Scientific Newsletter

WINTER 2023

Editorial

This end of the year 2023 marks the time of the publication of our fourth quarterly scientific newsletter, bringing together a selection of highlights from our UMRs (Unités Mixtes de Recherche) working on the key themes of Biology/Health, Energy/Environment, Physics/Digital and Cryothechnologies.

In the healthcare field, one of the highlights is the repair of DNA damage by the photolyase enzyme, observed using time-resolved crystallography on large free-electron X-ray lasers; another is the development of tumoroids for kidney cancer that can be used in pre-clinical studies.

In the field of Energy and Environment, you will discover the development of an innovative 3D confocal imaging methodology for the observation of photosynthesis at the cell level and studying photoprotection mechanisms in the face of light; a second highlight takes a look at the development of new materials with photochromic properties for dynamic dye solar cells to be used in stained glass windows, for example; another highlight exposes the orange protein as a catalyst for the photoreduction of water for hydrogen production.

In the field of Physics and Numerics, the first highlight presents an artificial intelligence topic that shows how spintronics in magnetic tunnel junctions can improve the energy performance of neural networks; a second highlight describes the miniaturization of a gallium nitride nanowire-based system to create a UV LED source; and a third highlight is about an international team in collaboration with IRIG that has investigated the fundamental principles of the Hall effect using a laser-based quantum simulator.

Finally, you will discover two illustrations of the instrumentation and engineering skills developed at IRIG: a new compact nanoscale resonator based on NEMS nano-electromechanical systems integrated into a mass spectroscope for the detection of nanoparticles or viruses; and the development of the HELIOS cryogenic loop based on liquid or supercritical helium to study heat transfer phenomena in accidental situations.

2023 was a very good year for the institute, first and foremost thanks to all the results obtained by the researchers at IRIG, which led to numerous high-level publications. This wealth is also remarkable by a very high level of participation in calls for projects issued by the French National Research Agency (ANR) with a historic success rate for IRIG of over 40%, compared with the national rate of 23.4%.

This year saw the launching more than 15 Priority Research and Equipments Programs (PEPR) wich were initiated in 2022 thanks to the considerable efforts of our research and support teams. IRIG is the co-leader of two of them: the PEPR SPIN will be officially inaugurated on January 29, 2024 in Grenoble, at the Spintec team site, in the presence of Sylvie Retailleau, Minister of Research; and the PEPR Medoc, which has just received its official letter of funding agreement, and is being led by our BGE team.

In parallel with the PEPRs, the European side has also been very dynamic this year, with a number of structuring successes such as the award of a prestigious European ERC Advanced grant to our IBS Institut de Biologie structurale, a dynamic that we must maintain in the future to reinforce our position of excellence in Europe.

Finally, the year was very active, with the extension of long-standing private partnerships strengthening our collaborations, and several new partnerships taking shape, illustrating our policy of valorizing our research and our capacity for innovation. For example, as part of the CEA Magellan maturation program, IRIG is leading two start-up projects and is preparing two others for the next selection committee.

We are also a co-founder of the FITInnovE university innovation cluster within the Université Grenoble Alpes, which will enable a better coordination of our activities in the field of technology transfer.

Thanks to our commitment and our collective efforts, this year has once again been a landmark one, establishing UMRs and IRIG as recognised players on the major issues facing our planet and our society.

I wish you all a merry Christmas and excellent vacation.

Pascale BAYLE-GUILLEMAUD
Head of the Interdisciplinary Research Institute of Grenoble

At the front page of IRIG

Spintronic spiking neuron

In the field of artificial intelligence the use of artificial neural networks inspired by the operation of our brains has been identified as a promising way of reducing the energy consumed by the algorithms that process information. However no neural network incorporating compact, energy-efficient spintronic components was yet available.

Liliana Buda-Prejbanu | Spintec | Spintronics and component technology

Researchers at IRIG have succeeded in developing a novel magnetic tunnel junction with two free layers capable of emulating the operation of a spiking neuron. This artificial neuron, stimulated by the applied electrical voltage, emits pulsed output signals whose frequency depends on the amplitude of the current flowing through the junction (**figure** 1).

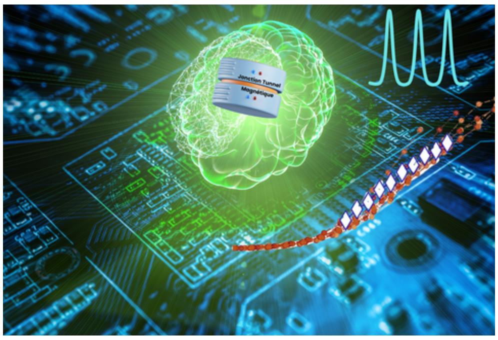


Figure 1: Artistic view of a perpendicular Magnetic Tunnel Junction with free layers that mimic the activity of a spiking neuron. On the right, the curve of its mean frequency response (0-80 MHz) as a function of applied voltage. (450-575 mV).

The device operates without the need a magnetic field. Furthermore it is not perturbed by stray magnetic fields, making it an ideal candidate for mimicking the behavior of neurons in a dense neural network.

The spintronic neuron's compact size (less than 100 nm) and its low power consumption (around 10^{-11}J/pulse) make it a major asset in the design of embedded electronics applications.

REFERENCE

Farcis L, Teixeira B, Talatchian P, Salomoni D, Ebels U, Auffret S, Dieny B, Mizrahi F, Grollier J, Sousa R , and Buda-Prejbeanu L
Spiking Dynamics in Dual Free Layer Perpendicular Magnetic Tunnel Junctions
NanoLetters 2023

3D Method for Studying Photosynthesis

For a long time, photo-autotrophic organisms have captured researchers' attention, as they serve as entry points for carbon in the life cycle and are the primary CO_2 fixers in the living world. Researchers at IRIG have developed an innovative approach to photo-physiology at the unicellular and subcellular levels. It is crucial to unravel the mechanisms optimizing photosynthesis at the individual cell level since light undergoes various transformations as it penetrates different cellular layers and even organs. Moreover, within the tissue, cells can react differently depending on their developmental stage or physiology.

Dimitri Tolleter | LPCV | Cell & Plant Physiology Laboratory

Fundings: Europenan Research Council, ERC Chloro-mito (grant n°833184) the European Union H2020 Project BIOTEC-02-2019 GAIN4CROPS (grant no 862087)

Researchers from IRIG, internationally renowned, have enhanced photosynthesis evaluation by combining a confocal microscope with saturating pulses to achieve the following three essential objectives:

1. Investigate the specialization of photosynthetic activities within the developing tissues of non-vascular plants. For example, in the moss Physcomitrium patens, photosynthetic capacities at the chloroplast level are similar across different vegetative tissues, with observable differences at the macroscopic level attributed solely to chloroplast density variation.
2. Identify a specific subpopulation of phytoplankton cells involved in marine photosymbiosis. Immediately after symbiosis establishment, symbiotic algae are photosynthetically inactive, in a quiescent state. After adaptation, they achieve better photosynthetic efficiency than free-living algae.
3. Explore the link between light penetration and photoprotection responses within different tissues composing a plant leaf's anatomical structure.

This simple method can be adapted to various sample types, serving as a versatile tool for studying plant and microalgae photosynthetic acclimation and consequently for CO_2 capture.

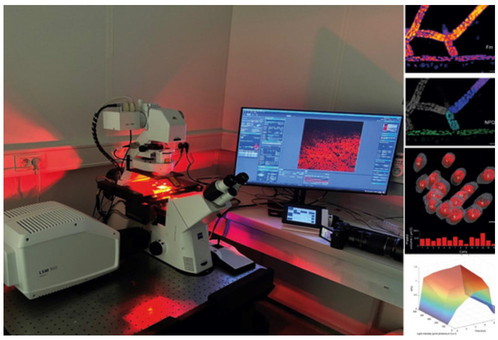


Figure 1: Overview of the confocal microscopy setup with its red light enabling photosynthesis activation. On the right: various types of achievable outcomes. Visualization of photosynthetic parameters directly on the microscopic image (Fmax and NPQ; top), 3D reconstruction of cells and analysis of their photosynthetic capacity (middle), representation of photosynthetic protection capacities based on time and light (bottom).

REFERENCE

Storti M, Hsine H, Uwizeye C, Bastien O, Yee D, Chevalier F, Decelle J, Giustini C, Beal D, Curien G, Finazzi G and Tolleter D
Tailoring confocal microscopy for real-time analysis of photosynthesis at single-cell resolution
Cell Reports Methods 2023

UV MicroLEDs: Nanowires light the way!

New ultraviolet (UV) light-emitting diodes (LEDs) have been commercially available for only a few years and are actually used for various applications such as fluorescence, polymerization, catalysis, skin disease treatment and UV disinfection. Researchers at IRIG have recently succeeded in miniaturizing this type of LED at micrometer scale to fabricate UV microLEDs, based on nanowire with a diameter 100 times smaller than a hair.

Christophe Durand | Pheliqs |
Quantum Photonics, Electronics and Engineering Laboratory

REFERENCES

[1] Grenier V, Finot S, Valera L, Eymery J, Jacopin G and Durand C
UV-A to UV-B electroluminescence of core-shell GaN/AlGaN wire heterostructures
Applied Physics Letters 2022

[2] Valera L, Grenier V, Finot S, Bougerol C, Eymery J, Jacopin G and Durand C
M-plane AlGaN digital alloy for microwire UV-B LEDs
Applied Physics Letters 2023

Researchers at IRIG, in collaboration with the Neel Institute, have developed an alternative approach using nanowires to fabricate UV microLEDs. This "nanowire" dramatically reduces the effect of dislocations within the material, increases the UV emissive surface area and improves UV light extraction. This micro-LED emits in UV-B range at 310 nm. Based on GaN nanowires, the UV-LED structure is epitaxially grown in a core/shell geometry, integrating a UV source inserted into an AlGaN diode (p-n junction). Two types of active structures emitting in the UV-B range have been successfully developed: 1) GaN quantum wells with a thickness of only 0.7 nm, corresponding to 3-4 atomic monolayers of GaN, or (2) a GaN/AlGaN superlattice to modulate the crystal composition at the scale of only 2 monolayers called a digital alloy (cf. **Figure**).

In the semiconductor field, these pioneering works on the development of miniaturized UV-LEDs with core-shell nanowire represent a significant advancement in the field of UV light sources and nanophotonics.

Today, researchers of IRIG target to design UV-C LED based on nanowires and hope to make flexible UV LEDs on large surface from an assembly of these nanowires. The very first results on flexible UV-LED look particularly promising and will soon be presented at the 14th ICNS conference 2023 in Japan.

This new device paves the way for new applications, such as UV pixel displays for biological detection and on-demand photolithography, or the fabrication of flexible UV-LEDs.

Fundings: Program Initiatives de Recherche Stratégiques (IRS) of IDEX Université Grenoble Alpes (ANR-15-IDEX-0002) and the ANR project HARALN (ANR-22-CE51-0032-01).

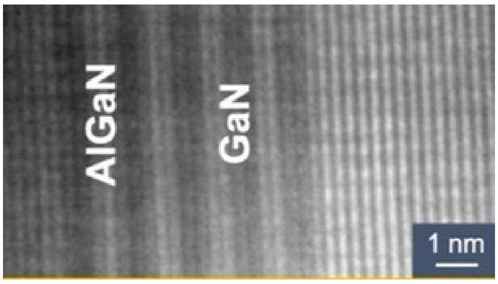


Figure: TEM Image of the UV active zone consisting on a GaN/AlGaN superlattice where each layer is 2 atomic monolayers thick.

Green hydrogen produced by illuminating orange protein

The energy transition is a major challenge for the 21st century. Research is focusing on new energy sources and new technologies to recycle carbon from CO_2 into hydrocarbons or organic molecules with high added value for industry. The electro- and photo-reduction of water into H_2 or of CO_2 into energy-dense organic chemical molecules is one of the key strategies for storing renewable energies, in chemical energy available at will (the energy contained in chemical bonds). The development of this technology requires the development of new catalysts, as well as a better fundamental understanding of the multi-electronic and multi-protein mechanisms associated with these reactions, in order to improve them for low-cost, stable, efficient and selective storage processes.

Mohamed Atta | LCBM |
Chemistry and Biology of Metals laboratory

Against this backdrop, researchers at IRIG, in collaboration with researchers from the College de France Laboratoire de Chimie des Processes Biologiques, have investigated the Orange protein (Orp) in terms of its ability to catalyze the reduction of protons to H_2.
This is a small monomeric protein of 120 amino acids containing an original metal cluster [S2MoS2CuS2MoS2]$^{3-}$ whose physiological function is still unknown. The choice of this protein was dictated by the structural similarity of its metal center to the metal active site of Mo-S-Cu carbon monoxide dehydrogenase (CODH), an enzyme known to reduce CO_2 to CO.

Studies showed that after 4 hours of irradiation under visible light in the presence of the photosensitizer [Ru(bpy)3]Cl2 and a sacrificial electron donor, the Holo-Orp protein exhibited excellent photo-catalytic hydrogen production activity for 890 cycles (see **Figure 1**).

REFERENCE

Labidi R J, Faivre B, Carpentier P, Veronesi G, Solé-Daura A, Björnsson R, Li Y, Atta M and Fontecave M
Light-Driven Hydrogen Evolution Reaction Catalyzed by a Molybdenum-Copper Artificial Hydrogenase
Journal of American Chemical Society 2023

In order to optimize the enzymatic system, different clusters of the formula [S2MS2M'S2MS2]$^{(4n)-}$ were inserted into the Orp protein, and the system containing a Mo and Fe-based cluster proved to be the most efficient catalyst, with 1150 catalytic cycles in just 2.5 hours, a record among artificial hydrogenases reported in the literature to date.

These results represent a breakthrough for future biotechnological applications

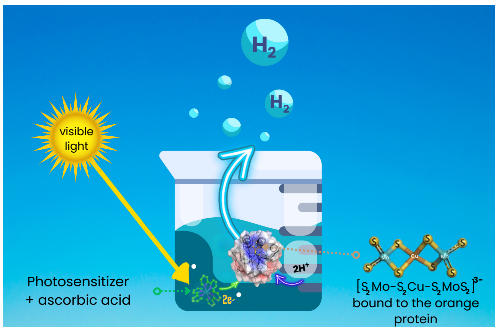


Figure 1 : H2 production after irradiation of the Holo-Orp protein in the presence of the photosensitizer [Ru(bpy)3]2+ and the sacrificial electron donor.

A laser light bends the trajectory of atoms

To understand the fundamental principles of the Hall effect, an international team, in **collaboration** with researchers at IRIG, has succeeded in bending the path of atoms using laser light. More conventionally, the Hall effect deflects electrical charges in conductors, enabling it to be used as a technique for characterizing materials and measuring the magnetic fields of our domestic appliances, such as cell phones.

Michele Filippone | MEM |
Modeling and Exploration of Materials Laboratory

Collaboration University of Florence, Laboratoire européen de spectroscopie non linéaire (LENS), Laboratoire de Physique et Modélisation des Milieux Condensés (LPMMC - CNRS), University of Geneva and Université Grenoble Alpes.

For 40 years, the behavior of particles subjected to a magnetic field, when their interactions become strong, has remained a mystery. Recent theoretical work, carried out by teams at IRIG and the University of Geneva, has predicted the remarkable behavior of these systems. Now, the experimental team at the University of Florence, in collaboration with theorists at IRIG, CNRS and the University of Geneva, has used a quantum simulator - a quantum computer "dedicated" to a specific task - to confirm this theory experimentally. It studied in real time how a jet of atoms bends under the effect of a magnetic field, something that had never been observed before: cooled to the extreme of a few billionths of a degree above absolute zero, neutral atoms behave like electrons. By irradiating the atoms with laser light, the researchers were able to describe precisely how their trajectories bend in the presence of an "artificial" magnetic field, just as charged particles would (*cf.* **photo** 1)

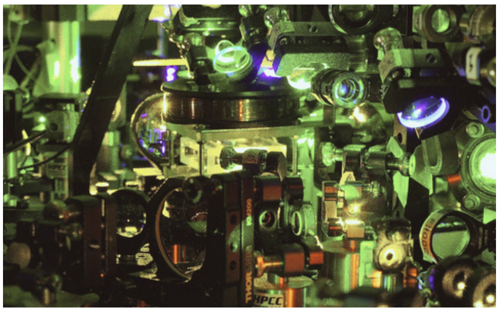


Photo 1: Details of the laser experimental setup © Carlo Sias.

Thus, confirming theoretical predictions for the first time, the Hall effect was measured by varying the interactions between the particles (*cf.* **Figure 2**). These promising results would finally elucidate the microscopic origin of the quantization of the Hall effect, which, 40 years after its discovery, remains in search of a complete theoretical interpretation.

This research will continue as part of the National Recovery and Resilience Plan (PNRR) initiatives dedicated to the development of new quantum technologies.

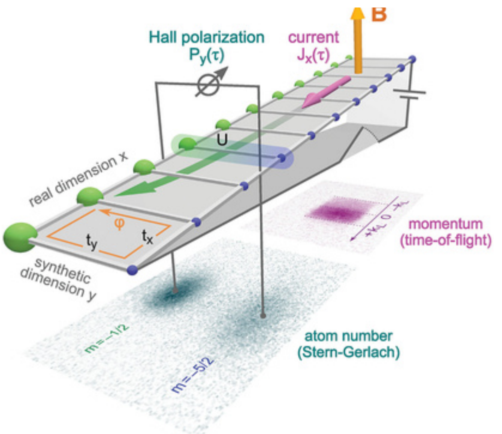


Figure 2: Observation of the Hall effect on strongly interacting fermions (courtesy of the journal Science).

Studies as part of the ERC Consolidator Grant TOPSIM research project and the PEPR EPIQ ANR-22-PETQ-0007 part of Plan France 2030.

REFERENCE

Zhou T-W, Cappellini G, Tusi D, Franchi L, Parravicini J, Repellin C, Greschner S, Inguscio M, Giamarchi T, Filippone M, Catani J and Fallani L
Observation of universal Hall response in strongly interacting Fermions
Science 2023

LIENS

Université de Genève website
University of Florence

New compact modular nano-resonator mass spectrometer

Mass measurements in the mega to giga-Dalton range are essential for the characterization of natural or synthetic nanoparticles but impossible to achieve with conventional mass spectrometers. Mass spectrometry based on nano-electro-mechanical systems (NEMS) has demonstrated unique capabilities for analysis at these ultra-high masses. However previously designed systems had constraints transferred from conventional instruments, such as the use of ion guides and high vacuum requirements.

Christophe Masselon | BGE |
Biosciences and bioengineering for health laboratory

The IRIG teams in collaboration with CEA-LETI have developed a more compact system. They studied the influence of pressure on the performance of the NEMS sensor and the aerodynamic focusing lens that equipped their original prototype. They realized that the spectrometer could operate at much higher pressures than anticipated, without compromising particle focusing or mass measurement quality.
Based on these observations, the researchers designed and assembled a new modular and frugal prototype. Its operation was validated in measurements of gold nanoparticles mass distribution.

REFERENCE

Reynaud A, Trzpil W, Dartiguelongue L, Çumaku V, Fortin T, Sansa M, Hentz S and Masselon C
Compact and modular system architecture for a nano-resonator-mass spectrometer
Frontiers in chemistry 2023

This new lighter modular mechanical design significantly improves the transfer and capture efficiency of nanoparticles by the resonators, enabling analysis ten times faster without compromising mass resolution.

Fundings: Europe ERC ENLIGHTENED (GA # 616251), France CEA PTC-ID (VIA-NEMS), PRCI AERONEMS (ANR-21-CE42-0028-01), GRAL (ANR-17-EURE-0003).

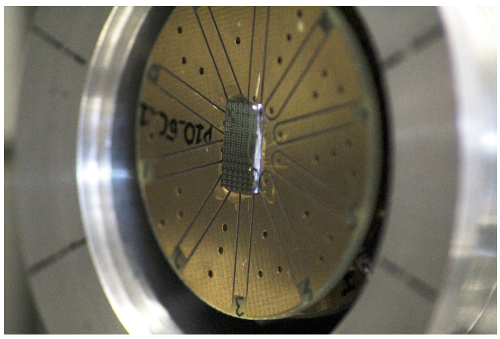


Figure 1: NEMS nano-electromechanical mass spectrometer system.

Photochromic dyes for solar cells

Since the 1990s, alternative photovoltaic technologies to silicon have been developed for a wide range of applications in buildings, transport and greenhouse agriculture. Researchers at Irig are developing dye-based solar cells. They have produced a photochromic cell that darkens when illuminated but still reproduces colors. As this phenomenon is reversible, it opens the door to applications in the field of glazing with dynamic optical properties.

Renaud Demadrille | SyMMES |
Molecular Systems and nanoMaterials for Energy and Health

Researchers at IRIG have developed and characterized solar cells based on carbazole-substituted photochromic dyes from the diphenyl-naphthopyran family. Compared to the diphenylamine-substituted reference dye, these new dyes show improved color rendering in the visible spectrum, broad absorption and faster fading kinetics. The results show yields of up to 3%. In addition, the researchers fabricated a semi-transparent solar mini-module with an active area of 14 cm2, whose transparency varies from 66% to 50% and produces a power of 14 mW. The color rendering index is greater than 95, whatever the colouring state of coloration of the cells (see Figure).

These results demonstrate that molecular engineering of photochromic photosensitizers is a relevant strategy for the development of semi-transparent solar cells with dynamic optical properties.

It is now possible to design transparent solar cells that can change color, and whose light transmittance is self-adaptative to light conditions, while ensuring the visual comfort for users.

This work was funded under the European Union's Horizon 2020 research and innovation program (grant agreement number 832606; PISCO project).

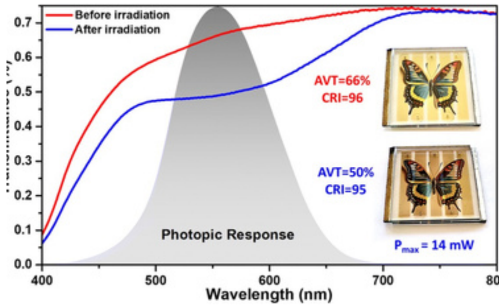


Figure: Visible light transmittance of a solar cell integrated in a semi-transparent mini-module and photopic response spectrum of the human eye. Photo of a colored butterfly taken through the mini-module (total surface area: 23 cm2) in the non-activated state (top) and in the activated state (bottom). Power output was measured under 1 sun (1000 W.m-2).

REFERENCE
Fauvel S, Riquelme A, Andrés Castán J-M, Mwalukuku V, Kervella Y, Kumar Challuri V, Sauvage F, Narbey S, Maldivi P, Aumaître C and Demadrille R
Push-pull photochromic dyes for semi-transparent solar cells with light-adjustable optical properties and high color-rendering index
Chemical *Science* 2023

Molecular movie of DNA repair by a photolyase

DNA damage induced by ultraviolet radiation can be fixed in many organisms by a light-activated enzyme known as photolyase. Researchers at IRIG have been involved in studying the mechanism of a methanogenic archaea photolyase that specifically repairs cyclobutane pyrimidine dimer (CPD) lesions. Using visible light, photolyase catalyzes the rupture of two covalent bonds linking two adjacent pyrimidine rings in a DNA strand.

Antoine Royant | IBS |
Institut de biologie structurale

REFERENCE
Maestre-Reyna M et al
Visualizing the DNA repair process by a photolyase at atomic resolution
Science 2023

The study of the molecular mechanism of DNA strand repair was carried out at the free-electron X-ray lasers (XFEL) SwissFEL in Switzerland and SACLA in Japan using time-resolved crystallography. Researchers at IRIG have analyzed spectroscopic and crystallographic data, on a timescale between 100 picoseconds and 200 microseconds covering more than 6 orders of magnitude in order to reveal an unprecedented level of detail. The mechanism consists in the transfer of one electron from the FAD (Flavine Adenine Dinucleotide) cofactor to the damaged DNA, the sequential breaking of two covalent bonds, the rearrangement of the various chemical groups involved in the reaction, and, finally, the back-flipping of the two repaired DNA bases, which leads to the dissociation of the enzyme/DNA complex (*cf.* **Figure**).

The data collected in this study constitutes a genuine molecular movie of all events, from the absorption of a blue photon by the cofactor to the release of the fully repaired DNA double-strand.

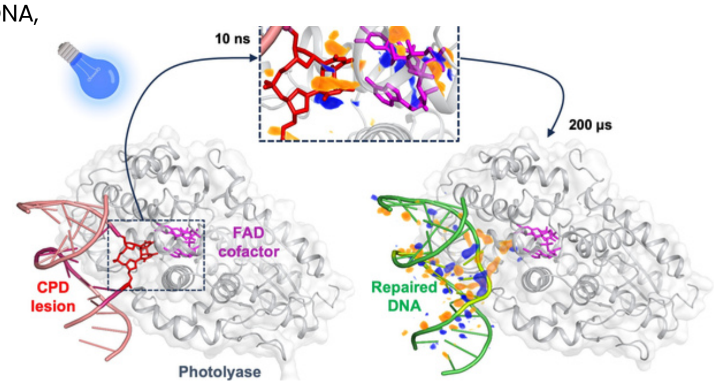


Figure 1: On the left: the damaged bases of the DNA strand point towards the inside of the enzyme photolyase. Upon blue light absorption by the FAD cofactor, the covalent bonds of the CPD lesion are sequentially broken in less than 10 nanoseconds, as illustrated by the difference electron density map (in orange and blue in the upper inset). On the right: after 200 microseconds, the repaired bases have reoriented towards the inside of the DNA double-strand, which is then ready to dissociate from the enzyme. © Nicolas Caramello (ESRF and University of Hamburg) and Antoine Royant (IBS)

Tumoroids for personalized anti-tumor treatments

A cancerous tumor is such a complex ecosystem that each patient must be treated individually. Researchers at IRIG have chosen to study kidney cancer specifically, as it is often detected late and by serendipity. Unfortunately, as current treatments are not very effective, several have to be evaluated to find the most appropriate one. For this reason, it's vital to have a good understanding of the initial patient's tumor! In this context, researchers are developing tumoroids, which are structures derived from biopsies. Importantly, these tumoroids display the molecular, genetic and morphological characteristics of the patient's tumor, to facilitate pre-clinical applications.

Odile Filhol-Cochet | Biosanté |
Biology and Biotechnologies for Health Laboratory

Researchers at IRIG have reconstituted mini-tumors (tumoroids) from the patient's primary tumor. Cells from a tumor fragment are dissociated and incubated with magnetized nanoparticles. Subjected to a magnetic field, the cells reassemble to form tumoroids (**Figure** 1).

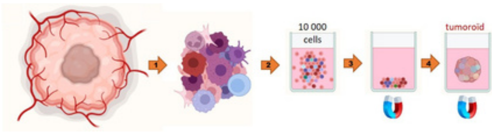


Figure 1: 4 steps methodology for building tumoroids from the tumor 1. Dissociation 2. Insertion of magnetized nanoparticles 3. Built in 4. Culture for 7-14 jours at 37°C.

Transcriptomic and immunohistochemical analyses confirm that these structures reproduce the spatial organization of the various cells present in the original tumor (*cf.* **Figure 2**) [1].

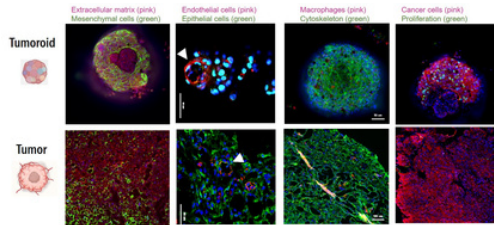


Figure 2: Immunofluorescence identifying elements of the tumor environment.

Comparison between tumoroids and the original tumor, implanted in mice, shows a strong similarity in response or resistance to various therapeutic agents. Thus, for a given tumor, it becomes possible to test several treatments in parallel directly on tumoroids to predict their toxicity efficacy against the tumor [2].

This simple and rapid method of tumoroid production offers a wide range of applications in oncology, from the study of tumor growth to the identification of new targeted therapies and the study of their toxicity, in order to offer personalized care for each patient. In addition, interest in tumoroids has recently increased following their validation by the Food and Drug Administration (USA) as a substitute for animal testing.

REFERENCES

[1] Séraudie I, Pillet C, Cesana B, Bazelle P, Jeanneret F, Evrard B, Chalmel F, Bouzit A, Battail C, Long J-A, Descotes J-L, Cochet C and Filhol O
A new scaffold-free tumoroid model provides a robust preclinical tool to investigate invasion and drug response in Renal Cell Carcinoma
Cell Death and Disease 2023

[2] Giacosa S, Pillet C, Séraudie I, Guyon L, Wallez Y, Roelants C, Battail C, Evrard B, Chalmel F, Barette C, Soleilhac E, Fauvarque M-O, Franquet Q, Sarrazin C, Peilleron N, Fiard G, Long J.A, Descotes J-L, Cochet C and Filhol O
Cooperative blockade of CK2 and ATM kinases drives apoptosis in VHL-deficient Renal Carcinoma cells through ROS overproduction
Cancers 2021

Protecting against overpressure in cryogenics

As with any cryogenic installation, the cryo-distribution system must be protected from accidental overpressure, since the most common major accident is the sudden loss of the isolation vacuum. Following such an event, the gases in the air condense on the cold walls and cause a significant thermal power deposit on the cryogenic fluid. The result is a sharp rise in system pressure. To prevent any risk of explosion, the fluid must be evacuated at a rate that can become very high.

Jean-Marc Poncet | DSBT |
Low Temperature Systems Department

Quantifying the heat inputs that generate this flow rate is a key factor in sizing safety devices. Until now, this has been based on the use of experimental flow values obtained on tanks at certain points only. In this configuration, fluid physics is based on natural convection and possibly film boiling and nucleate boiling.

Thanks to the **HELIOS** platform, researchers at IRIG were able to test such accident conditions, in order to measure the flows exchanged by forced convection.

In particular, these results will enable more precise dimensioning of safety devices, such as a valve or rupture disk, for geometries with cryogenic fluid circulation, to protect against an accident causing untimely heating.

This work was carried out as part of Sulayman Shoala's thesis, defended in November 2023.

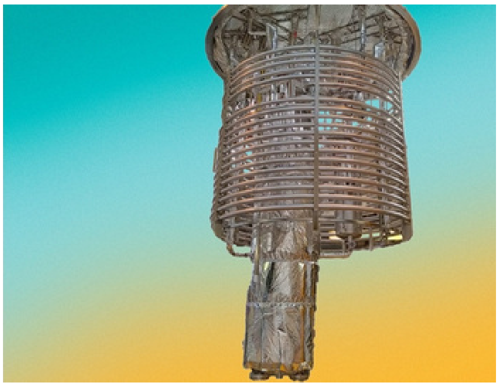
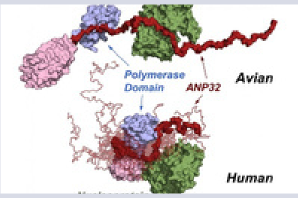


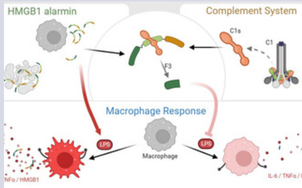
Figure: HELIOS is a supercritical helium loop initially developed to study the smoothing of variable thermal loads received by the cryogenic system of the Japanese JT-60SA fusion reactor. It has now been adapted to carry out vacuum rupture tests on part of the installation, thereby enhancing our knowledge of the safety of large cryogenic installations.

Other scientific news of the laboratories



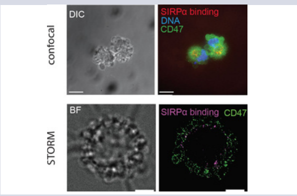
NMR reveals how bird flu exploits multivalency and intrinsic disorder to adapt its replication machinery to humans

On IBS website



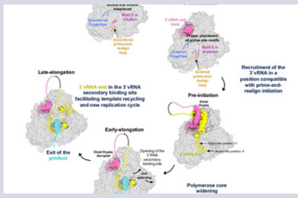
HMGB1 cleavage by complement C1s and its potent anti-inflammatory product

On IBS or LCBM website



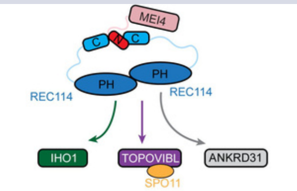
Super-resolution microscopy on the surface of cells in apoptosis reveals the play of molecules involved in their elimination by phagocytosis

On IBS website



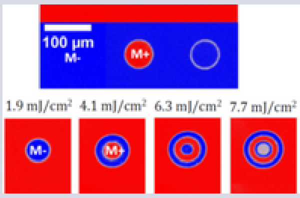
Molecular movie of Hantaan virus genome replication by its viral polymerase revealed using high resolution cryo-electron microscopy

On IBS website



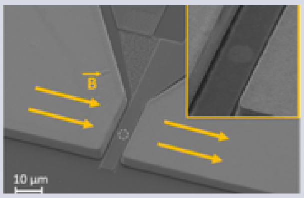
Characterization of a key meiosis regulatory complex

On IBS website



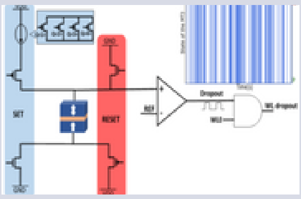
In plane reorientation induced single laser pulse magnetization reversal

On Spintec website



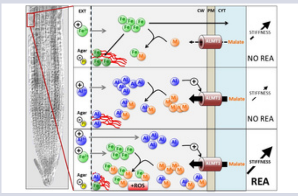
A high gain flux concentrator greatly amplifies the sensitivity of a magnetic field sensor

On Spintec website



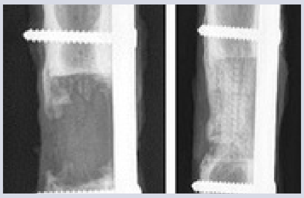
SpinDrop: Dropout Based Bayesian Binary Neural Networks with STT-MRAM

On Spintec website



10 plus 10 does not make 20 : the stress response of Arabidopsis thaliana seedling to Fe and Al metals

On IBS website



3D printing to reconstruct a long bone

On Biosante website

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European Research Council
Established by the European Commission

Jérôme Boisbouvier wins ERC Advanced Grant 2022

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Renaud Demadrille co-winner of the Académie des Sciences' Ivan Peychès 2023 prize

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FONDATION BETTENCOURT SCHUELLER

Rebekka Wild laureate of the 2023 Impulscience® program Fondation Bettencourt Schueller

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