of AuNC-based nanomaterials.

As part of this collaborative project, researchers took on the challenge of combining DNA fragments with AuNCs with fully controlled stoichiometry. To do this, they developed ligand engineering and controlled DNA functionalisation for nanoclusters of defined sizes, enabling them to construct one-dimensional (1D) assemblies of nanoclusters as well as three-dimensional (3D) architectures. Their characterisation, combining a set of analytical, structural and optical approaches, demonstrated high reproducibility and assembly efficiency for these superstructures.

This work establishes a fundamental synthetic and analytical basis for the high-yield, high-purity preparation of defined multidimensional photonic nanoarchitectures. These biohybrid platforms offer particularly interesting prospects for their application as novel **theranostic agents***.

***photonic nanomaterials:** materials with dimensions close to the wavelengths of visible light that interact with it.

***theranostic agents:** molecules or nanomaterials used for imaging (diagnostics) and/or therapy (therapeutics).



(**left**) Schematic representation of a DNA tetrahedron functionalised by four gold nanoclusters at its vertices. (**right**) Transmission Electron Microscopy (TEM) images of hybrid DNA-nanocluster tetrahedral nanostructures (scale = 5 nm). © CEA

SyMMES is a joint research unit (**UMR**): Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP - UGA

Collaborations:

- Institut de Biologie Structurale (IBS), CEA-Irig,
- Institute for Advanced Biosciences (IAB)

Fundings:

- UGA (CBH-EUR)
- ANR
- Labex Arcane et Labex Gral
- CEA-PTC

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Alhalabi A, Saint-Pierre C, Boeri-Erba E, Elchinger P.-H, Kaur H, Gasparutto D and Le Guevel X.
Designing atomically precise gold nanocluster architectures with DNA-guided self-assembly and biofunctionalization approaches
Nanoscale 2025

Selective Cu+ ionophores for cancer therapy

Aurélien Deniaud & Giulia Veronesi
Chemistry and Biology of Metals Laboratory

Copper is an essential trace element for humans, and some cancer cells have evolved to exploit it for their own growth. Researchers at **CEA-IRIG/LCBM** and the Free University of Brussels have developed a new family of compounds that can redistribute intracellular copper, thereby exerting anti-cancer activity.

Copper is an essential trace element for humans, used for numerous physiological functions. Given the high toxicity of free copper, its transport and storage are very finely regulated in human cells. Over the last decade, copper has been shown to play an important role in tumorigenesis. Various anti-cancer therapies targeting copper are currently under development.

Researchers at **CEA-IRIG**, the Institute for Advanced Biosciences and the Free University of Brussels (ULB) have developed a new family of molecules that selectively bind and transport copper ions carrying a single positive charge (Cu^+) which corresponds to the intracellular form of copper [**1,2**], across a biological membrane (**Figures a-b**). Some compounds in this family have shown anti-cancer activity in cultured cells. The most active compound, named Cuphoralix, was identified (**Figure a**) [**2,3**]. The expertise of CEA-IRIG researchers in **copper homeostasis*** has helped to elucidate the mechanism of action of Cuphoralix in liver cancer cells. In collaboration with researchers at the ESRF synchrotron in Grenoble, elemental nano-imaging experiments showed that the Cuphoralix redistributes copper in cancer cells, resulting in copper poisoning, and ultimately cell death (**Figure c-d**).

The selectivity of molecules such as Cuphoralix developed for Cu+ transport has led to the discovery of a completely new anti-cancer mechanism of action. Considering that Cuphoralix has no specific intracellular target, cells cannot develop resistance mechanisms. This also makes it active against all types of cancer cells tested to date, including resistant and non-resistant cancer models, as well as those with or without an aggressive phenotype. All these properties make Cuphoralix a very promising molecule for anti-cancer therapy.

***Copper homeostasis** refers to the set of mechanisms that maintain the appropriate intracellular concentration and distribution of copper.

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Transmembrane transport of copper(i) by imidazole-functionalised calix[4]arenes
Chem. Com. 2020

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Brevet EP23305100.2. 2023

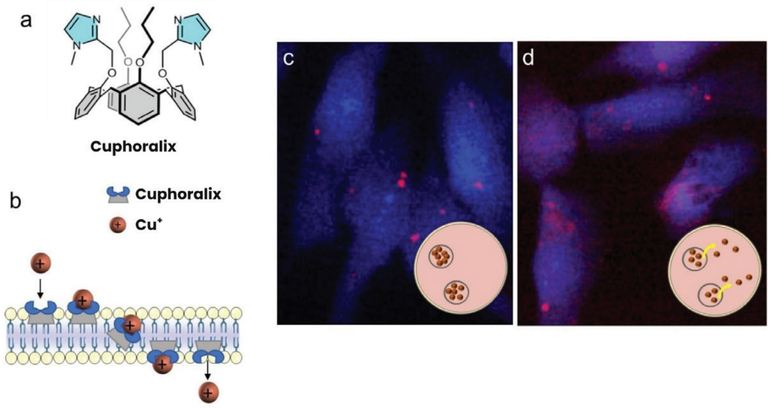
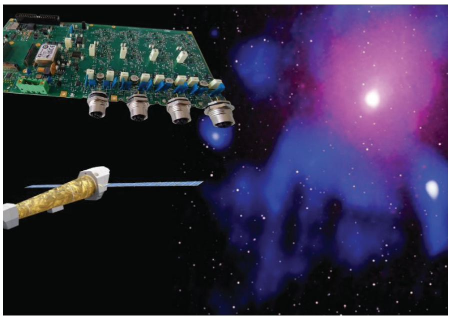


Figure: a) Structure of Cuphoralix. **b)** Mechanism of Cu+ ion transport across a lipid bilayer by Cuphoralix. **c-d)** X-ray fluorescence microscopy images showing the distribution of potassium (blue) and copper (red) in liver cancer cells exposed to 10 µM Cu (**c**) or 10 µM Cu and 100 nM Cuphoralix (**d**).
These maps show that copper is physiologically stored at high concentrations in intracellular vesicles (**c**, intense red spots) and that Cuphoralix prevents this storage, leading to a redistribution of copper throughout the cell with local concentrations 10 times lower (**d**). The insets show a schematic representation of the location of copper in cells. © CEA

ATHENA/X-IFU project: top stability at very low temperatures (50 mK) for observing the cosmos

Anthony Attard
Low Temperature Systems Department



The ATHENA project, a space observatory developed by ESA to explore the mysteries of the cosmos, will be equipped with the X-IFU instrument dedicated to detecting X-rays. In this context, the **CEA-IRIG/DSBT** teams played a key role in designing the high-precision cooling system capable of maintaining the instrument at a stable temperature of 0.05 K (very close to absolute zero).

ATHENA (Advanced Telescope for High-Energy Astrophysics) is the future European space observation satellite operating in the X-ray domain. It will enable the study of the most extreme phenomena observable in the Universe, such as galaxy clusters and supermassive black holes, with exceptional detail and sensitivity. Designed by the European Space Agency (ESA), the satellite will carry an X-ray detection instrument called X-IFU. The result obtained is even better than that required by the CNES, since the stability measured over more than 10 hours reached a record 0.4 µK.

The teams at **CEA-IRIG/DSBT** and CEA-IRFU/DAP worked together to develop temperature measurement electronics compatible with the specific constraints of space. In recent years, DSBT has developed instrumentation that powers the sensor with an extremely low current (only 2 nA) to prevent any parasitic heating due to the Joule effect. In addition, the instrumentation is also equipped with a very low-noise amplification chain designed to guarantee the stability of the temperature sensor measurement at 0.8 µK sensitivity. The electronic board (see figure) was then implemented in a specific cryostat containing several cooling stages developed by the DSBT to reach the very low temperature of 50 mK. The result obtained is even better than that required by the CNES, since the stability measured over more than 10 hours reached a record 0.4 µK.

The electronic board and its control box will soon be delivered to the French National Center for Space Studies (CNES) to characterize the complete system, including the X-IFU instrument. For their part, the CEA-IRFU teams will continue the specific development of the electronics, which will be adapted to withstand the space conditions endured by the ATHENA satellite, and validate their performance on the flight model.

DSBT is a joint research unit (**UMR**): CEA, UGA

Fundings: CNES

Collaborations: CEA-IRFU/DAP

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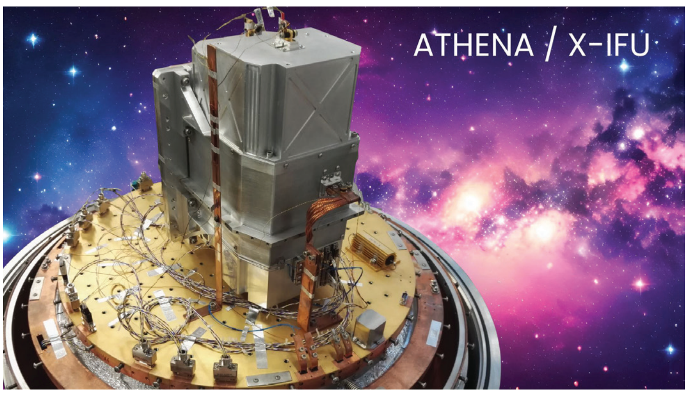
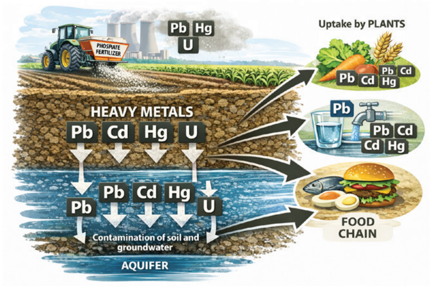
Experimental results of ADR cooling tuned for operation at 50 mK or higher temperature.
Cryogenic Engineering Conference 2020



Left, the cryostat dedicated to the X-IFU study. © CEA. **Right**, The Very Low Temperature electronic board. © CEA.

When uranium disrupts genetic regulation in plants

Claude Alban
Cell & Plant Physiology Laboratory



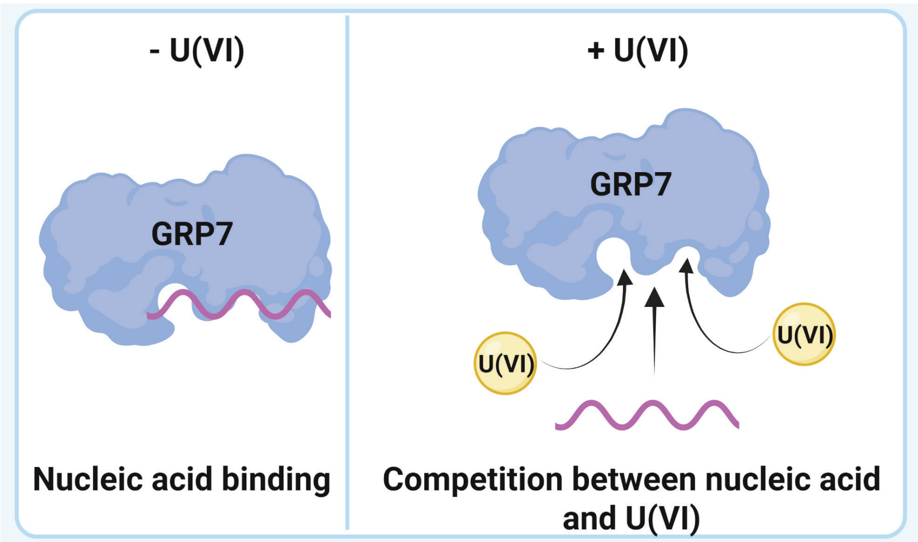
Plant proteins able to bind uranium in vivo have been identified, including the GRP7 protein, whose ability to bind to RNA is blocked, revealing a completely new mechanism of toxicity.

Uranium (a natural **radionuclide***) is an environmental contaminant found in certain soils and waters, particularly near mining or nuclear activities. Its accumulation can pose potential risks to ecosystems, agrosystems and human health, as the radionuclide has toxic chemical effects.

Its toxic effects on plants are well known, but the molecular mechanisms involved remain poorly understood. This study, conducted by researchers at **CEA-IRIG/LPCV** and other collaborators, represents a major breakthrough with the direct identification of cellular proteins targeted by uranium, revealing a new mechanism of uranium toxicity in plants.

Using an integrated **metalloproteomics approach*** combining chromatography, mass spectrometry and NMR, researchers identified 57 proteins capable of binding to uranium from Arabidopsis thaliana cell extracts. One of these, GRP7, plays a key role in RNA regulation. The study shows that uranium binds to two specific sites on this protein and prevents its normal interaction with nucleic acids, thereby disrupting gene expression regulation.

This work reveals a novel molecular mechanism of uranium toxicity in plants. It opens up new insights for better assessing environmental risks and developing strategies for soil decontamination using plants (phytoremediation).



For the GRP7 protein, the study reveals that the ionised form of uranium U(VI) binds to two sites and interferes with RNA binding, thereby disrupting gene regulation mediated by this protein. This reveals a completely new mechanism of uranium toxicity in plants. © CEA

Tutelles UMR: Univ. Grenoble Alpes – INRAE – CEA – CNRS

Fundings: ANR-17-CE34-0007, GreenU project; ANR-17-EURE-0003, CBH-EUR-GS; ANR-10-INBS- 08–3, the French Proteomics Infrastructure, (ProFI).

Collaborations: IBS, CEA-Irig Grenoble ; UA13 BGE, CEA-Irig Grenoble ; LCBM, CEA-Irig Grenoble; Laboratoire de Spectrométrie de Masse BioOrganique, IPHC UMR 7178, Université de Strasbourg.

***Radionuclide:** a type of radioactive atom.

***Metalloproteomics approach:** an approach enabling the study of all proteins containing one or more metal ions in an organism or cell extract.

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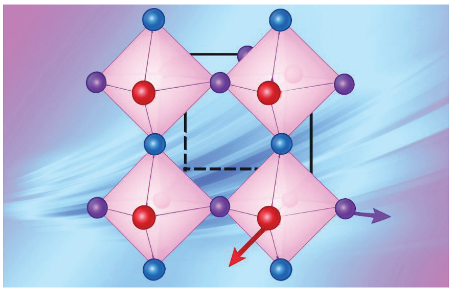
Identification of uranyl-binding proteins in Arabidopsis thaliana cells exposed to uranium: Insights from a metalloproteomic analysis and characterization of Glycine-Rich RNA-binding protein 7 (GRP7)
Journal of Hazardous Materials
2025

Frustrated octahedral antiferromagnets: emergent complexity in magnetic field

Michaël Zhitomirsky
Quantum Photonics, Electronics and Engineering laboratory



Scientists from **CEA-IRIG/Pheliqs** and the Institute Laue-Langevin have theoretically proposed a new family of **frustrated magnetic materials*** that are based on spin octahedral units. These novel octahedral materials possess complex and intriguing phase diagrams. Computer simulations of a realistic spin model for octahedral **antiferromagnets*** have been used to obtain the unique phase diagram in an applied magnetic field.

Geometrical frustration—where the lattice geometry prevents spins from simultaneously satisfying all interactions—is a key source of exotic quantum and classical magnetic states. Geometrically frustrated magnets are also promising materials for **magnetocaloric*** applications as entropy storage refrigerants. While lattices based on triangles and tetrahedra, *e.g.* kagome and pyrochlore (see **fig.1**) have been extensively studied, three-dimensional networks of octahedra represent a distinct and poorly-explored class. Such crystal structures are found in antiperovskites, *e.g.* Eu_3PbO, Mn_3Pt, and certain face-centered cubic alloys.

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.

The work introduces octahedral antiferromagnets as a new class of geometrically frustrated magnets, distinguished by their crystal lattices composed of octahedra of magnetic ions. Theoretical investigation of the magnetic field (H) –temperature (T) phase diagram in the fully frustrated edge shared octahedral lattice revealed a remarkably rich sequence of eight successive antiferromagnetic phases stabilized by thermal fluctuations (**fig.2**). This is an interesting example of entropy-driven selection between different types of magnetic order. The complexity of this diagram, with multiple first and second order transitions and the appearance of stable fractional **magnetization plateaus*** at m = 1/3 and 2/3 is truly unique, exceeding complexity of the known phase diagrams of kagome and pyrochlore antiferromagnets.

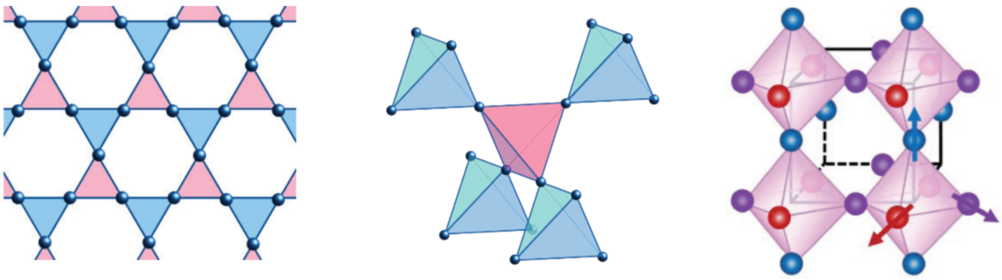


Figure 1:. Geometrically frustrated lattices (from left to right): kagome, pyrochlore and octahedral.

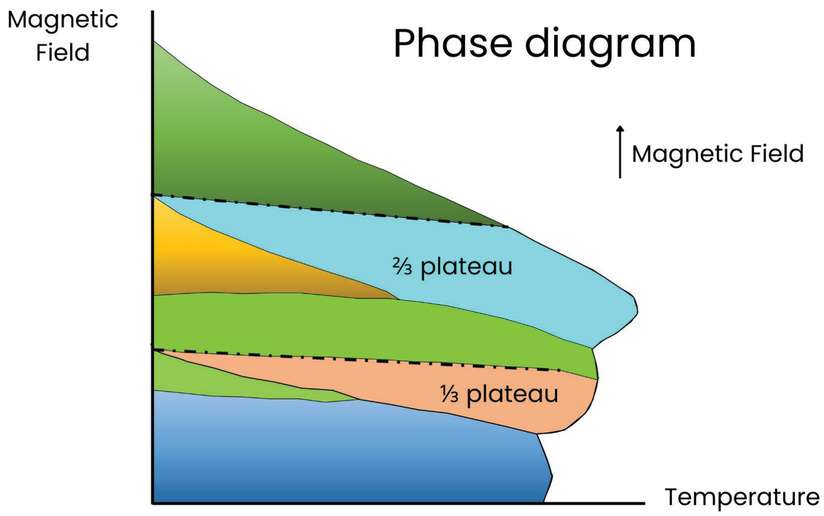


Figure 2: Phase diagram of octahedral antiferromagnet in magnetic field

The richness of the phase diagram originates from the frustrated nature of the spin octahedral building blocks. In a single octahedron, the impossibility to satisfy 12 antiferromagnetic bonds simultaneously leads to a large continuous degeneracy, which by far exceeds the degeneracy of spin triangles or spin tetrahedra. In an applied magnetic field, this degeneracy is partially lifted, resulting in a variety of collinear and coplanar spin arrangements. Examples include the ↑↑↑↑↓↓ magnetic state at the 1/3 plateau or the ↑↑↑↑↑↓ configuration at the 2/3 plateau. Extensive computer simulations using a so-called Monte Carlo method fully validate this picture.

Obtained results establish octahedral antiferromagnets as a distinct new class of geometrically frustrated magnets and a fertile platform for exploring complex magnetism, bridging together material realizations in antiperovskites, *e.g.* Eu_3PbO, Eu_3SnO, $Mn_3Pt(Ge)$, and theoretical models. It establishes the direct link between the frustration of the six-spin octahedral unit and the emergence of fractional magnetization plateaus.

Furthermore, it demonstrates how the entropic (fluctuation) mechanism can give rise not to just one ordered state but to a variety of phases from a highly degenerate classical ground state. The results bridge the physics of local octahedral units and long-range ordered states in three dimensions, offering new insights into the exploration of exotic states in frustrated magnets and suggests new routes to finding suitable magnetocaloric materials.

PHELIQS is a Joint Research Unit (**UMR**): CEA – UGA – Grenoble INP

Fundings: ANR Fresco (PI : Daniel Braithwaite, Pheliqs

***Geometric frustration:** A situation in which not all spins (atomic magnets) can align stably due to the structure of the lattice.

***Antiferromagnetic:** A material in which neighboring spins are aligned in opposite directions (unlike ferromagnetic materials, such as iron).

***Fractional magnetization plateaus:** Regions where magnetization remains constant (at 1/3 or 2/3 of its maximum value) despite variations in the magnetic field.

***Magnetocaloric:** The property of certain materials to heat up or cool down under the influence of a magnetic field, useful for innovative refrigeration systems

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Fully frustrated octahedral antiferromagnets: Emergent complexity in external field
Physical Review B 2025

Filming a vitamin B12 photoreceptor in action

Martin Weik
Institute of Structural Biology

Vitamin B12 is an **organometallic cofactor*** found in many enzymes that control essential processes in various organisms, including humans. An international consortium led by scientists from the Institute of Structural Biology (**CEA-IRIG/IBS**) has combined experimental techniques to discover the molecular functioning of a prototype vitamin B12 **photoreceptor***, CarH.

Ten years ago, it came as a surprise that vitamin B12 derivatives have been repurposed for light detection by a large family of previously unknown photoreceptors in bacteria, which perform various functions.

A prototype vitamin B12 photoreceptor, CarH, regulates the expression of genes involved in protecting bacteria from excessive sunlight. It does so by binding to DNA in the dark, acting as a molecular stopper. When exposed to light, its tetrameric architecture breaks down, enabling transcription by detaching from the DNA.

However, the precise molecular functioning of this photoreceptor and other vitamin B12 photoreceptors has remained a mystery ever since. An international consortium led by scientists from CEA-Irig/IBS has now combined experimental techniques using X-ray free-electron lasers (XFEL) in Switzerland (SwissFEL) and Japan (SACLA), as well as the synchrotrons in Grenoble (ESRF) and England (DLS), with quantum chemistry calculations to elucidate the molecular functioning of CarH.

After triggering photoactivity in CarH using an intense pulse of visible laser light, the researchers observed structural changes in the photoreceptor in real time. From the first moments after light absorption on the nanosecond scale to the loss of the photoreceptor's tetrameric architecture, the study reveals the sequence of orchestrated molecular events underlying its functioning. Surprisingly, the researchers discovered an unexpected intermediate state that the photoreceptor transiently adopts during the reaction process. This state appears to protect the photoreceptor from returning to its initial state and directs it towards continuing the reaction. Such an intermediate state has not been observed in vitamin B12 enzymes, making it a plausible explanation for the light-detecting ability of vitamin B12 photoreceptors.

Understanding how CarH works at the molecular level will enable this photoreceptor to be modified for biotechnological applications, such as optogenetics, which involves controlling cellular processes using light.

The IBS is a joint Research Unit (**UMR**): CEA-CNRS-UGA).

Fundings: ANR, the CNRS, the Hubert Curien Partnership (PHC) Sakura, and the EPSRC, and involved PhD students funded by the CEA, GRAL, and ENS Paris.

Collaborations: the study was conducted as part of a collaboration between researchers from IBS, ESRF, the Universities of Manchester (England), Louisville (United States), Hyogo (Japan), Saarland (Germany), the XFELs at the Paul Scherrer Institute (Switzerland) and SACLA (Japan), and the DLS synchrotron (England).

***organometallic cofactor:** organic molecule containing one or more metal ions, necessary for an enzyme to catalyse a given reaction.

***photoreceptors:** light-sensitive proteins.

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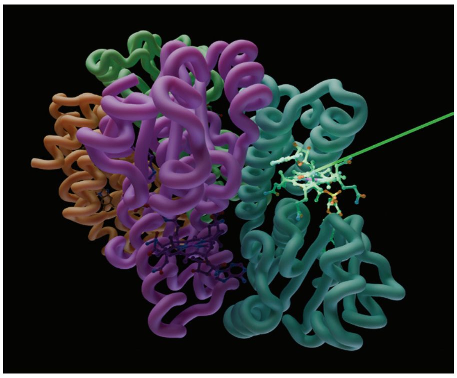
Integrated structural dynamics uncover new modes of B12 photoreceptor activation
Nature 2026



An intense laser pulse photoexcites a vitamin B12 molecule within the CarH photoreceptor. The resulting conformational changes lead to the disintegration of its tetrameric architecture. © CEA

Advancing neonatal outcomes: a strategic initiative in prematurity care

Nadia Alfaidy - Benharouga
Biology and Biotechnology for Health Laboratory

AI generated image

Prematurity remains a major public health challenge today. In light of this, Dr. Nadia Alfaidy, Inserm research director at the U1292 **Biology and Biotechnology for Health laboratory** located within the IRIG Institute of the CEA-Grenoble, is launching an ambitious project to transform the diagnosis and management of high-risk pregnancies, with support from INSERM transfert, the French Medical Research Foundation (FRM) and the University Innovation Cluster (PUI) at the University of Grenoble-Alpes.

Prematurity affects approximately 10% of pregnancies and is the leading cause of neonatal morbidity and mortality. In this context, the specialized team at the Biosanté laboratory, led by Dr. Nadia Alfaidy, has been conducting intensive research for more than twenty years. It has identified a key factor, the PROK1 protein, which could be used as a biomarker for the occurrence of this pathology.

Under the coordination of Dr. Nadia Alfaidy, a new project aims to validate the use of PROK1 as an early diagnostic tool and develop new therapeutic strategies to better prevent prematurity.

This program brings together a consortium of experts from leading research centers:

- Pr Tiphaine Barjat (CHU de Saint-Étienne)
- Pr Mohamed Benharouga (Université Grenoble Alpes)
- Dr Laurent Chatre (CNRS - Université de Caen)
- Dr Mathilde Keck (CEA Saclay).

At the heart of research: the PROK1 protein

Based on work carried out over the past 20 years, and consolidated in particular by two doctoral theses defended in 2024 and 2025, the specialized team has identified a key factor: the PROK1 protein.

Research has shown that the protein is an innovative biomarker: PROK1 concentration levels vary significantly in maternal blood and amniotic fluid in patients at risk of preterm birth.

A protective role
PROK1 acts as a "quiescence factor" helping to maintain pregnancy by limiting inflammation and oxidative stress, particularly in the event of infection.

A therapeutic avenue:
Experimental tests show that modulating this protein reduces the incidence of premature births and preserves the integrity of the placenta and fetal brain.

The project brings together expertise from the University of Grenoble Alpes (UGA), the French Atomic Energy Commission (CEA), the National Center for Scientific Research (CNRS), the French National Institute of Health and Medical Research (INSERM), and the University Hospitals of Grenoble and Saint-Étienne. It will officially begin in June 2026.

" This crucial support from the FRM and our partners enables us to advance an issue of international relevance and offer better health prospects for newborns."
— Team MAB2

Biosante is a Joint Research Unit (**UMR**): CEA, Inserm, UGA

Collaborations: UGA, CHU Grenoble, CHU Saint Etienne, CNRS, Université de Caen, CEA-Saclay.

Fundings: This project has received prestigious funding of €500,000 from the Foundation for Medical Research (FRM).

This support is supplemented by €60,000 in aid provided by the Pôle Universitaire d'Innovation (PUI) - Université Grenoble Alpes (UGA).

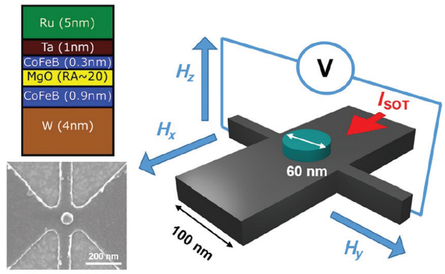
FRM FONDATION RECHERCHE MÉDICALE

UGA Université Grenoble Alpes

REFERENCE
Tiphaine Raia-Barjat, Céline Chauleur, Constance Collet, Florence Rancon, Pascale Hoffmann, Morgane Desseux, Nicolas Lemaitre, Mohamed Benharouga, Antoine Giraud & Nadia Alfaidy.
EG-VEGF maternal levels predict spontaneous preterm birth in the second and third trimesters in pregnant women with risk factors for placenta-mediated complications
Scientific Reports 2023

Excessive current erases memory

Gilles Gaudin
Spintronics and Technology of Components laboratory



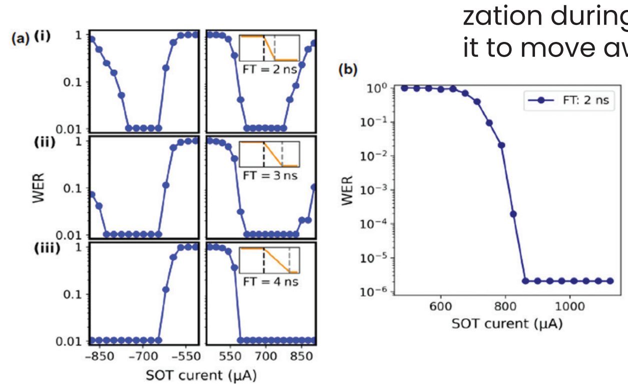
Studies on spin-orbit torque magnetic memories (SOT-MRAM) have shown that an excessively high write current can, paradoxically, prevent switching by returning the memory element to its initial state (back-switching). One proposed remedy is to terminate the electrical pulse gradually rather than abruptly.

Spin-Orbit Torque magnetic memory (SOT-MRAM) is the only non-volatile memory technology fast enough to be used in close proximity to the processing unit as a replacement for SRAM-type memories. This advancement enhances electronic circuit performance and significantly cuts down energy consumption. However, in the case of SOT-MRAM with so-called perpendicular magnetization, it has been shown that thewrite probability may collapse or even oscillate at high current.

A team from **SPINTEC**, in collaboration with Antaios, a company originating from the laboratory, quantified this detrimental phenomenon in SOT-MRAM devices based on β-W/CoFeB/MgO stacks. By measuring the write error rate (WER), they demonstrated that this phenomenon is not random but, on the contrary, deterministic.

The researchers performed so-called macrospin numerical simulations (assuming uniform magnetization), based on experimental parameters. These simulations reproduced the WER maps and elucidated the underlying mechanism. When a high-amplitude current pulse is injected, the magnetization of the SOT-MRAM tilts into the plane, at 90° from its initial direction along the -z axis (corresponding to bit 0). However, this dynamic position is unstable, and at the end of the pulse, during the relaxation phase, thermal fluctuations may drive the magnetization back to its initial -z direction, causing the write operation to fail by leaving the bit in state 0, instead of orienting it toward the +z direction to write bit 1.

A straightforward solution, without relying on exotic materials or physical effects, involves modifying the shape of the current pulse. By extending the decay time of the pulse, the current continues to act on the magnetization during relaxation, allowing it to move away from its unstable equilibrium position in a controlled manner. Thus, for pulses with a duration of 10 ns, increasing the fall time from 2 ns to 4 ns is sufficient to prevent the back-switching effect.



(a) Increase in the write window of a simplified memory element (minimum WER) as a function of the electrical pulse fall time. (b) Validation of this solution on a complete and functional memory cell.

This solution was successfully demonstrated on an individual SOT-MRAM memory cell, for which no write errors were detected after several hundred thousand cumulative write tests (WER < 2×10^{-6}).

Beyond these results, these simulations pave the way for memory-circuit design tools that incorporate back-switching. The next objectives for the industrial development of this technology are to achieve writing using current alone and to reduce the amplitude of that current.

Spintec is a Common Research Unit (**UMR**): Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP

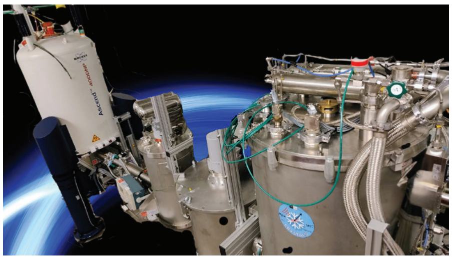
Fundings: EU Horizon 2020 Marie Skłodowska Curie ITN SPEAR project (Grant 955671) ; Région Auvergne Rhône Alpes (Pack Ambition Recherche, 19 009938 01 MAPS) and the French RENATECH network implemented at the Upstream Technological Platform in Grenoble (PTA, ANR 22 PEEL 0015)

Collaboration: Société Antaios

REFERENCE
Ray K, Vigier, J, Usé P, Martin S, Lefoulon N, Bouard C, Drouard M, and Gaudin G.
Intrinsic back-switching phenomenon in spin-orbit torque MRAM devices
Physical Review Applied 2025

Overcoming the dark side of hypersensitivity in NMR

Sabine Hediger et Gaël De Paëpe
Modeling and Exploration of Materials laboratory

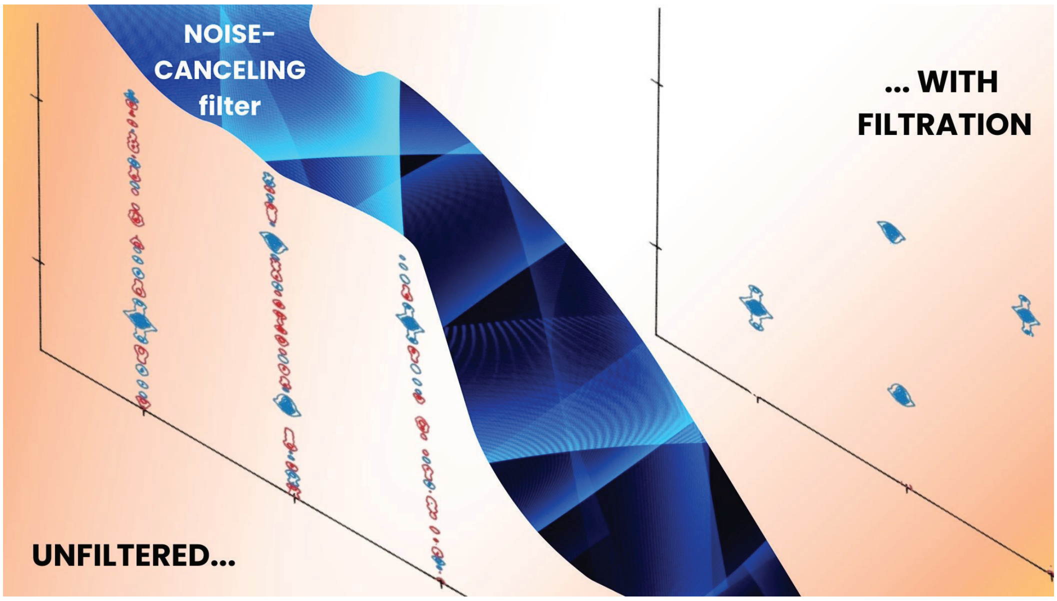


Researchers at **CEA-Irig/MEM** have developed a method to fully exploit the increased sensitivity of NMR spectroscopy combined with ultra-low-temperature hyperpolarization by eliminating the noise artifacts caused by this extreme sensitivity.

To enhance the sensitivity of NMR (**Nuclear Magnetic Resonance***) spectroscopy, a team at the **MEM** Laboratory at CEA-Irig has developed a **hyperpolarization*** technique known as **dynamic nuclear polarization*** (DNP) at ultra-low temperatures (20 K). However, the extreme sensitivity achieved with this instrument—virtually unique in the world—has revealed a downside: fluctuations in the detected signals from one scan to the next exceed thermal noise, generating artifacts that render certain multidimensional experiments partially unusable.

Solid-state NMR with hyperpolarization (DNP) offers the advantage of enabling the structural analysis of organic compounds through the detection of $^{13}C/^{15}N$ nuclei without the need for isotopic enrichment. For example, this technique allows for the observation of **"double-quantum" coherences*** between two ^{13}C atoms (whose abundance is only 1%) even in the presence of **"single-quantum" coherences*** that are approximately 10^4 times more intense. However, these experiments are often affected by artifacts generated by fluctuations in the "single-quantum" signals.

In this study, the authors achieved the feat of eliminating the main source of artifacts — *i.e.* the intense signals from isolated ^{13}C atoms—while preserving the ^{13}C-^{13}C two-spin correlations that provide information on the spatial proximity between carbon atoms, thereby preventing the appearance of parasitic noise.



On the left, The typical DNP-NMR spectrum obtained without a filter. **On the right**, the same spectrum using a modified pulse sequence based on the combined use of two RF pulse sequences: 1. A zz filter that specifically removes unwanted correlations (spurious signals) prior to detection. 2. A z filter that removes residual noise, ensuring a final spectrum free of artifacts. © CEA

« Here we present a method, based on the use of RF pulses, for removing t1 noise from ^{13}C – ^{13}C correlation spectra. This filter, called the zz filter, significantly improves the quality of spectra obtained on commercial DNP spectrometers operating at 100 K, as well as on our home-built prototype that can reach 20 K. This methodology, tested on model samples such as ampicillin (an antibiotic), produces clearer and more sensitive spectra with an improvement in the signal-to-noise ratio by up to a factor of 5, making it possible to detect long-range interactions that were previously invisible » explains Sabine Hediger, one of the co-authors.

Thanks to this new methodology, the unprecedented sensitivity of this instrument—virtually unique in the world—will enable the study of complex systems, for which it is difficult, if not impossible to extract a structural information at the atomic scale. This could, for example, involve the structural analysis of amorphous active ingredients in drug formulations, or ligand-binding at the surface of in innovative nanomaterials.

The MEM laboratory is a joint research unit(**UMR**) : Univ. Grenoble Alpes, CEA, CNRS.

Fundings : EENS-Lyon, ANR (ANR-17-EURE-0003 through the labEx Arcane, ANR-15-IDEX-02 through the CDP Glyco@Alps2, and ANR-22-CE07-0046-03), FEDER

***Nuclear Magnetic Resonance** (NMR) is an analytical technique used to study the structure and dynamics of molecules. It is based on the detection of signals emitted by atomic nuclei subjected to a strong magnetic field.

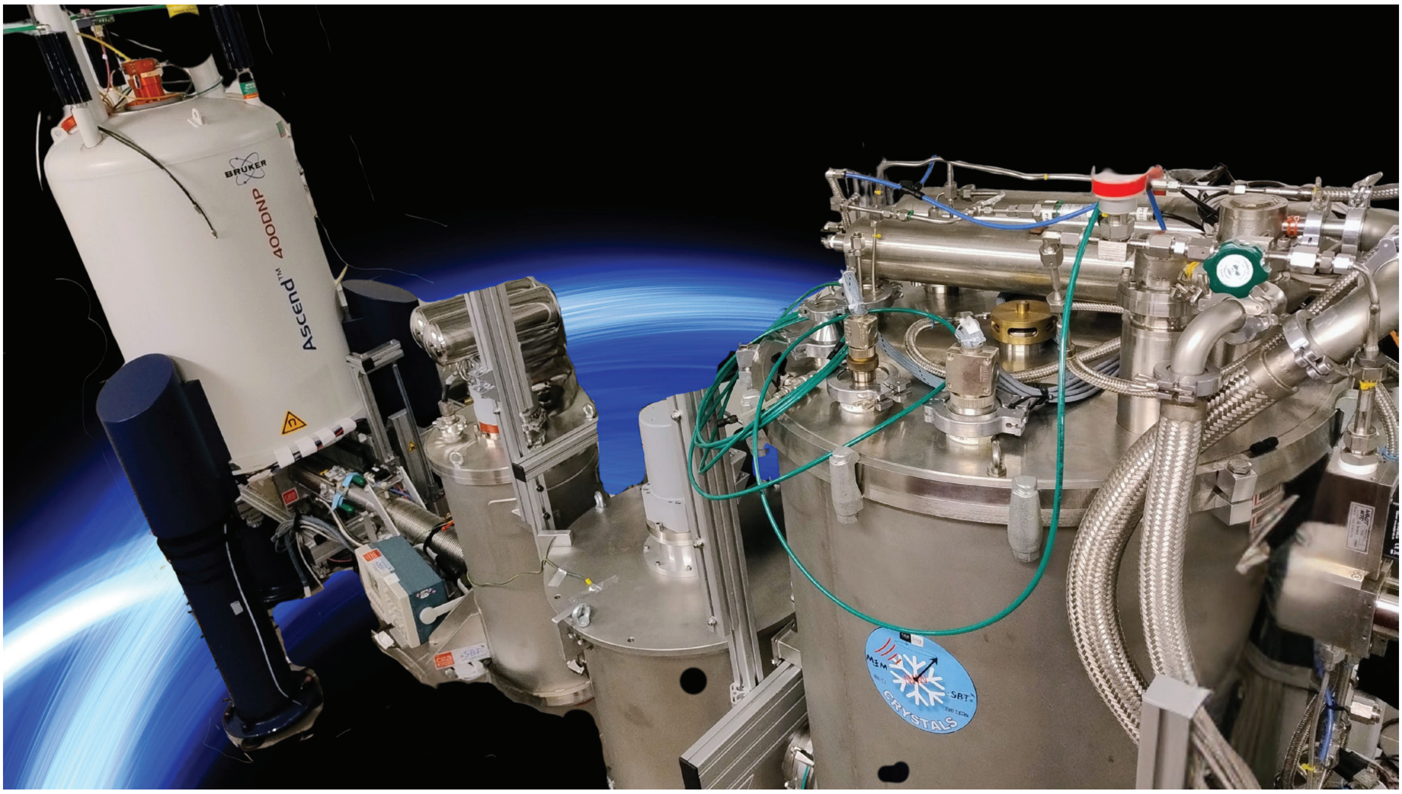
***Hyperpolarization** is a technique that increases the sensitivity of NMR by further aligning atomic nuclei in a specific direction, thereby amplifying the detected signal.

***Dynamic Nuclear Polarization** (DNP) is a hyperpolarization method that uses unpaired electrons (free radicals) to transfer their polarization to atomic nuclei, thereby increasing the sensitivity of NMR. What sets this method apart is that it is performed at ultra-low temperatures (20 K).

***"Double-quantum" coherence:** signals detected between two atomic nuclei (for example, two carbon-13 atoms) provide information about the interactions between these nuclei.

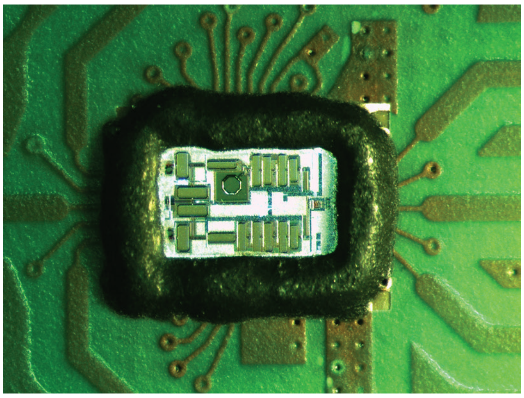
***"Single-quanta" coherence:** Signals detected on a single atomic nucleus, which are generally more intense but provide less information about interactions between nuclei.

REFERENCE
Reynard-Feytis Q, Paul S, Hediger S and De Paëpe G.
Artifact-free ultralow-temperature DNP-enhanced NMR of molecular assemblies at natural isotopic abundance
Science Advances 2025



Expérimental set-up of the dynamic nuclear polarization (DNP) and its cryogenic module (30K). © CEA

Press releases - Prizes- Media



Validation of the First Ultra-Fast, Battery-Operated EPR Spectrometer at Chip Scale.
An article presented at ISSCC, jointly authored by CEA-Leti and **CEA-IRIG/SyMMES**, presents a new 22 nm integrated circuit offering record scanning speed, wide spectral coverage, and high sensitivity, enabling the integration of electron paramagnetic resonance into portable systems.

Read more

Irina Gutsche CNRS Research Director and group leader at **CEA-IRIG/IBS**, has been awarded the Jacques Piraud Prize by the French Foundation for Medical Research (FRM). This prize, endowed with €15,000 comes from a donation by Marcel Piraud dedicated to his son Jacques.
It is intended to support research on infectious diseases.

Read more

The JCJC 2026 prize was awarded to **Sarah Hostachy** who conducts her research within the **SyMMES** laboratory (UMR 5819). This prize, awarded by the Chemobiology Division of the French Chemical Society (SCF), aims to reward a young researcher who has started a career in one of the fields of chemobiology.

Read more

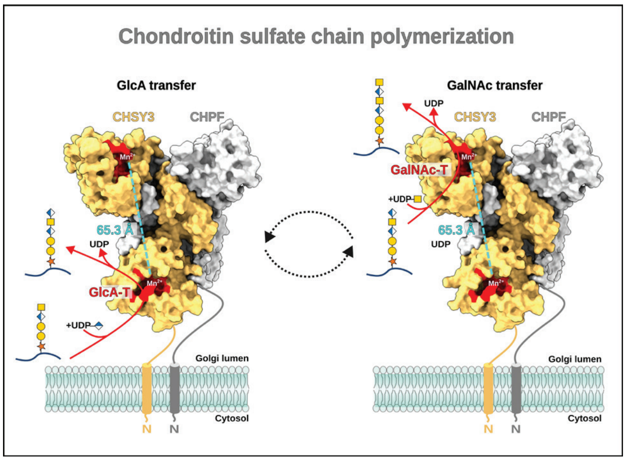
François Parcy Director of Research at the **Laboratory of Cellular and Plant Physiology** (**CEA-IRIG**, CNRS, Inrae, UGA) has been elected to the Academy of Sciences. He will sit on the Integrative Biology Section.

Read more

Rebekka Wild CNRS research fellow at **CEA-IRIG/IBS** received the Paoletti Prize 2025 for her work on understanding glycosaminoglycans at the molecular level. The Claude Paoletti Prize rewards young researchers who have distinguished themselves during their doctoral or post-doctoral studies for their work in the life sciences.

Read more

Other scientific results from the laboratories



Understanding how chondroitin sulfate is synthesized by human cells

Chondroitin sulfate (CS) is a long, highly sulfated polysaccharide found at the cell surface and in the extracellular matrix. CS plays important roles in numerous biological processes, including cell signaling and morphogenesis.

IBS

Fibril Structure of Desiccation-Protective Tardigrade Protein CAHS-8 : Keyto its stress resistance?

Tardigrades are microscopic aquatic animals that exhibit remarkable resistance to environmental stress, including radiation, cryogenic temperatures and desiccation.

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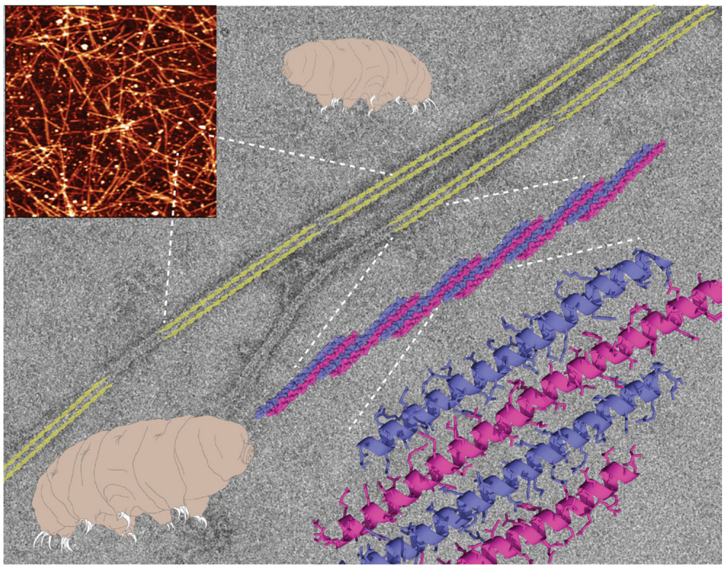

From flexibility to structure: Progressive folding of a protein at the heart of cellular communication

Intrinsically disordered proteins (IDPs) play central roles in cellular signaling and regulation by mediating dynamic, context-dependent protein-protein interactions. While IDPs exist as conformational ensembles in their unbound state, they often undergo folding transitions to form structured complexes upon partner protein binding.

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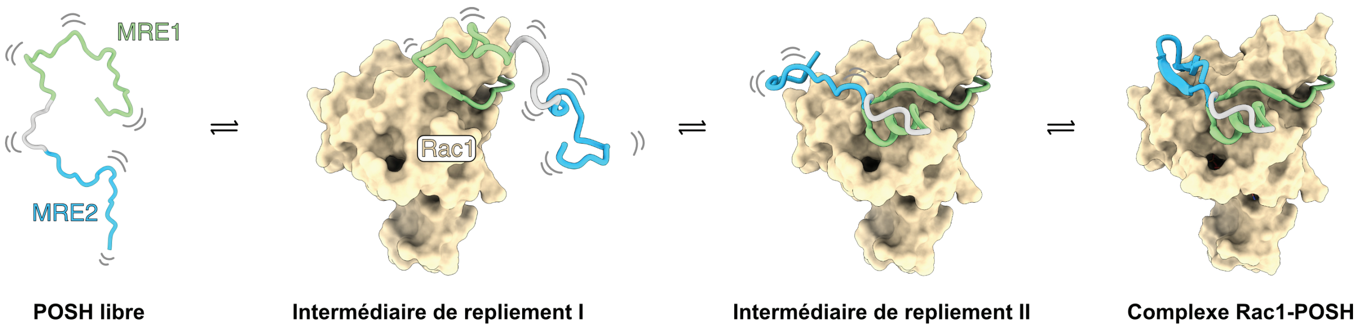

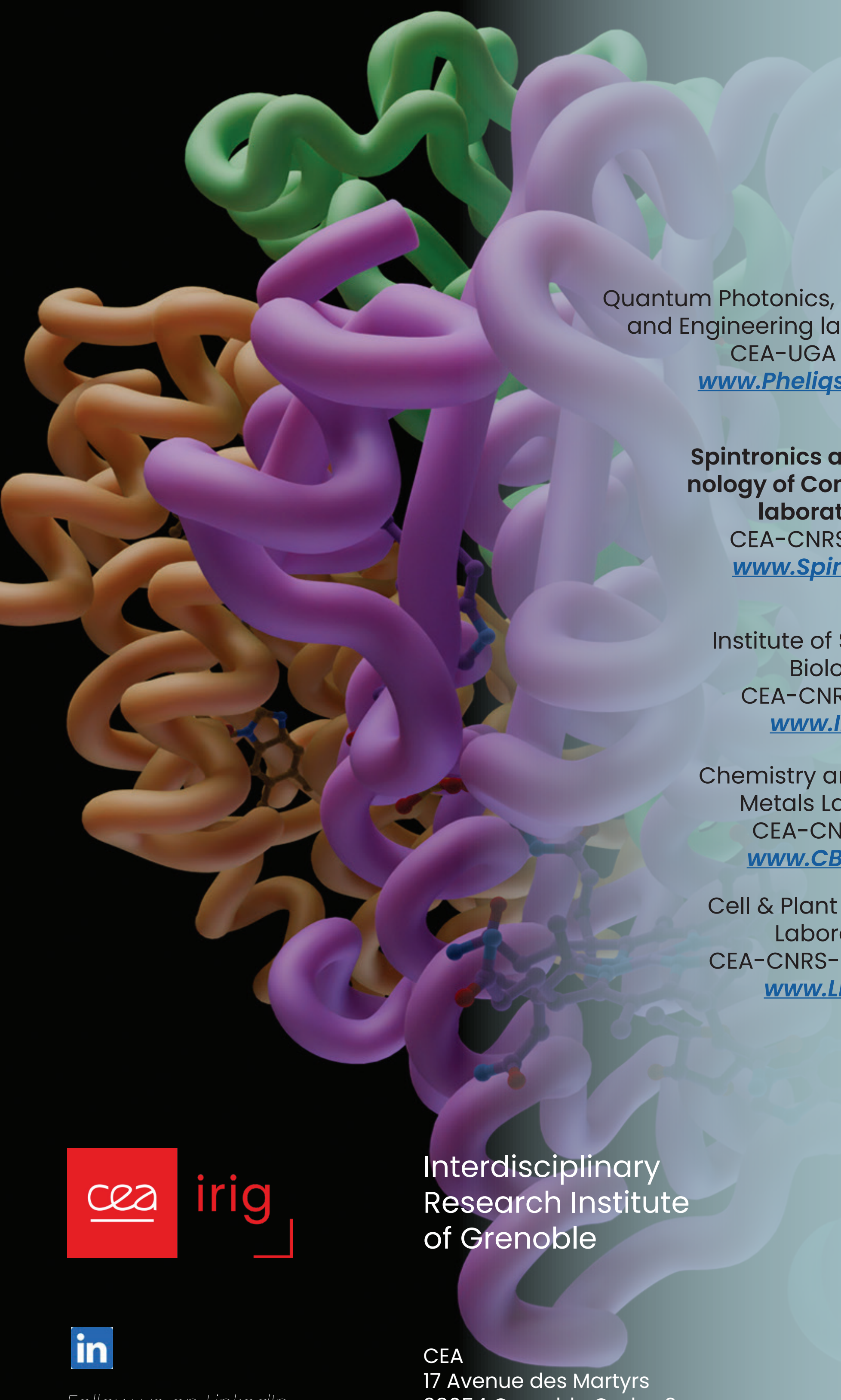

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Follow us on LinkedIn

CEA
17 Avenue des Martyrs
38054 Grenoble Cedex 9

Publishing Director
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Editor
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