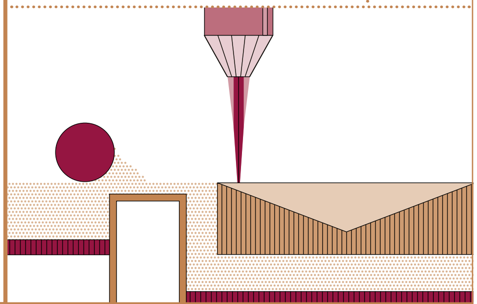
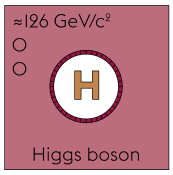
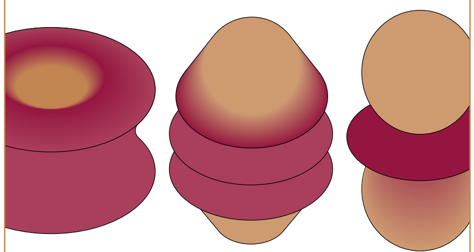
L'Édition of université paris-saclay autumn 2022

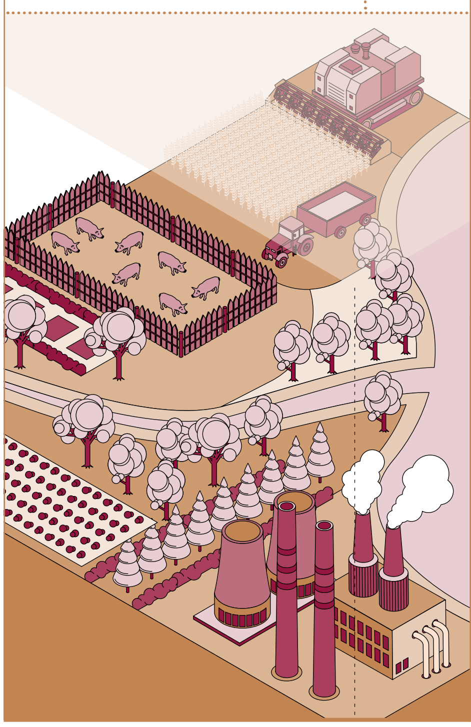
Issue

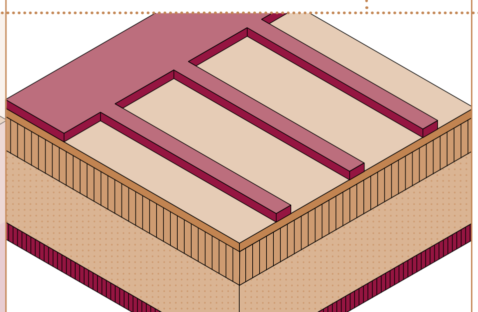
19











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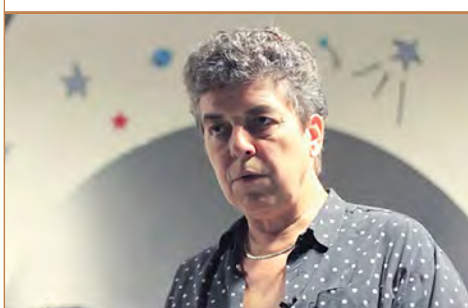
RESEARCHERS

Agnès Barthélémy and **Manuel Bibes**, from the CNRS/Thales joint physics unit (UMPhy – Univ. Paris-Saclay, CNRS, Thales), are winners of the **Europhycs EPS 2022 prize** for their contributions to condensed matter physics.

Denis David, professor at the Center for Research in Epidemiology and Population Health (CESP – Univ. Paris-Saclay, UVSQ, INSERM) is the winner of the **2022 Schaefer Research Scholar Award** from Columbia University, which funds his research project on the CA3 region of the hippocampus and its various implications.

© IHES

Hugo Duminil-Copin was awarded the **Fields Medal** at the 29th International Congress of Mathematics. The most prestigious award in the field of mathematics, this medal honors the tenured professor of the Institut des hautes études scientifiques (IHES) and his exemplary career in the field of statistical physics.



© CEA

Lucie Hertz-Pannier, a pediatrician, radiologist and head of the clinical and translational neuroimaging research unit (UNIACT - Univ. Paris-Saclay, CEA), has been awarded the **Chevalier de l'ordre national du Mérite medal** (Knight of the National Order of Merit) in recognition of her career dedicated to children with neurodevelopmental pathologies.

Elias Khan, from the Irène Joliot-Curie – Physics of the Two Infinities Laboratory (IJCLab – Univ. Paris-Saclay, CNRS, Univ. Paris Cité), **Nicolas Pavloff**, from the Laboratory of Theoretical Physics and Statistical Models (LPTMS – Univ. Paris-Saclay, CNRS), and **Grégory Quenet**, from the Centre for the Cultural History of Contemporary Societies (CHCSC – Univ. Paris-Saclay, UVSQ), have been named **senior members of the Institut universitaire de France** (University Institute of France – IUF) for a five-year term. Six other researchers from Université Paris-Saclay have also been named junior members of the IUF.

Denis Le Bihan has been named a **full member of the French National Academy of Medicine**. The physician-physicist is a specialist in magnetic resonance imaging (MRI) and diffusion MRI, and a member of the very high field MRI neuroimaging research center (NeuroSpin – Univ. Paris-Saclay, CEA).

© LPS

Philippe Mendels, from the Solid State Physics Laboratory (LPS – Univ. Paris Saclay, CNRS), has been awarded the **Grand Prix Scientifique 2022 of the Charles Defforey Foundation of the Institut de France** for his work on the emerging exotic properties of quantum materials.

Michel Beaudouin-Lafon, from the Interdisciplinary Digital Sciences Laboratory (LISN – Univ. Paris-Saclay, CNRS, CentraleSupélec, Inria), **Bertrand Maury**, from the Orsay Mathematics Laboratory (LMO – Univ. Paris-Saclay, CNRS), **Frédéric Pierre**, from the Centre for Nanoscience and Nanotechnology (C2N – Univ. Paris-Saclay, CNRS, Univ. Paris Cité), and **Vincent Tatischeff**, from the Irène Joliot-Curie – Physics of Two Infinities Laboratory (IJCLab – Univ. Paris-Saclay, CNRS, Univ. Paris Cité), have been awarded the **2022 CNRS Silver Medal**, which recognises the originality, quality and importance of their work. In addition, **five researchers** were awarded **2022 CNRS bronze medals** for the quality of their initial work, and **two engineers** were awarded **2022 CNRS crystal medals** for their contributions to research.

STUDENTS

© SciencesPo

A team composed of **Inès Sedrati** and **Alex Vézina** (titulars), **Canelle Etchegorry** and **Anna Royneau** (substitutes), all law students at Université Versailles – Saint-Quentin-en-Yvelines, an associate institution of Université Paris-Saclay, won the **first prize of the 17th edition of the International Arbitration Competition of Paris**. First place in this competition, which involves writing two dissertations, pleading a case and taking part in a mock arbitration tribunal, offers a prize of €8,000, a six-month internship in a prestigious law firm to the two titular students and several books.

© ECOTROPHELIA

On the occasion of the 23rd edition of the ECOTROPHELIA France competition, the food innovation **Fan de Fanes, carried by students from AgroParisTech,** was awarded two prizes. This culinary innovation, which consists of using Landes carrot tops and Ossau-Iraty cheese to create a pesto-like sauce, received the **bronze Trophélia** and the **Coup de cœur du Grand Nancy prize**.

COMPANIES/ PROJECTS

Two start-up projects from the Department of Medicines and Technologies for Health (DMTS – Univ. Paris-Saclay, CEA) have won awards in the 2022 i-Lab innovation competition, organized by the French government in partnership with Bpifrance. The **V4 AQUA** project was awarded **one of the ten grand prizes** of the competition, while **I-Ther Platform** was crowned **the national winner** of the 2022 i-Lab competition.

EDITOR'S LETTER

© Univ. Paris-Saclay / Christophe Peus

If there is one particular moment that we cherish in the life of our University, it is when our students are back in the alleys of our campuses after their summer break, when this community regains possession of its auditoriums and classrooms, and when our laboratories come to life and buzz again with their ever-exciting research activities. Life starts again on all our campuses, bringing our University back to its rightful place.

And at the start of the 2022/2023 academic year, our campus on the Saclay plateau is welcoming students and research staff from the Faculty of Pharmacy – previously at Châtenay-Malabry – and the Orsay Institute of Molecular Chemistry and Materials (ICMMO), as well as the University's chemistry and biology masters degrees, which have moved from their former buildings to the brand-new ones on the Henri Moissan site. This is also the first academic year on the new Agro Paris-Saclay campus in Palaiseau.

On 15 August 2022, Université Paris-Saclay was confirmed as a world-class research university. For the third year in a row, our University has been ranked in the Top 20 of the Shanghai Academic Ranking of World Universities (ARWU) and has become a permanent member of the top research universities. In addition, it retained its world number one position in mathematics in the Global Ranking of Academic Subjects (GRAS) published one month earlier. It is still ranked 9th in the world in physics and 11th in agricultural sciences. Université Paris-Saclay is also in the Top 50 in several other disciplines: clinical medicine (20th in the world), statistics (25th in the world), telecommunication engineering (25th in the world), biotechnology (30th in the world), automation and control (34th in the world), Earth sciences (48th in the world) and mechanical engineering (49th in the world).

Once again, these results honour us, as they commit us: more than ever, our University must train scientists and decision-makers capable of envisioning and responding to the challenges faced by our societies.

In response to rising temperatures and climatic upheavals due to human activity, effective measures must be taken quickly. In line with their scientific projects, our scientists are involved on all sides. In this issue of *L'Édition*, you will discover several research initiatives aimed at better storing carbon in soils and protecting the fragile soil/plant balance, in order to prepare for future climate variability. You will also read about the University's initiatives and strengths in the field of ecological transition.

This issue also celebrates a very special event: the tenth anniversary of the discovery of the Higgs boson, the last missing piece of the Standard Model of particle physics. Our journal looks back at the consequences of this major event and takes the opportunity to discuss another major scientific event of recent years: the first observation, in 2015, of gravitational waves from the merger of two black holes thanks to the LIGO and Virgo interferometers.

This issue also highlights important results in attosecond ultrafast science, the factory of the future and the contribution of additive manufacturing and the digital twin to this new way of conceiving industrial production.

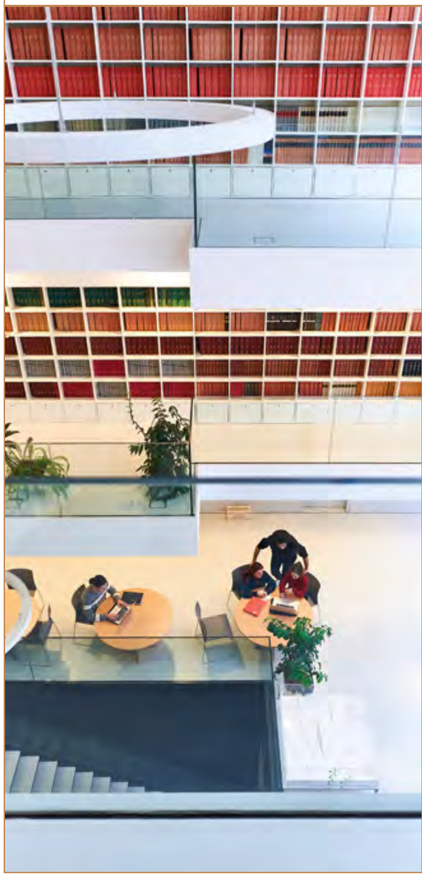
Enjoy your reading and have a great start into the new academic year!

Estelle Iacona,
President of Université Paris-Saclay.

Keywords
Cross-disciplinary programmes – QUARMEN
Erasmus Mundus Master – 2022 Ultrafast X-ray
Science International School

Title

Cross-disciplinary programmes to enrich educational courses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© Michel Denance

Cross-disciplinary programmes were introduced in 2021 to meet the need for new skills and knowledge by students at Université Paris-Saclay. Short, scalable and potentially distributed over several of the University's Graduate Schools, these programmes harness research-based skills which are linked to key subjects and to addressing society's challenges.

Conceived at a time when the creation of the Graduate Schools was seen as an innovative format available to institutions wishing to offer complementary, interdisciplinary or cross-disciplinary training to address the challenges in society, these cross-disciplinary programmes are part of an experimental approach, both in terms of their design and their content. "*They were created to be flexible and not permanent, and not limited to just following a few additional teaching units, but to in fact be driven by a desire for educational innovation. This commitment is reflected in the wide range of activities available – traditional EU courses, as well as summer schools, projects and work placements – leading to a certificate or a university diploma (UD) once they have been validated,*" explains Claire Lartigue, Deputy Vice-President in Charge of Master's at Université Paris-Saclay. As far as the training offer itself is concerned, different approaches are used to meet the needs identified. "*The cross-disciplinary programmes may be based on a common educational area in order to respond to challenges in society, such as the ecological transition, or they offer a pathway on a cross-disciplinary or highly interdisciplinary subject not covered by a Master's type programme, or they offer complementary skills in terms of soft skills such as entrepreneurship or interculturality. What these different approaches have in common is that they are always strongly linked to research,*" points out Claire Lartigue.

Climate action: a UD focusing on climate transition

The first cross-disciplinary programme created last year as an extension to the interdisciplinary Alliance For Climate Action Now! (AllCAN), the Climate Action UD, which is managed by the Engineering and Systems Sciences Graduate School, aims to educate and familiarise a significant number of students with the challenges of climate transition. "*The idea is to take advantage of the interdisciplinary initiatives already in place in the environmental field and to go further by structuring learning around a project with a climate action component,*" explains Jeanne Gherardi, a lecturer at UVSQ and co-director of this programme. Open to students in their 1^{st} or 2^{nd}-year of Master's degree, from engineering schools or those studying for a PhD either in parallel or as an extension to their training, this UD is obtained at the end of two consecutive semesters. The first semester is structured around nine theory-based teaching units on topics such as climate change, the circular economy, environmental law and governance. The second semester is devoted to the creation of a group project in response to a challenge related to the issues of transition and climate action. "*Using this interdisciplinary approach, and thanks to the support of the researchers involved, we want to help our students build a common language, to make them capable of drawing on different disciplines in the professional projects they will have to carry out, and to provide them with a systemic vision which is essential for understanding the challenges of ecological and climate transition,*" adds Jeanne Gherardi.

BioProbe: a complementary programme for training through research

The objective of the interdisciplinary initiative BioProbe, managed by the Chemistry, Physics, Life Sciences and Health, and Health and Drug Sciences Graduate Schools is to promote innovative projects in chemistry and physics related to the study of biological processes in complex environments for diagnostic and imaging applications. "*To achieve this goal, we need our students to be able to work at the interface of disciplines, to understand how they work and the scientific issues involved. This is why we offer students, between the two years of their Master's programme, the chance to consolidate their education through research by means of two five- to six-month work placements in BioProbe laboratories in order to acquire scientific knowledge in a discipline which complements their initial training, as well as some sixty hours of theory-based teaching, and, as a result, to have all the cards in their hands to build a strong professional project, to succeed in their Master's programme and to integrate into a doctoral school in the best possible way,*" explains Marie Erard, coordinator of the personalised complementary BioProbe programme. Every student is supported by an academic advisor who helps them to identify laboratories within the Université Paris-Saclay community which are likely to welcome them for a work placement and to choose the courses suitable for their study and professional project. "*Because of the numerous exchanges it allows, this programme will also contribute greatly to boosting the research component of BioProbe,*" adds Marie Erard.

The ENS Paris-Saclay Research/creation UD is now open to everyone

Another cross-disciplinary programme which was created within the Graduate School Research and Higher Education is the Research/creation UD (ARRC). This course, which is at the interface between the arts, sciences and technology, is initially being managed by ENS Paris-Saclay. It draws on the programming and resources of the Scène de Recherche in order to offer students an innovative educational approach. This results in a first semester of theory-based courses (in epistemology, history of art or science), practical courses (in programming, robotics, immersive sound, etc.) and field expeditions, which then concludes with the completion of a group project combining different skills and leading to the delivery of a final prototype. "*Last year, we were particularly impressed by the range and quality of the prototypes presented to us,*" remembers Volny Fages, who manages the DU ARRC. The second semester involves a work placement of four to six months. The DU ARRC team and its many partners (the Pompidou Centre, the 104, the Institute for Acoustic/Music Research and Coordination IRCAM, the Centre for Research and Restoration of Museums in France C2RMF and the Théâtre de la Ville) are very much looking forward to the year ahead. "*Our aim more than ever before is to put in place a sweeping interdisciplinarity in order to turn our students into better researchers. We're also committed to enabling everyone to develop a critical perspective on the role of science and technology in contemporary societies,*" says Volny Fages in conclusion.

Please note: The AVERROES programme aims to train a generation of leaders in research, biomedical innovation and health policy. This highly original cross-disciplinary programme is open to students from non-health science backgrounds, and to medical and pharmacy students who wish to complete their training in basic or human and social sciences.

Title

QUARMEN Master's degree: at the cutting edge of quantum physics

Specialising in quantum science and technology, the Master's degree Erasmus Mundus QUARMEN (Quantum Research Master Education Network) opened its doors in September 2022 and has places for around twenty students. With its teaching on cutting-edge topics and its public and private partners such as the French start-ups Pasqal and Quandela, QUARMEN trains future researchers, engineers and high-level entrepreneurs. "*Quantum technologies are a priority for national and European research and training,*" points out Marino Marsi, who manages the course and is a researcher at the Solid State Physics Laboratory (LPS – Univ. Paris-Saclay, CNRS). As QUARMEN involves a consortium of four universities (Université Paris-Saclay, University of Porto, Sapienza University of Rome and University of Toronto), enrolled students follow an international programme that combines geographical mobility and educational coherence, with at least two semesters of courses at two different universities. The Master's linked to this course are the 1st year of Master's degree in General Physics and the 2nd year of Master's degree in Quantum, Light, Materials and Nanosciences at Université Paris-Saclay, and the Master's in Physics and Quantum Information at the University of Porto, Sapienza University and the University of Toronto. "*At the end of the course, the student obtains a diploma from each university where he or she has spent a semester,*" explains Marino Marsi. Places are limited, but additional grants are available. The prerequisite is a solid grounding in quantum physics.

https://www.master-quarmen.eu/

Title

The 2022 International School on Ultrafast X-ray Science at Paris-Saclay

Université Paris-Saclay, in partnership with Politecnico di Milano (Italy) and Ohio State University (United States) is organising an International School for Master's and PhD students and young researchers on ultrafast X-ray science from 10 to 14 October 2022. It will take place at the Centre for Nanoscience and Nanotechnology (C2N – Univ. Paris-Saclay, CNRS, Univ. Paris Cité). After the events organised in Erice (Italy) in 2017 and 2019 and at Université Paris-Saclay in 2018, this event is being held jointly on the University campus for the first time. Its aim is to bring together speakers in the field of ultrafast science who are both renowned and informative. They will provide an introduction to the fundamental concepts of ultrafast X-rays and attosecond science, and an insight into their applications. The principle of this research field is "*to initiate and probe extremely rapid dynamics in matter,*" outlines Thierry Ruchon, a researcher at the Interactions, Dynamics and Lasers Laboratory (LIDYL – Univ. Paris-Saclay, CEA, CNRS) and member of the organising committee. Its scientific and technical challenges concern the drastic improvement of energy storage and the speed of tomorrow's processors.

https://ultrafast2022.sciencesconf.org/

Keywords
Science games – Perception(S) of research exhibition – VO-VF festival

Title

Listening, feeling and touching science

So that the public could experience the atmosphere of an agronomy laboratory, Marine Froissard, a researcher at the Jean-Pierre Bourgin Institute (IJPB – Univ. Paris-Saclay, INRAE, AgroParisTech), invited several artists to explore and to convey its ambiance. The result is an exhibition which combines photographs by Dan Ramaën, a sound creation by Olivier Dizet and original fragrances created by Master's degree perfumery students. "*It's a window into the world of research which gives pride of place to sensation,*" explains the researcher. The public can interact with some of the works. A cloche can be lifted to smell a perfume or the model of a growing bud can be manipulated, etc. The format is aimed at a diverse audience, including families and people with disabilities. The exhibition will be travelling to INRAE Île-de-France – Versailles-Saclay Centre for the 2022 heritage days, and to the Saint-Quentin-en-Yvelines University Library for the 2022 Science Festival.

Title

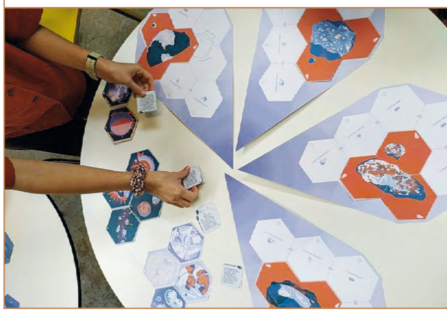
The science of decoding at the VO-VF festival

From 30 September to 2 October 2022 in Gif-sur-Yvette (Essonne), the VO-VF festival will be celebrating its 10th anniversary. Literary conferences will be held alongside film screenings, storytelling, manga workshops and translation contests. The public will learn to decipher a text in an unknown foreign language, such as Ukrainian, and will be made aware of endangered languages. Three speakers will show that translation can also be scientific. David Bessis, author of the popular book *Mathematica*, will share his passion for mathematics. "*The themes of dissemination and openness found in his work encapsulates the festival's spirit,*" explains Hamidou Soumare, a member of the organising team. Astronomy enthusiasts will learn more about the book by the Dutch astrophysicist Heino Falcke about the first photograph of a black hole, the French edition of which is the result of work by translator Corinna Gepner and astrophysicist Mathieu Langer from the Institute for Space Astrophysics (IAS – Univ. Paris-Saclay, CNRS).

https://www.festivalvo-vf.com/

Title

Science games: a powerful science outreach tool!



© Florian Delcourt – S[cube]

A training programme, supported by the Diagonale Paris-Saclay and the S[cube] association has brought together scientists at Université Paris-Saclay to help them create games based on their research.

Is it impossible to learn science while having fun? "*Absolutely not!*" say in union the Diagonale Paris-Saclay and its long-time partner S[cube] – a science outreach association based in Les Ulis (Essonne). After having set up the *Faites vos jeux [scientifiques]* show, whose first edition took place in March 2022, the Diagonale Paris-Saclay and S[cube] have recently created a new training programme for research staff at Université Paris-Saclay and its wider community. They have offered interested scientists support in creating science games related to their research. This training in 'game design', which lasted for three non-consecutive days, took place between late May and late June 2022. Four projects, selected from a dozen applicants, participated. All involved board games.

Original game topics

The project by Anaïs Brosse from the Food Microbiology for Human Health Institute (MICALIS – Univ. Paris-Saclay, INRAE, AgroParisTech) focuses on gut microbiota. It wants to show the diversity of microorganisms in the gut, the influence of microbiota on health and the impact of ingested foods and substances. The project by Samuel Hybois from the Complexity, Innovation, Motor and Sport Activities laboratory (CIAMS – Univ. Paris-Saclay, Univ. d'Orléans) introduces all the tools and types of measurement used in motion science and the quantities measured. The third project, led by Flavie Mauvais from the Vigie-Ciel participatory science programme, addresses the issue of meteorites fallen from the sky in France. Its objective is to show that there are several types and that it is possible to reveal their history using analysis. Finally, the project led by Charlotte Heinzlef from the Cultures, Environments, Arctic, Representations, Climate laboratory (CEARC – Univ. Paris-Saclay, UVSQ), deals with risk management (e.g. flooding), the decision-making in advance, during and after the risk, and the professions involved. The chosen formats are different and include a puzzle game, card game, speed game and cooperative memory game.

A playable prototype

As the training progressed, participants were able to better identify the player experience, develop a prototype and then test it with others and between themselves. Finally, they met with professional game designers in order to look to the future. "*The idea was to have something playable by the end. This was achieved, even though there's still work to be done in order to reach a very wide level of distribution, or even carry out marketing,*" says Florian Delcourt, who is responsible for cultural engineering at S[cube] and who manages the training programme.

The participants and trainer plan to meet in September to work through the remaining issues and to consider full-scale testing. The Diagonale Paris-Saclay is also considering financial support on a case-by-case basis and assistance with promotion. A second training session is being considered for 2023.

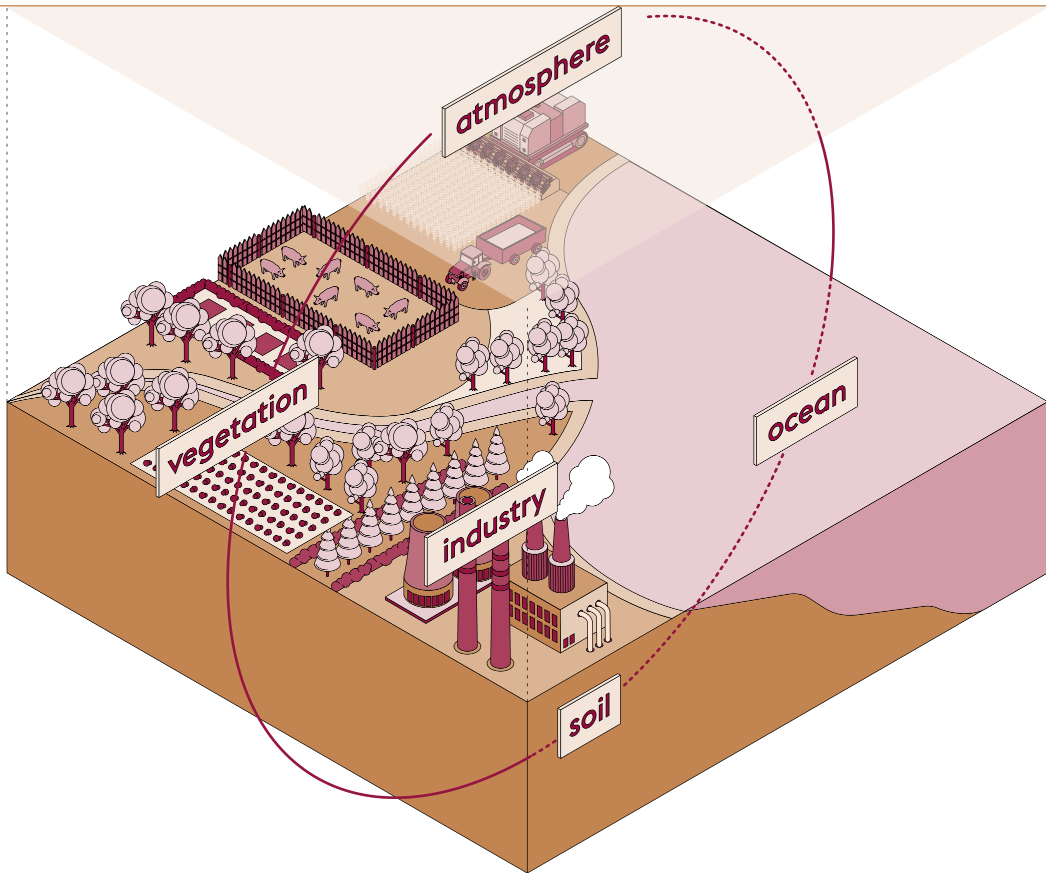
Illustrations right-hand page and page 22: **Benoît Aupoix**

Keywords
Soils and Plants – Climate – Carbon cycle

Title

Reconciling carbon, plant, soil, and climate

CARBON CYCLE



As the fourth most abundant element on Earth, carbon is everywhere. Yet it plays different roles according to the environments in which it is found.
In the form of gas in the atmosphere, carbon contributes to global warming. But when it is absorbed by soils, especially through plants, it becomes essential to the health and fertility of agricultural land. Couldn't this present a multi-faceted opportunity to better store carbon in soils?

About one third of the Earth's surface is land. In June 2020, members of the Intergovernmental Panel on Climate Change (IPCC) released a special report on *Climate Change and Land* in which world scientists stated that one quarter of the land on Earth is considered degraded, and three quarters is under anthropogenic exploitation or occupation. The planet's soils are being depleted, ignored, and mistreated and yet they are home to a large proportion of the Earth's biodiversity. In 2010, scientists appointed by a European commission established that the land surface was at that time home to about one quarter of the planet's total biodiversity.

To maintain this terrestrial biodiversity, it is imperative to devote attention to soil health. Healthy soils are defined as those that do not pollute their environment due to toxic elements in their composition and that have fertile properties arising notably from an abundance of many kinds of microorganisms. These are living organisms of microscopic size. Bacteria or certain fungi feature as some of the most common microorganisms in our soils. They compose the living organic matter of the Earth's soils. In soil organic matter (SOM), there are also plant and animal compounds of all kinds (roots, carcasses, etc.) and decomposing products. While this SOM does not represent more than 10 % of the total mass of soils, it is vital to soil health. When it is depleted in organic matter, its quality deteriorates, rendering it more vulnerable to erosion and less fertile.

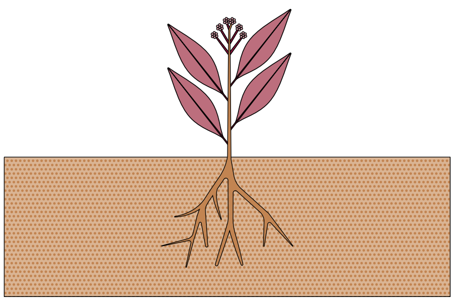
It was in this context that the "4 per 1,000, soils for food security and climate" initiative was launched in 2015, during the Paris Climate Change Conference (COP21). The programme is designed to improve SOM content and foster carbon uptake in soils. Its target is to increase soil carbon by 0.4 % per year. The purpose behind the ambition to increase SOM is threefold: Soil carbon sequestration makes soil more fertile, thus better able to meet the food security challenges that humanity will confront in the next century, while mitigating global warming.

Carbon cycle and anthropogenic activities

As major actors in the Earth's carbon cycle, plants play a vital role in maintaining soil health. Carbon exchanges between soils and the atmosphere are mediated by plants, and they are part of the global carbon cycle. The planet can be divided into four systems: The atmosphere (all the gases that surround the planet), the hydrosphere (oceans, seas and rivers), the biosphere (living beings, animals and plants), and the lithosphere (the surface layers of the soil). Each of these constitute carbon sinks (carbon reservoirs). Carbon flows constantly and naturally between these planetary reservoirs. For instance, through photosynthesis, plants absorb carbon dioxide (CO_2) present in the atmosphere and release dioxygen (O_2), before releasing CO_2 through noctural respiration.

Taking human activities out of the equation, the cycle is balanced. However, many human activities directly and indirectly endanger this stability. Soil artificialization is a perfect example. Concrete manufacture requires the use of stocks of chalk and other similar minerals that come from the hydrosphere's carbon reserves. The creation and use of concrete releases enormous quantities of carbon into the atmosphere. Especially since once a territory is concreted, there is no longer any supply of organic plant matter or water to the soils concerned, and the microorganisms eventually disappear. Moreover, fossil fuels (oil, natural gas) from the lithosphere are consumed by humans (consumption that also releases carbon dioxide into the atmosphere) at a rate far exceeding that at which they are naturally formed. There are many anthropogenic disruptions of the carbon cycle, and they contribute directly to climate change, soil resource depletion and ocean acidification.

Is there a better way to fertilise soils?



If we are to continue using fragile soils – for agriculture in particular – it is imperative to implement measures that will safeguard the soils, such as those set out by the 4 per 1000 initiative. Sabine Houot at the Functional ecology and ecotoxicology of ecosystems laboratory (ECOSYS – Univ. Paris-Saclay, AgroParisTech, INRAE) studies organic waste products and their possible valuations. "*Organic waste products are defined as all types of organic matter. Let's take manure as an example. Made up of animal litter and faeces, as well as other livestock by-products (mostly sourced from some other human activity), manure can be recovered in agriculture with or without prior processing (transformation by composting, methanisation, etc.),*" *explains* the researcher. "*When manure is processed, it becomes a digestate, which is no longer an organic residual product. However, methanisation - a process by which organic matter is decomposed in the absence of oxygen - can serve to generate electricity. What's more, the digestates obtained from this process are excellent fertilisers.*"

On the subject of agricultural soil fertilisation, the researcher objects to the prevalent energy-intensive cycle since there are other solutions available that are better for the environment. "*Field crops are fertilised with mineral salts, and the whole process requires a lot of energy. Human beings consume these crops, which means that they're also consuming the mineral fertilising salts. These salts are then released into our faeces, to be disposed of by waste-water treatment, a polluting and low-efficiency system. It's a waste,*" Sabine Houot concludes. "*Recent research shows that there is enough nitrogen in all the urine produced in Île-de-France to fertilise all the crops in the region. Directly reusing this urine through recycling would cause significantly less pollution than treating it. Nitrogen is indeed present in its ammoniacal (NH_4) form in urine and digestates. This form of nitrogen easily turns into NH_3, which affects air quality. If we are to reduce the volatilisation of nitrogen from our urine and digestates, then we should bury it in our soils as fast as possible.*"

How plants balance carbon uptake and carbon release

Observing the interactions between plants and carbon, it might at first glance seem that carbon is transferred to the lithosphere mainly via the leaves and upper parts of the plant. When these die, they fall to the ground and are slowly absorbed into the soils, along with the carbon they are composed of. But the reality is somewhat different. "*First of all, I should point out that carbon inputs to the soil by plants do not only take place via litter, as one might imagine,*" says Christine Hatté, geochemist at the Laboratory for Climate and Environmental Sciences (LSCE – Univ. Paris-Saclay, CNRS, CEA, UVSQ). Litter is the set of leaves and other plant debris that accumulates on the ground and is then incorporated to form soil matter. However, according to the researcher, this does not occur in sufficient quantities to make a major difference. "*The fact that leaves settle on the ground and decompose there, releasing carbon, does not contribute in a dominant way to the build-up of soil carbon,*" says Christine Hatté. "*It is mainly through the roots of plants that carbon enters the soil. As it grows, a plant exudes mainly sugars and amino acids, thus attracting microorganisms by providing them with energy. Using this energy, the microorganisms in turn release nutrient salts that are essential to the needs of the plant. It's a symbiotic system.*"

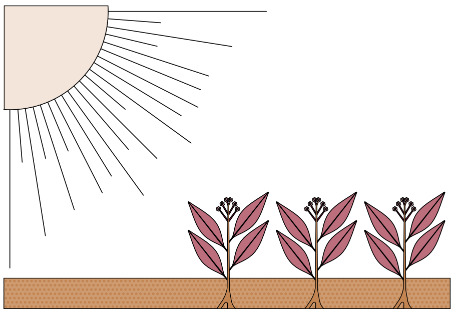
The soils' microorganisms consume molecular products exuded by plants into the soil but also organic molecules that have been present in the soil for a longer period of time. "*Each time a new molecule is introduced into the soil, part of its carbon will be released in the form of CO_2. In the end, whenever carbon enters the soil, it is later released in fairly equal quantities. The challenge, therefore, is to find plant species that can store more carbon in the soil than they remove, and to promote virtuous agricultural practices.*"

The ability to transfer carbon to the soil according to plant species was the subject of a recent study co-led by Christine Hatté. By means of a double isotopic marking method using carbon 13 and carbon 14, it is possible to reconstitute the carbon transfers between the plant and the soil. The isotopes used are 'variants' of carbon; they have a different number of neutrons (in this case 13 or 14) from that of the most widely used carbon (12). This tiny difference means that the carbon can be accurately traced as it undergoes chemical, biochemical or physical reactions (in this case, between the plant and the soil). "*Our isotopic method allowed us not only to measure the amount of carbon introduced into the soil by plants and then calculate the amount of carbon released, but also to assess the age of this carbon released from soils. In fact, the carbon that comes out of the soil is not necessarily the carbon that was originally introduced by the plant. If that's the case, it doesn't matter that much. However, if the carbon released as CO_2 turns out to be really older than the carbon originally introduced, so old that it was no longer recorded as part of the active carbon cycle, then it becomes a problem.*"

The compounds exuded by plant roots also lead to the formation of 'sleeves' that coat the roots, protecting them against possible droughts affecting the soil. "*These exudates appear systematically, regardless of the type of plant we use. However, not all plants have the same exudation capacity,*" says the researcher. Plants also show a strong capacity to adapt to their environments: "*The same plant, placed in two different soils or in two different climates, will not develop in the same way. For example, in an environment where the risk of drought is high, a plant's exudation will be greater than in a less dry environment; it will produce thicker sleeves to better protect itself. Its leaves will also be less developed, to reduce water loss.*" This type of study makes it possible to identify which type of plant is the most strategic to plant in a given environment. Such information is essential to the task of adapting crops to soils and climate change.

Is it possible to adapt soils and plants to global warming?

In summer 2022, a great number of unsustainable heat waves assailed many parts of the world. Such heat waves are the result of human-induced climate change and they have had a very serious impact on land soils. In the fields of Villiers-le-Bâcle (Essonne) near Université Paris-Saclay, the field bean crops literally roasted under the sun during the first heat wave of June 2022. Yet, according to the IPCC, this summer will be one of the 'freshest' of the years to come. Beyond the fight against global warming, it has therefore also become imperative to adapt crops and soils to the already existing and future impacts of climate change.



At LSCE, Nathalie De Noblet-Ducoudré re-evaluates land use in terms of its impact on the climate. The climatologist is concerned about the strategies currently in place to combat global warming: "*Reforestation at all costs is not the solution,*" she declares. "*To start off with, revegetating does not mean simply replanting any tree anywhere: If the plant variety is wrong at the time of planting, there is a risk of biodiversity loss, which goes against the original purpose. There is a general idea that revegetation can solve everything... But can we, in a context of research, take the right decisions?*" asks the researcher.

"*How can a plant supply water to a body of air?*" continues the scientist. "*I'm currently studying the relationship between two precipitation zones, where the precipitation of the second place comes from the first. I wonder whether it's possible to say that one area must be vegetated so that another can then be supplied with water. I'm also studying the impact of global warming on agriculture. With what degree of certainty can farmers be assured that their crops are likely to suffer the same fate as the Villiers-le-Bâcle field bean in times to come, and with increasing frequency?*"

For the time being, the soil water deficit remains prevalent, as all eyes turn to the sky in search of a rain cloud.

Publications

• N.Puche *et al.* Mechanisms and kinetics of (de-) protection of soil organic carbon in earthworm casts in a tropical environment. *Soil Biology and Biochemistry*, 170, 2022.

• S. Houot, *et al.*, Valorisation des matières fertilisantes d'origine résiduaire sur les sols à usage agricole ou forestier. *Rapport pour le ministère de l'Agriculture*. 2014.

• P. M. S. Ndour *et al.*, Rhizodeposition efficiency of pearl millet genotypes assessed on a short growing period by carbon isotopes (13C and F14C). *SOIL*, 8, 49–57, 2022.

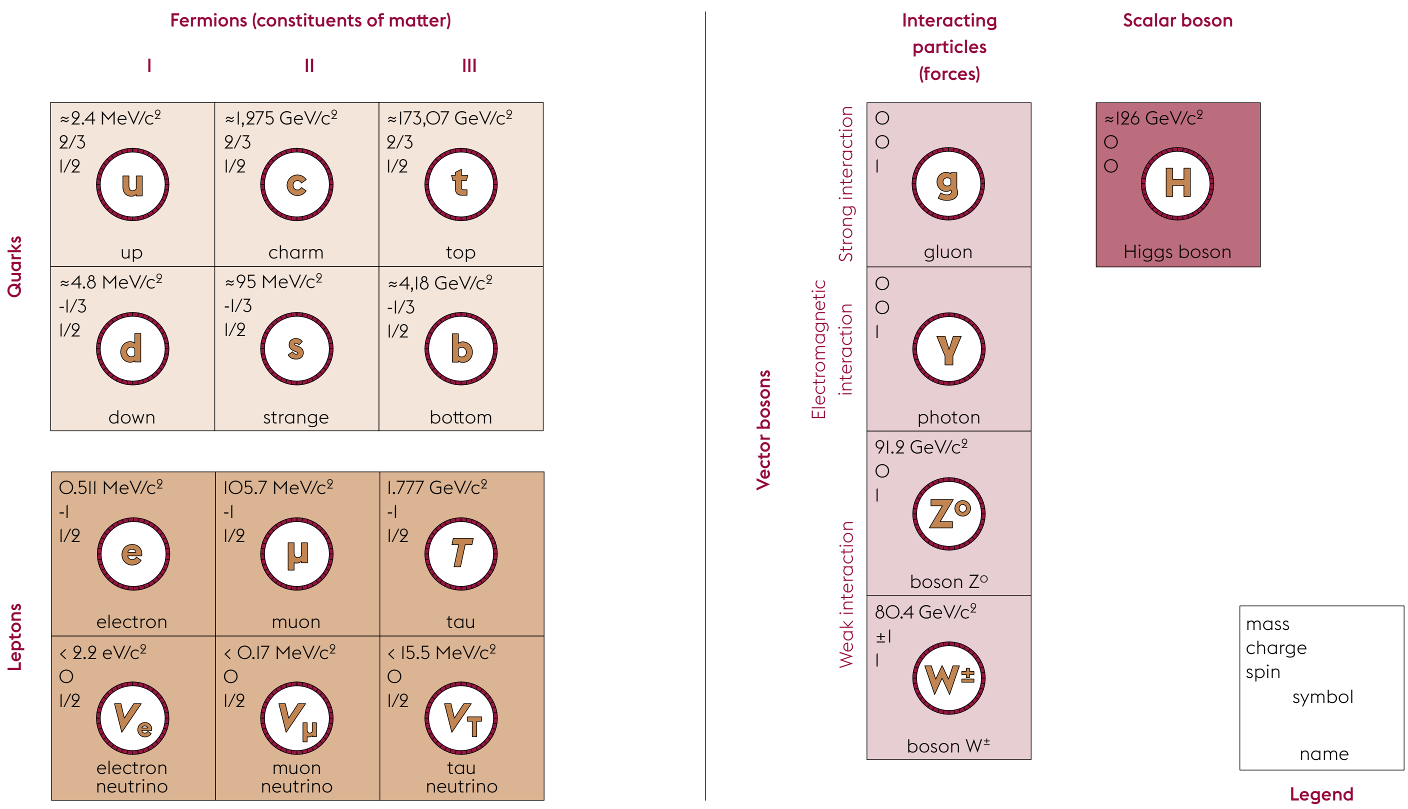
• N. de Noblet-Ducoudré et al. Terrestrial Processes and Their Roles in Climate Change. *Oxford Research Encyclopedia of Climate Science*, 2021.

Keywords
Higgs boson – Particle physics – Gravitational waves – Interferometer

Title

The discovery of the Higgs boson celebrates its tenth anniversary

STANDARD MODEL OF PARTICLE PHYSICS



In 2012, researchers at the European Organisation for Nuclear Research (CERN) caused a sensation by announcing the discovery of the Higgs boson, the ultimate elementary particle. Ten years later, what are the consequences of this event for particle physics? Here are how physicists at Université Paris-Saclay respond.

"*I think we have it.*" At the CERN headquarters in Geneva on 4 July 2012, Rolf-Dieter Heuer (the Managing Director of the international research centre) uttered these words in front of a huge audience to announce the discovery of a new subatomic particle, a few characteristics of which he knew at the time were very similar to the boson theorised by Peter Higgs in 1964. The British researcher, who was in Switzerland when the discovery of the boson which now bears his name was announced, later received the 2013 Nobel Prize in Physics for his work which led to the discovery of this new particle.

The announcement of this discovery caused an enormous stir in the scientific community as it validated the theory describing particles and matter. "*It was the final piece in what is known as the Standard Model of particle physics,*" explains Sébastien Descotes-Genon from the Irène-Joliot Curie – Physics of Two Infinities Laboratory (IJCLab – Univ. Paris-Saclay, Univ. Paris Cité, CNRS).

"If it weren't for this field, everything would move at the speed of light"

The physicist from the IJCLab explains. "*This model is the result of the insight, gained over nearly 50 years, into what matter is like at the smallest scales currently being probed. Today, we're even able to answer the question 'What is matter made of?' using a very small number of particles which we call fermions.*" Among these fermions, specialists differentiate between quarks, of which there are six, and leptons (which include electrons, for example), of which there are also six. Scientists also associate three fundamental interactions with these particles which are necessary for the construction of matter. These are electromagnetic interaction and two interactions on a subatomic scale – namely strong and weak interactions.

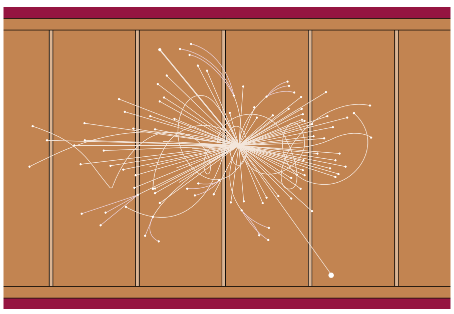
"*Up until the 1990s, we made an inventory of all elementary particles, their interactions and behaviours, while incorporating them into a coherent framework. For this, we needed an unified description of electromagnetic and weak interactions. Much theoretical work was done in this respect,*" continues Sébastien Descotes-Genon. "*However, when we tried to find a cohesive description of all the electromagnetic and weak interactions, we had to add an 'extra ingredient' to the Standard Model…and this was the Higgs boson.*" More precisely, it is the Higgs field, which is the key to the Standard Model and explains how the electromagnetic and weak interactions, although very different in appearance, are in fact two sides of a single interaction. Providing enough energy to a field creates an excitation which, like a wave on the sea, spreads and interacts with its environment, and which corresponds to a particle that we can observe. To confirm their theory of the Standard Model of particle physics, physicists spent years relentlessly exploring the Higgs field in search of a significant excitation which corresponded to the elusive boson.

The LHC or Large Hadron Collider at CERN was built underground between Switzerland and France in 2008. Today, it still remains the

Keywords

Higgs boson – Particle physics – Gravitational waves – Interferometer

most powerful and largest particle accelerator in the world. From its beginning, it has carried the hope of the entire community that the Higgs boson will one day be observed. "*The LHC was built in part to observe phenomena at the energy scales at which we expected the Higgs boson, or something else that would link the weak and electromagnetic interactions, to be present. It was designed to collide particles at energies sufficient to excite the Higgs field, create the boson particle and allow the study of its decay,*" explains Sébastien Descotes-Genon. In fact, it is not the Higgs boson itself which scientists have been observing since its discovery in 2012, but the particles into which it decays. "*The announcement on 4 July 2012 referred to the observation on several decay channels of events with similar energies which were not simply background. We therefore knew, with a certain level of statistical confidence, that this corresponded to a specific physical phenomenon,*" explains Sébastien Descotes-Genon.



"*The Higgs field is everywhere. Unlike other fields, and this is what makes it special, it has the property of disturbing and 'slowing down' the propagation of other particles. If there were no such field, nothing would have mass and everything would go at the speed of light,*" adds the physicist from the IJCLab.

The boson at Paris-Saclay

For ten years now, researchers throughout the world have been working to define the Higgs boson ever more precisely. The A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS) collaborations have both been historically linked to the Higgs boson and its study. Moreover, it was scientists from these two experiments who announced the particle's discovery in 2012. Since then, their goal has been to measure all possible properties of the Higgs boson. "*To begin with, it was 'basic' things, such as its mass or spin (a quantum property which describes sensitivity to the electromagnetic field), as well as the frequency of the different modes of production of the Higgs boson and its decays,*" outlines Sébastien Descotes-Genon.

With this in mind, several laboratories attached to Université Paris-Saclay have been involved in the international scientific effort to develop particle-acceleration systems. The sensors used by ATLAS were in part designed, tested and built at the IJCLab, while the Institute for Research on the Fundamental Laws of the Universe (Irfu – Univ. Paris-Saclay, CEA) helped to develop the sensors for ATLAS and CMS. The two laboratories are also involved in discussions on future particle accelerators.

"*The CEA Paris-Saclay group plays an essential role in the calibration of photon energy by participating significantly in the design of the electromagnetic calorimeter, which detects electrons and photons and measures their energy,*" explains Julie Malclès, who manages the CMS team at the Particle Physics Departement of Irfu. "*The Higgs boson can notably be decayed into two photons. This diphoton channel is ideal to observe the boson, because it allows us to access to the four main production modes of the boson, with a good sensitivity. We have participated in many studies via this channel, such as the coupling between the boson and the top quark.*" Apart from the formation and decay of the Higgs boson, Julie Malclès' team are also wishing to improve the accuracy of the various characteristic measurements of the particle. "*Our work aims at reducing the uncertainties on the measurements of the boson properties. For this, the improvement of the analysis methods, with for example strategies based on artificial intelligence, plays a very important role. The increased number of collisions studied is also crucial to reduce the statistical uncertainties. This will require a redesign of the collider, to collect more collisions, and also a rejuvenation of the detectors, with drastic improvements in performance.*"

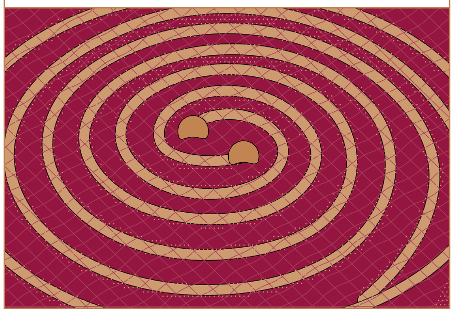
"*Within the framework of a collaboration between the Institute of Theoretical Physics (IPhT – Univ. Paris-Saclay, CNRS, CEA) and the IJCLab, we're also interested in the theoretical considerations which the results and observations generate, in particular to determine the space potential,*" says Sébastien Descotes-Genon, before pondering. "*What alternative assumptions to the Standard Model are still possible?*"

Publications

- The ATLAS Collaboration. A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery. *Nature* 607, 52–59 (2022).
- The CMS Collaboration. A portrait of the Higgs boson by the CMS experiment ten years after the discovery. *Nature* 607, 60–68 (2022).

Title

Gravitational waves: listening to the vibrations of the universe



Gravitational waves were theorised over 100 years ago by Albert Einstein and can now be seen thanks to very high-tech instruments called interferometers. What interest do these waves have for scientists and how will they be measured in the future?

Gravitational waves were predicted by Albert Einstein in 1916, several months after he had published his groundbreaking work on general relativity. They are the result of the most gigantic phenomena in the universe. One example of this is when two black holes attract one another and merge. The mass and energy involved in this process are such that they distort space-time. This disturbance then spreads throughout the universe. The physicists then guessed that only extreme phenomena, such as the merging of black holes or the explosion of very dense stars, were capable of distorting space-time and generating gravitational waves.

However, space-time is something very rigid and only small disturbances result from its alteration. Over the past 50 years, the challenge for physicists throughout the world was to design a device capable of perceiving the minute movements of space-time (in the order of 10^{-18} m, or one billionth of a billionth of a metre). In the 1970s, the American physicist, Rainer Weiss suggested using interferometers to study the interference caused by gravitational waves. This is the concept which is still used by the community today.

Interferometers – a powerful collaborative tool

"*When two black holes revolve around each other before merging, they emit gravitational waves, lose energy and spin faster and faster until they merge. Two coalesced (merged) black holes are typically the kind of object which can be observed,*" explains Nicolas Leroy, who directs the Gravitational Waves team at the Astroparticles, Astrophysics and Cosmology hub (A2C) from the Irène Joliot-Curie – Physics of Two Infinities Laboratory (IJCLab – Univ. Paris-Saclay, Univ. Paris Cité, CNRS). In 2015, the merging of two black holes was observed for the first time thanks to two interferometers at the Laser Interferometer Gravitational-wave Observatory (LIGO) based in Livingston (Louisiana) and at Hanford (Washington) in the United States. In addition to pairs of black holes, scientists are now able to study gravitational waves from the merger of a neutron star and a black hole, or two neutron stars, thanks in particular to Virgo, the interferometer based in Pisa in Italy and resulting from a European collaboration.

An interferometer is an instrument capable of measuring the interference it experiences through the phase shift of its laser. In an L-shaped set-up, the same laser is split into two beams, each of which meets a mirror at a precisely known distance. After reflection, the beams return to the point of separation and reunite in perfect alignment. When a gravitational wave passes through the Earth, i.e. when space-time is disturbed in the vicinity of the Earth, the distances covered by the laser beams are altered. As a result, in the final stage, the reunited laser is out of sync. "*As it travels through space, a gravitational wave contracts space in one direction and expands it by 90°. An interferometer gives you the optical path in one direction relative to another at 90°. As a result, it's a perfect and infinitely precise instrument for measuring one distance from another,*" concludes Nicolas Leroy. During the 19th century, when they were being designed, interferometers were used to confirm or refute the theory of ether, which had been advocated since the 17th century by Descartes and Newton. This hypothesis, disproved with the help of interferometers, implied that celestial bodies left behind 'vortices' of ether following their movement.

The major drawback of an interferometer is that the instrument receives all the perturbations coming from the Universe as a whole. "*An interferometer is closer to an antenna than a telescope,*" laughs Nicolas Leroy. To address this, it was essential to build several interferometers on Earth – the two at LIGO, Virgo and the Kamioka Gravitational Wave Detector (KAGRA) – an underground interferometer at the University of Tokyo. Thanks to the time-of-flight technique, by cross-referencing the data received by each terrestrial interferometer, researchers around the world are able to precisely define the zone of a wave's origin. In 2007, the first collaboration took place between the LIGO and Virgo teams. "*It was only a few years later, in 2015, that this collaboration proved to be a phenomenal success,*" says Nicolas Leroy with pride.

Two future instruments to broaden the field of observation

Far from being content with this success, the scientific community is looking to the future, and the future of gravitational wave detection will be played out in space... and underground. The Laser Interferometer Space Antenna (LISA) is an international project which will be completed in 2036. This space interferometer, currently under development, will consist of three satellites, each emitting a laser. "*Our perception of the electromagnetic field has broadened over time and we're now able to see the entire spectrum (visible, ultraviolet, infrared, radio waves, etc.). With LISA, we'll be able to observe new frequencies which are different from those we get on Earth. LISA will observe the merging of supermassive black holes, as well as the whole life of a binary system and the whole signal modulation. This will allow us to test general relativity in a very thorough way,*" adds Nicolas Leroy. In addition, the Einstein Telescope project, a new underground interferometer which will greatly increase the sensitivity of terrestrial detectors, is being developed. "*Much like LISA, the Einstein Telescope will also be triangular in shape, but will consist of six interferometers,*" the physicist from the IJCLab says. This project, which is the result of a European collaboration, will be completed by 2040.

Within Université Paris-Saclay, researchers at the IJCLab and the Institute for Research on the Fundamental Laws of the Universe (Irfu – Univ. Paris-Saclay, CEA) are actively contributing to the global effort to detect and analyse gravitational waves and to develop these tools of the future. They are conducting analytical and instrument preparations for LISA. "*I'm working on both data analysis and the improvement of sensors,*" explains Nicolas Leroy. "*At the moment, I'm interested in squeezing – a technique which uses the quantum entanglement effect to improve gravitational wave detectors. This is the equivalent of trying to increase the laser power of a detector by using quantum effects rather than the power itself.*"

Gravitational waves have been fascinating physicists for over a century. And from the Saclay plateau to the Earth's orbit, their study continues to captivate these scientists.

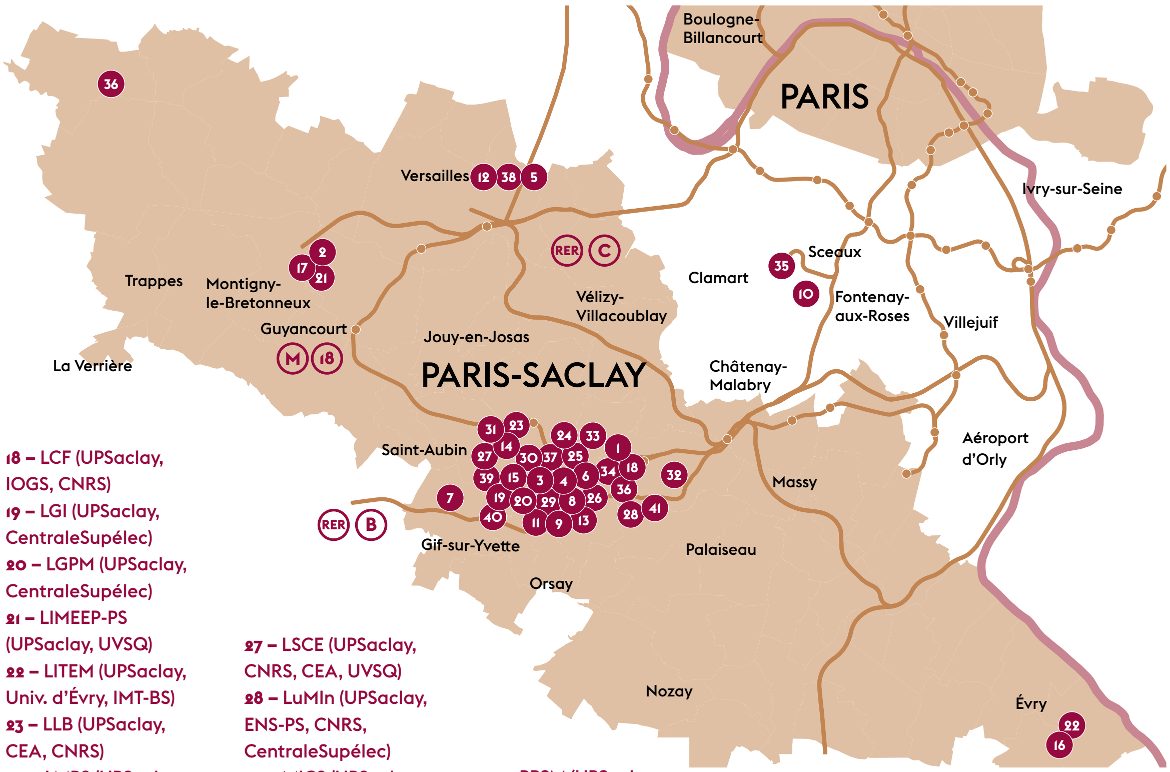
Publication • R. Abbott *et al.* Search for Gravitational Waves Associated with Gamma-Ray Bursts Detected by Fermi and Swift during the LIGO–Virgo Run O3b. LIGO Scientific and KAGRA and VIRGO Collaborations. *Astrophys.J.* 928, 2, 2022.

Keywords
Ecological transition

Title

The ecological transition at Université Paris-Saclay

A brief overview of the forces involved in the climate, energy, industrial and agri-food transitions at Université Paris-Saclay.



LABORATORIES

1 – C2N (UPSaclay, CNRS, Univ. Paris Cité)
2 – CEARC (UPSaclay, UVSQ)
3 – EM2C (UPSaclay, CNRS, CentraleSupélec)
4 – GeePS (UPSaclay, CentraleSupélec, CNRS, Sorbonne Univ.)
5 – GÉMAC (UPSaclay, UVSQ, CNRS)
6 – GEOPS (UPSaclay, CNRS)
7 – I2BC (UPSaclay, CEA, CNRS)
8 – ICMMO (UPSaclay, CNRS)
9 – ICP (UPSaclay, CNRS)
10 – IDEP (UPSaclay)
11 – IJCLab (UPSaclay, CNRS, Univ. Paris Cité)
12 – ILV (UPSaclay, UVSQ, CNRS)
13 – ISMO (UPSaclay, CNRS)
14 – I-Tésé (UPSaclay, CEA)
15 – L2S (UPSaclay, CNRS, CentraleSupélec)
16 – LAMBE (UPSaclay, Univ. d'Évry, CNRS, Cergy Paris Univ.)
17 – LAREQUOI (UPSaclay, UVSQ)
18 – LCF (UPSaclay, IOGS, CNRS)
19 – LGI (UPSaclay, CentraleSupélec)
20 – LGPM (UPSaclay, CentraleSupélec)
21 – LIMEEP-PS (UPSaclay, UVSQ)
22 – LITEM (UPSaclay, Univ. d'Évry, IMT-BS)
23 – LLB (UPSaclay, CEA, CNRS)
24 – LMPS (UPSaclay, CentraleSupélec, ENS-PS, CNRS)
25 – LPS (UPSaclay, CNRS)
26 – LPTMS (UPSaclay, CNRS)
27 – LSCE (UPSaclay, CNRS, CEA, UVSQ)
28 – LuMIn (UPSaclay, ENS-PS, CNRS, CentraleSupélec)
29 – MICS (UPSaclay, CentraleSupélec)
30 – MTS (UPSaclay, CEA, INRAE)
31 – NIMBE (UPSaclay, CEA, CNRS)
32 – ONERA
33 – PPSM (UPSaclay, ENS-PS, CNRS)
34 – PSAE (UPSaclay, INRAE, AgroParisTech)
35 – RITM (UPSaclay)
36 – SADAPT (UPSaclay, INRAE, AgroParisTech)
37 – SATIE (UPSaclay, ENS-PS, CNRS, UGE, CNAM, Cergy Paris Univ.)
38 – SOURCE (UPSaclay, UVSQ, IRD)
39 – SPEC (UPSaclay, CEA, CNRS)
40 – SPMS (UPSaclay, CentraleSupélec, CNRS)
41 – UMPhy (UPSaclay, CNRS, Thales)

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• University Diploma in Climate Action

• European University Alliance for Global Health (EUGLOH)

The Graduate Schools involved

• Biosphera (Biology, Society, Ecology & Environment, Resources, Agriculture and Food)
• Chemistry
• Economics & Management
• Engineering and Systems Sciences
• Geosciences, Climate, Environment, Planets
• Institute for Sciences of the Light
• Life Sciences and Health
• Physics
• Research and Higher Education
• Sociology and Political Science

The areas of research and innovation addressed:

— Dynamics and management of biodiversity
— Ecosystem management and agro-ecological transition
— End-use and efficiency
— Energy and society: transition, innovation and sustainability
— Energy networks
— Energy production from natural resources
— Energy storage and conversion
— Practical, systemic and technological analysis of climate change mitigation and biodiversity restoration strategies
— Quantifying and reducing impacts related to climate and ecological transitions
— Specific studies on suburban areas and promoting sustainability in these regions
— Understanding and supporting the transition to sustainable socio-ecological systems

The Doctoral Schools involved:

— Agriculture, Food, Biology, Environment, Health (ABIES)
— Chemical Sciences: Molecules, Materials, Instrumentation and Biosystems (2MIB)
— Electrical, Optical, Biophysics and Engineering (EOBE)
— Environmental Science, Île-de-France (SEIF)
— Interfaces (Innovative Materials and their Applications Centre)
— Mechanical and Energy Sciences, Materials and Geoscience (SMEMAG)
— Plant Sciences: from Genes to Ecosystems (SEVE)
— Social Science and Humanities (SSH)
— Structure and Dynamics of Living Systems (SDSV)
— Waves and Matter (EDOM)

The inter-disciplinary initiatives involved

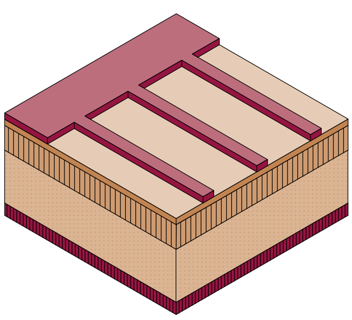
• All-Can
• C-BASC
• IES

ENS Paris-Saclay and EDF cooperate for energy transition

On 19 April 2022, ENS Paris-Saclay, a component institution of Université Paris-Saclay, and the energy production and supply company EDF confirmed a cooperation agreement. *"Energy transition is a considerable challenge for EDF, with the objective of being climate-neutral by 2050,"* explains Bernard Salha, who is Technical Director of EDF, as well as EDF's Director of Research and Development. *"Partnerships with key academic players are essential to address this."* The research programme resulting from this agreement is called 'Contributing to the technological and societal challenges of energy production, transport and storage infrastructures'. A total of nine pairs, comprising scientists from ENS Paris-Saclay and EDF, will be working on projects dealing with this topic. *"With this partnership, ENS Paris-Saclay is confirming its place in an industrial cluster,"* says its former President, Pierre-Paul Zalio with pride.

https://ens-paris-saclay.fr/actualite/acceleration-de-la-cooperation-entre-lens-paris-saclay-et-edf

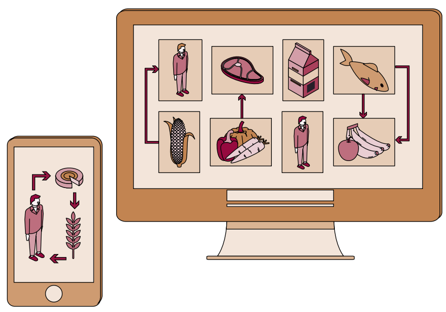
Photovoltaic cells with unprecedented efficiency and thickness



A collaboration between the Centre for Nanoscience and Nanotechnology (C2N – Univ. Paris-Saclay, CNRS, Univ. Paris Cité), the Fraunhofer Institute for Solar Energy Systems in Germany (Fraunhofer ISE – Fraunhofer-Gesellschaft) and the Photovoltaic Institute of Île-de-France (IPVF) is focusing on the design of ultra-thin solar cells with conversion efficiencies approaching 20%.The cells are essentially made of a gallium arsenide (GaAs) alloy, just over 200 nanometres thick, which is 1,000 times thinner than commercial silicon solar cells (about 200 micrometres) with similar efficiencies. Such thin cells offer the possibility of significantly reducing manufacturing costs. The academic/industry collaboration between C2N and IPVF has been responsible for several other research projects on high-efficiency ultra-thin photovoltaic cells, and several patents have already been filed to assist in the industrial transfer of these technologies.

Publication • H.-L. Chen *et al.* A 19.9%-efficient ultrathin solar cell based on a 205-nm-thick GaAs absorber and a silver nanostructured back mirror. *Nature Energy* 4, 761-767, 2019.

CircularIT: the chair seeking to link the digital and circular economy



The Alliance CircularIT, which is the result of a collaboration between CentraleSupélec (a component institution of Université Paris-Saclay) and the SystemX Institute for Technological Research (IRT), is aiming to use digital technology to promote the environment and sustainable development. This chair, which was officially created on 10 May 2022 for five years, will develop decision-making tools for citizens and companies alike which promote sustainability and subsequently new business models based on the principles of a circular and sustainable economy. *"CentraleSupélec is using its expertise in industrial activities and flows and the circular economy to create a digital twin reference framework, so as to be able to drive the circular economy and the sustainability of regions and businesses and industrial value chains,"* explains Bernard Yannou, Deputy Director of Research at CentraleSupélec. An upstream research cluster will be led by CentraleSupélec, and IRT SystemX will lead an industrial research cluster.

https://www.centralesupelec.fr/fr/lancement-dalliance-circularit-le-numerique-et-lintelligence-artificielle-au-service-de-leconomie

VivAgriLab: promoting a sustainable agriculture and food system

Set up in 2021, VivAgriLab is a dialogue platform which aims to developing applied research projects involving agri-urban regions in south-western Île-de-France. The platform brings together key players in research, including the Centre for Interdisciplinary Studies on Biodiversity, Agroecology, Society and Climate (C-BASC) at Université Paris-Saclay, regional associations such as Terre & Cité, technical experts and local authorities and institutional players. From the Versailles plain to the Saclay plateau and the Triangle Vert area, VivAgriLab hopes to promote the sustainability of agriculture in areas close to the University. With the expansion of the Parisian urban area, it is becoming essential to preserve regional agricultural and natural areas by including them in a circular economy. The first project launched by VivAgriLab involves the reconnection of food circulation on a regional scale, with the diversification of farms and the development of local food supplies, and the reconnection of organic matter circulation (compost) on a similar scale.

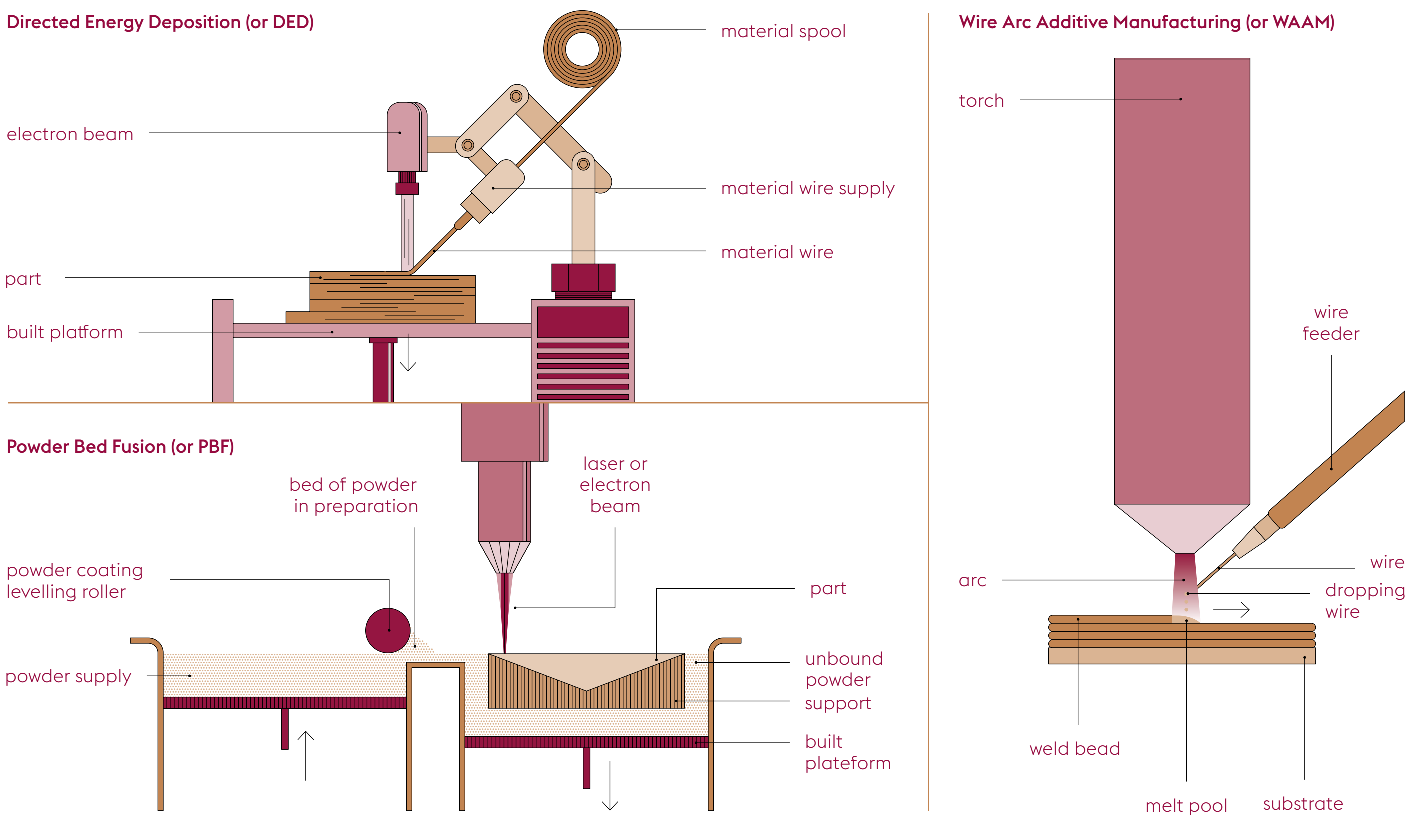
https://www.universite-paris-saclay.fr/objets-interdisciplinaires/centre-detudes-interdisciplinaires-sur-la-biodiversite-lagroecologie-la-societe-et-le-climat-c-basc/plateforme-multi-acteurs-pour-la-transition-du-territoire

Keywords
Factory of the future – Additive manufacturing – Digital twin

Title

A new boom in additive manufacturing

PRINCIPLE OF SOME ADDITIVE MANUFACTURING PROCESSES



Several laboratories in Université Paris-Saclay are focusing their research on additive manufacturing and factories of the future. This includes process optimisation, part control and the development of new manufacturing processes.

Medical prostheses, cars, houses, satellites...the list of objects which can now be manufactured using 3D printing or additive manufacturing (AM) just continues to grow. Although the first patent application was in 1984, the technology only really took off in the mid-2000s with the gradual removal of patents on its processes and the marketing of the first 3D printers. To begin with, these were only used for fun before being applied to rapid prototyping.

Whether it is in the field of bioprinting, transportation, architecture, design or many others, manufacturers are quickly realising the many advantages of this technology. AM frees up designers' creativity (by optimising the shapes and properties of manufactured parts) as much as it lowers production costs (by reducing wastage of materials or the number of parts to be manufactured). Since 2015, its world market has grown exponentially and industrial production is now counting on it to develop the industry of the future. As a result, several laboratories at Université Paris-Saclay are working on the optimisation of its processes and the quality of the parts manufactured.

A wide range of manufacturing processes

AM is the manufacture of parts in volume based on the addition of material, layer by layer, from a 3D digital model produced by computer-aided design (CAD) software. It includes seven types of process: vat photopolymerisation, material spraying, binder jetting, powder bed fusion, material extrusion, directed energy deposition and layer lamination. The choice of the process used depends on the type of material (thermosetting or thermoplastic polymers, wood, metals, ceramics), the final size of the part, the precision of the production or the desired output.

For the production of metal parts, which is particularly studied in the University laboratories, fusion processes are often preferred as they are more productive. Manufacturing is done using molten wire deposition, powder deposition or powder bed fusion.

From new materials...

Scientists working within the Saclay's Advanced Manufacturing and Technological Applications (SAMANTA) platform at CEA Paris-Saclay are particularly interested in the processes known as Direct Energy Deposit or DED using a laser or electron beam on powder or wire, as well as Laser Powder Bed Fusion or LPBF. They are focusing on developing new alloys or controlling the physical and chemical properties of a material with regard to its final application.

AM is also now increasingly becoming a technological building block for the discovery of new materials and the SAMANTA team is turning its attention to metal powders. They are seeking to develop high-entropy materials, also known as five-element alloys (iron, cobalt, aluminium, chromium, tungsten, titanium, molybdenum...). As part of the DIADEME Priority Research Programme and Equipment (PEPR), they are counting on artificial intelligence (AI) to help. "*The first step is to produce a large number of samples using the DED process and then carry out a rapid screening of their properties. The large amount of data generated will then be dealt with using AI,*" explains Hicham Maskrot, who manages the Surface Engineering and Laser Laboratory in the Physical Chemistry Department of CEA Paris-Saclay.

... to unusual behaviours

AM causes phenomena which did not exist before. It creates new microstructures in materials. For example, AM helps creating metamaterials (artificial materials with a periodic structure). As a result, the research carried out at SAMANTA has led to the development of metal filters, the manufacturing procedures for which were previously quite onerous. As a continuation of this work, the start-up AME2L, which is in the course of being set up, will be developing metamaterials for the filtration, shock absorbers and energy industries.

"*Due to very rapid solidification processes, the constituent atoms in the material are arranged in very specific ways,*" comments Hicham Maskrot. "*It's now just a question of determining whether these phenomena give the material a particular behaviour and how to influence its composition. For example, is the material manufactured more resistant to corrosion or irradiation than a conventional material?*" In relation to these issues, SAMANTA addresses the needs of research teams and industry working on the energy mix.

Obsolescence, repair and monitoring of wear

In this area, AM is proving to be useful for adressing part obsolescence through reverse engineering. By taking an old part, whose original drawing is missing, and scanning it, it is possible to remake it using AM. "*The use of LPBF allows a damaged part to be repaired locally on site,*" points out Hicham Maskrot.

It is also possible to insert tracers (optical fibres, chemical or deformation sensors) into objects. They provide information on the state and behaviour of the material and the stresses undergone (temperature, irradiation, cracking, etc.) throughout the life of the object. "*AM promotes the development of intelligent objects. For example, by placing phosphors or optical fibres in 316L steel (the most commonly used material in the nuclear industry), it's possible to check in real time what state it is in. We know when to change the part and need only replace it when it's worn out,*" says Hicham Maskrot.

The necessary qualification of parts

However, like any new technology, AM is not without its obstacles. These include the efficiency of the machines, the size of the parts and, above all, their qualification. At the Control Methods Laboratory at CEA-List, Steve Mahaut's team is working to improve the control of manufactured parts in order to better qualify the finished parts. "*Today, manufacturers have monitoring data at their disposal. This is a manufacturing report certifying that the manufacturing process went well and that the customer's instructions were respected. It remains to check that the manufactured part is compliant, or free of defects such as porosity, a lack of material or inadequate fusion,*" says Steve Mahaut.

Is this data sufficient however to guarantee the correct conformity of the part? Even when all the machine parameters (temperature, speed, laser power, etc.) are controlled, process-related phenomena can disrupt the manufacturing. For example, with Wire Arc Additive Manufacturing or WAAM, the distance between the part and the torch (the wire arc) changes during the manufacturing process as the part distorts with heat and time. If the distance becomes greater, this leads to the two welding plates being less well fused. In the case of laser fusion processes, ejected powder grains can shield and lead to poor fusion.

It is for these reasons that the team at CEA-List is developing sensors which are complementary to existing tools based on electromagnetic, non-contact ultrasound or radiographic methods. The challenge is to develop sensors which are as sensitive as possible to the most relevant information and to establish an intelligent correlation between all the physical data collected and the actual parts manufactured. "*In this way, if we see in real time that for a given part, material or machine, the parameters guaranteeing the correct conformity of the part are not respected, we can either decide to stop production or correct – and this is AM's ultimate goal – the part during production,*" points out Steve Mahaut.

Qualification at the heart of projects

To this end, his team is involved in several French (within the Additive Factory Hub on the Saclay plateau) and European collaborative research projects, each involving a large consortium of academic and industrial players. The INTEGRADDE project, which revolves around the DED manufacturing of certified metal parts, aims to develop a smart data pipeline. This digital solution will integrate the part design data (CAD), the manufacturing data (laser trajectory and applied strategy), the data recorded during manufacturing, the control data and the finished part.

The GRADE2XL project is focusing on the WAAM process and its goal is the production of large bi-material parts. "*The idea is to locally control specific material properties (hardness, corrosion resistance) in exposed or mechanically loaded areas. This would open up a whole new field of industrial processes,*" says Steve Mahaut. Finally, the NUCOBAM project is looking at the control of parts during post fabrication and their qualification for use in the nuclear field.

A robot which speaks volumes

At the University research laboratory for automated production (LURPA – Univ. Paris-Saclay, ENS Paris-Saclay), researchers are also interested in the quality of parts made using AM. Their qualification involves using metrology instruments to measure, in one, two or three dimensions, deviations in the shape and dimensions of manufactured parts in order to plan for any post-processing operations which need to be carried out. In accordance with industry 4.0, their work aims to integrate this measurement step directly into the part production line. They are developing a solution based on an anthropomorphic robot (which reproduces the movements of a human arm) combined with a laser sensor.

"*By putting laser sensors on an assembly line or on a robot and moving either the laser or the robot arm which holds the part, information can be obtained to qualify the part in mid-air. This avoids having to stop the line in order to carry out control measures. And if there's any deviation, we'd know that the manufacturing process has to be changed,*" explains Olivier Bruneau, who manages LURPA.

Identifying defects to perfect the manufacturing process

However, a robot has a great deal of joint and (to a lesser extent) segmental flexibility, loose, friction, parallax and vibration issues, small errors in geometric dimensions, etc., which ultimately leads to problems of accuracy and repeatable trajectories. Researchers at LURPA are trying to identify all these faults. Their goal is to develop new modelling methods which digitally incorporate these faults in order to obtain the best possible initial trajectory.

The laboratory has recently been equipped with a hybrid additive/subtractive manufacturing robot cell. An initial anthropomorphic robot manufactures a part using the WAAM process, while a second robot arm machines the part. "*It doesn't move from its support between steps, which reduces errors and saves time,*" points out Olivier Bruneau. Cameras placed in the space ensures the correct implementation of the processes is monitored and controlled. The first experiments have started.

However, manufacturing a part in AM using a robot is a real challenge. "*Three main parameters govern this manufacturing process. The speed at which the wire moves down and out of the feeder, the laser power used by the torch* *to melt the wire and the forward speed of the robot. The combination of the three influences the quality of the manufactured part,"* explains Olivier Bruneau. "*We must therefore determine the influence of each of the process parameters, then do the same with the robot faults and finally estimate the influence of combining one with the other. This creates a combinatorial explosion for which artificial intelligence will help us to identify the right areas of the part to manufacture.*"

Additive manufacturing has definitely not yet finished reinventing itself.

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Title

Digital twin: a virtual image which can predict the future

Through numerical modelling and data input, scientists at Université Paris-Saclay can predict the behaviour of a real system and anticipate variations.

Digital twins are relative newcomers to the manufacturing world, yet they promise to change the way things are done. The result of a combination of simulation and data, they provide the digital image of a real system (machine, part or process) which they model as faithfully as possible. Thanks to digital twins, predicting the functioning of a system and finding new ways of operation become possible. Digital twins are the focus of research being carried out at several laboratories at Université Paris-Saclay, including the Mechanics Laboratory Paris-Saclay (LMPS – Univ. Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS).

A loop of information exchange

To develop this hyper-realistic modelling, scientists use physical models, such as those of continuum mechanics, which they enrich with data from real life provided by sensors placed at the level of the system. However, a digital twin is not simply a virtual and static copy of a system. The model evolves according to the information collected. These include Dynamic Data Driven Applications Systems or DDDAS. In this case, the real system and the digital twin continuously and actively communicate with each other. "*The physical system sends experimental data to the digital twin via the sensors. This allows the model to be recalibrated if the real system changes or deviates from its assumed functioning,"* explains Ludovic Chamoin, who leads the STAN team at LMPS and who is familiar with this feedback loop. "*The digital twin becomes able to predict what will happen before it happens. This facilitates decision making and avoids entering a critical area of system operation.*"

The challenge is to get the most suitable model possible. "*If the model is too complicated, it'll be difficult to run the simulation and make predictions in a reasonable time. On the other hand, if it's too simple, we'll understand nothing of the phenomenon studied.*"

Anticipating the behaviour to damage

Ludovic Chamoin and his colleagues at LMPS are interested in the behaviour of mechanical structures made of concrete or composite materials which are subjected to damage processes. Together with the Mechanical and Thermal Research Department (SEMT – Univ. Paris-Saclay, CEA), his team has recently applied a dynamic model updating strategy during seismic testing on a shaking table. "*As the building model was damaged during the test, its properties changed. The control law, which was based on a sound structure, gradually lost its effectiveness and this compromised the way the vibration table was controlled, leading to the risk of instability.*" Thanks to accelerometers placed on the structure, measurements were added to the model in order to modify the control law on the go and to take into account the evolution of the structure. "*The idea is to not stop testing but instead to assess the damage to the structure continuously and in real time.*"

The DREAM-ON project, which won an ERC Consolidator Grant in 2021, aims to go even further and look at smart, connected mechanical structures which can monitor their health and adapt autonomously during use. In this case, an array of distortion-sensitive optical fibres is embedded in the material. "*This 'on-board' aspect makes it possible to have real time access to what's happening in the structure with a very high spatial resolution,*" says Ludovic Chamoin.

Ultimately, DREAM-ON plans to provide a proof of concept in the form of an experiment where the integrity of a real structure under controlled loading is preserved. One of the difficulties lies in the processing of the signal as the model must be recalibrated in real time. "*We'd like to achieve a prediction in the region of one second.*" To achieve this, the team is relying on artificial intelligence (AI). "*We start with a fairly simple law of behaviour which is representative of what is happening, and the AI adds what we don't know and cannot model analytically. This is learnt through machine learning, combining knowledge from engineering and materials science, thermodynamics and the laws of fundamental physics.*"

The applications are mainly in the field of wind turbines. "*All those structures which can get damaged randomly,*" sums up Ludovic Chamoin. "*We want to know when to act, and not to do it too soon because we want to put this type of structure out of action as little as possible.*"

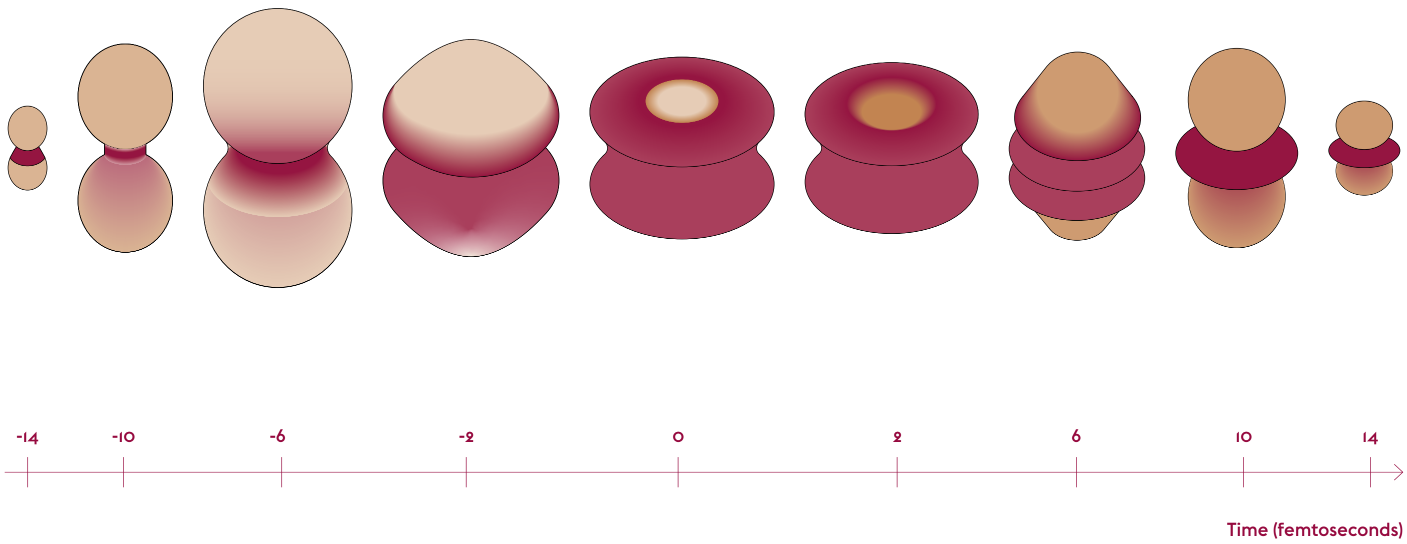
Publication • Guzman E. A. R., Lacroix D. Accessing ground-state and excited-state energies in a many-body system after symmetry restoration using quantum computers. *Phys. Rev.* C 105, 024324, (2022).

Keywords
Ultrafast, attosecond science – Lasers

Title

Attosecond science to define the infinitely short

ATTOSECOND FILM OF THE PHOTOELECTRIC EFFECT



Evolution of the atomic orbitals of helium during its ionisation

How does matter behave on an infinitely small time scale? Is it possible to observe or even control the interactions of its constituents at this scale? What might the possible applications be? Every day, researchers specialising in ultrafast science working in several of the laboratories at Université Paris-Saclay are trying to find the answers to these questions.

A billionth of a billionth of a second. The attosecond (10^{-18} second) is the smallest currently measurable unit of time. Even light is slow at this scale: it 'only' travels 0.3 nanometres (0.3 nm or 0,3.10^{-9} m) per attosecond. The Attophysics research group at the Interactions, Dynamics and Lasers Laboratory (LIDYL – Univ. Paris-Saclay, CEA, CNRS) is aiming to study matter on the femtosecond (10^{-15} second) and attosecond time scale. "*The increasingly short processes we're interested in in matter belong to smaller and smaller time scales,*" explains Pascal Salières, who leads the group. "*Typically, the rotation of molecules takes place in a few picoseconds (10^{-12} seconds). The vibration of molecules, and the movement of atoms inside molecules – all this takes place on a smaller scale: in femtoseconds.*" It was the observation of atom dynamics on the femtosecond scale during a chemical reaction which earned the Egyptian American chemist, Ahmed Zewail the Nobel Prize for Chemistry in 1999.

Beyond the atomic scale lies the challenge of the electron, one of the constituents of the atom. How can we detect electron dynamics, knowing that they are even faster than atom movements? "*For the electron, the typical time scale given is 150 attoseconds. This figure corresponds to the rotation time of an electron on the first Bohr orbit of a hydrogen atom,*" explains Pascal Salières. Observing electron movements would lead to a detailed study of fundamental processes, including the transport of information and the transformations of matter, which have electrons for privileged vectors (via the transfers of charge, energy, etc.). After this analytical stage, the manipulation of these processes would follow. "*Once all this behaviour has been understood on the electronic scale, it will be possible to try to direct it, to optimize it, to accelerate it, etc.*" adds the researcher.

The problem with attosecond radiation sources

Which process makes it possible to see ultrafast interactions? Just as in photography, it is crucial to be able to 'capture' images to within a few attoseconds or femtoseconds. This requires the use of ultra-short pulses of light generated by a laser. However, a key issue has persisted for a long time: lasers are fundamentally incapable of forming attosecond pulses. "*This is because the optical cycle time is being approached. Radiation shorter than a few femtoseconds cannot be produced while remaining at a wavelength in the visible range or in the near-UV wavelength,*" explains Pascal Salières.

In 1988, researchers at the Department of Atomic and Surface Physics (now LIDYL) discovered the generation of high-order harmonics – the key to attosecond pulses. In electromagnetics, the smaller the wavelength of a signal, the greater its frequency (the number of signal oscillations per second). By generating waves in the extreme ultraviolet (XUV) range, it is possible to obtain very fast oscillating pulses with greatly reduced pulse duration. The current record is around 50 attoseconds. "*It's done by focusing a very intense laser. It passes through a jet of gas, where it interacts with atoms. It then* *tears off a tiny fraction of the electron cloud and accelerates its electrons,"* continues Pascal Salières. "*However, as the laser field reverses every optical half-period, the electrons are drawn back to the nuclei at this point. However, they've accumulated a lot of kinetic energy when they come into contact with the laser, which they release in the form of a flash of radiation in the XUV range.*" So, by playing with the 'elasticity' of the bond between the electrons and their nucleus, scientists can create an attosecond XUV flash at each half-period of the laser. This is the goal of the ATTOLab, created in 2016 and managed by LIDYL, which provides attosecond radiation sources to users throughout Europe.

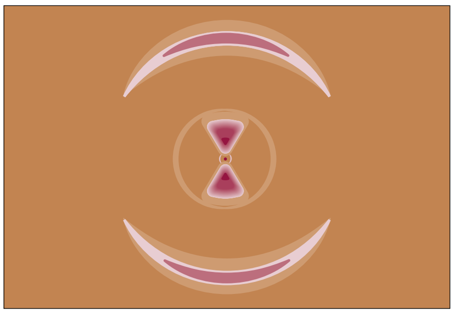
Two pulses are better than one

The 'photograph' of an event on an attosecond scale is actually done using two pulses. Today, this is the basis of the 'pump-probe' method used to observe such processes. "*The 'pump', or first pulse, excites an atom and as a result one of the electrons moves to the conduction band in the higher electronic layers,*" explains Marino Marsi, an associate professor at the Solid State Physics Laboratory (LPS – Univ. Paris-Saclay, CNRS). "*The electron then 'descends' through the electronic layers, through a natural process of de-excitation. It's by using a second laser pulse (the 'probe'), that the dynamics of this phenomenon are observed. This allows us to study nature in an excited quantum state – to look at matter in a nonequilibrium state.*" By modulating the distance between the two laser pulses, and by repeating the experiment many times (under strictly identical conditions), scientists are able to reconstruct, image by image, the excitation and de-excitation processes of matter by the attosecond.

However, what about the 'recording' in addition to this 'snapshot'? The most effective spectrometer capture system is Velocity Map Imaging (VMI). Unlike other detection techniques, such as the magnetic bottle electron spectrometer, angular resolution is maintained here. Using a VMI spectrometer, it is possible to project the electrons and reconstruct their direction of ejection and their energy.

At LIDYL, thanks to the pump-probe method, researchers in the Attophysics team have studied resonant two-photon ionisation using excited states of helium. "*These measurements are very interesting because they give us access, in a very precise way, to the potential of movement of the electron and to all the electron-electron, electron-nucleus or crystal lattices interactions. Understanding those interactions is fundamental to the study of chemical bonding,*" explains Pascal Salières. The researcher is full of hope and is exploring the possibilities offered by this new physics. "*This type of experiment will then be extended to systems more complex than helium, such as molecules, nanoparticles, solids, etc., in order to study the electronic correlations.*" Indeed, only theoretical approximations are currently capable of handling these complex systems. With new experiments such as these, physicists will be able to challenge and validate, or not, established theoretical approximations. "*It'll be possible to measure the diffusion times of electrons, and the decoherence effects due to their interactions with the environment. This is essential for defining the electrical properties of materials and their ability to carry information.*"

Observing the emission of an electron 'with the naked eye'



"*More and more applications are emerging now that we're able to produce well-controlled attosecond radiation sources,*" reveals Pascal Salières. Within his LIDYL team, attosecond physics is used, for example, to observe the phenomenon of the photoelectric effect as it has never been seen before. During the 19th century, Heinrich Hertz was the first to define the photoelectric effect. In 1921, Albert Einstein received the Nobel Prize in Physics for his photoelectric effect theory, where the absorption of an energy particle (a photon) by an atom results in the almost instantaneous emission of an electron. It is this 'almost instantaneous' aspect that tormented the LIDYL researchers. What was happening between the absorption of the photon by the atom and the emission of the electron?

Using attosecond pulses and the pump-probe technique, scientists finally succeeded in reconstructing the dynamics of electron emission during these phenomena. In March 2022, the physicists at LIDYL, together with colleagues from the Institute of Molecular Sciences, Orsay (ISMO – Univ. Paris-Saclay, CNRS), the Institute for Light and Matter (ILM – Univ. Claude Bernard, CNRS) and the Laboratory of Physical Chemistry - Matter and Radiation (LCPMR – Sorbonne Univ., CNRS) published the first ever three-dimensional film which followed the photoemission process at the atomic level and on the attosecond scale. For the first time, the photoelectric effect, which had been just theory for over 100 years, could be observed attosecond by attosecond. In doing so, they also solved the quantum process of two-photon photoemission from helium. This is an important result. As photoemission is the basis for some of the finest spectroscopic analysis methods, this work paves the way for a deeper understanding of electronic correlation effects in matter – from atoms and molecules to solids.

Lou Barreau, a lecturer at ISMO, is also interested in the photoelectric effect. "*Thanks to attosecond science, we discovered that photoemission is not instantaneous, but that it's also variable depending on the type studied, the energy sent and the environment of the atom,*" explains the chemist, who above all wants to link these studies to chemical phenomena. As part of the Dynamics and Interactions: Radiation, Atoms, Molecules (DIRAM) team at ISMO, she is studying the photoemission process in different molecules. "*I analyse photoemission in rare gases and also monitor the dynamics (dissociation, or isomerization) within a molecule using the pump-probe method. In this way, I can observe the dynamic couplings of electrons.*" The molecules being studied are iodine compounds (diiodine I_2, iodine monochloride ICl or iodine monobromide IBr) used in the gas phase for practical reasons, as, unlike the condensed phases (liquid or solid), gas phase molecules are isolated and do not interact with solvents, which allows access to their intrinsic dynamics. "*However, observation of attosecond events in solution is being developed. This will be of huge interest! This is something which the attosecond community is moving towards,*" explains Lou Barreau.

Researchers at LIDYL, in partnership with ISMO, are also taking a closer look at electron ejections and what these processes entail. "*A hole is made in the electron cloud of a molecule which can then migrate from one edge of the molecule to the other,*" explains Pascal Salières. "*Depending on where this hole is located, the bonds in the molecule become weakened, causing the molecule to fragment. By controlling where this hole is located, it would become possible to direct molecular fragmentation and control chemical reactivity. The applications which would follow, such as the creation of new products which couldn't be designed naturally, would be endless.*"

Physics with infinite applications

At the LPS, Marino Marsi is focusing on quantum matter and topological materials. These have characteristics which are as rare as they are intriguing. A topological material is electrically conductive on its surface but insulating in its interior. "*The electrons in these materials have special properties. They are particularly insensitive to disturbances, as they are in 'protected' states. These are the same properties which make these materials ideal conductors,*" continues the professor. Using ultrafast laser pulses, he studies the electronic dynamics of different quantum materials (graphene, bismuth selenium Bi_2Se_3 alloy, bismuth and tellurium Bi_2Te_3 alloy, etc.).

The LASERIX platform, which is housed at the Irène-Joliot Curie – Physics of Two Infinities Laboratory (IJCLab – Univ. Paris-Saclay, Univ. Paris Cité, CNRS), is dedicated to the development of coherent XUV sources produced by intense lasers and their applications. It provides Sophie Kazamias, the scientific manager of the platform, and various teams, with the possibility of studying several types of physics. Among the projects covered here, PALLAS is aiming to develop a plasma laser accelerator. "*This involves transforming a gas into a plasma and then exciting it in order to create an electric field which will then accelerate the electrons,*" explains Sophie Kazamias and Moana Pittman, the technical manager of LASERIX. "*This type of acceleration is 1,000 times more powerful than current particle acceleration technologies. However, it's still very difficult to control,*" point out the scientists.

Of equal interest is the DeLLight experiment (which stands for Deflection of light by light) which explores the vacuum and its as yet unknown properties using an ultra-intense pulse laser. The researchers involved are hoping to show that, like any existing optical medium, the vacuum is a nonlinear optical medium. This means that the application of a very high intensity electromagnetic field in a vacuum would be able to change its optical index.

If the attosecond currently represents an 'ultimate barrier', it will probably be crossed one day. The zeptosecond (10^{-21} second) is already being discussed among specialists. "*When I started my research, the picosecond was THE ultimate barrier!*" remembers Marino Marsi. It is therefore easy to imagine the new barriers which remain to be crossed and what future discoveries are still subsequently waiting to be made.

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• C. Alexandridi *et al.*, Attosecond photoionization dynamics in the vicinity of the Cooper minima in argon, *Physical review research* 3, L012012, 2021.

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• S. Robertson *et al.*, Experiment to observe an optically induced change of the vacuum index. *Physical Review* A 103.2 (2021): 023524.

• A. de las Heras *et al.* Extreme-ultraviolet vector-vortex beams from high harmonic generation. *Optica* 9.1 (2022): 71-79.

Journal

franceinfo:

Title

CLASSEMENT DE SHANGHAI : « CETTE 16E PLACE CONFIRME LA STATURE INTERNATIONALE » DE L'UNIVERSITÉ PARIS-SACLAY, ESTIME SA PRÉSIDENTE

Si l'université française perd trois places par rapport au classement 2021, elle reste dans le top 20.

« *Cette 16e place confirme la stature internationale* » de l'université Paris-Saclay, a réagi lundi 15 août sur franceinfo sa présidente, Estelle Iacona, après la publication du classement de Shanghai dans lequel quatre établissements français se maintiennent dans le top 100. Premier établissement non-anglo-saxon avec sa 16e place, l'université Paris-Saclay a toutefois perdu trois places par rapport au classement 2021. « *On n'a jamais eu autant d'entreprises qui sont venues discuter et collaborer avec l'université Paris-Saclay depuis que nous sommes classés dans le top 20 de Shanghai* », a souligné Estelle Iacona.

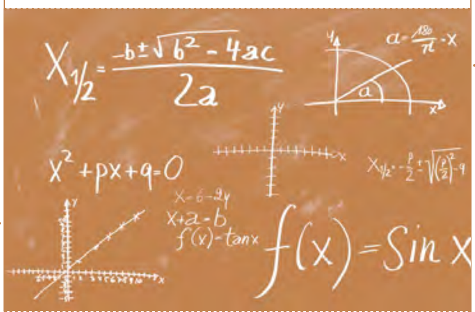
https://www.francetvinfo.fr/societe/education/classement-de-shanghai-cette-16e-place-confirme-la-stature-internationale-de-l-universite-paris-saclay-estime-sa-presidente_5309809.html

Journal

Research Professional News

Titre

SACLAY LEADS SHANGHAI MATHS RANKING



More French institutions enter subject-specific rankings, to research minister's delight Paris-Saclay University has retained the top spot in the Shanghai Ranking's Global Ranking of Academic Subjects (GRAS) for mathematics, marking its third consecutive year at the top of the table.

https://www.researchprofessionalnews.com/rr-news-europe-france-2022-7-saclay-leads-shanghai-maths-ranking/

Journal

THE WORLD UNIVERSITY RANKINGS

Titre

PARIS-SACLAY PRESIDENT AIMS FOR GLOBAL PROFILE

After predecessor exits to become higher education minister, Estelle Iacona is tasked with completing integration of ambitious, elite amalgam.

Making sure France's ambitious mega-university has a truly global profile, and that it bridges the internal divide long thought to weaken the nation's system, are among the aims of its new president, after her predecessor became higher education minister under Emmanuel Macron.

https://www.timeshighereducation.com/news/paris-saclay-president-aims-global-profile

Journal

ThePrint

Title

STUDY: SHIFT WORKERS CAN'T ALL ADJUST TO NIGHT SHIFT

Scientists have challenged the widespread belief that shift workers adjust to the night shift, using data drawn from wearable tech.

By monitoring groups of French hospital workers working day or night shifts during their working and free time, the researchers have not only shown that night work significantly disrupts both their sleep quality and their circadian rhythms, but also that workers can experience such disruption even after years of night shift work.

https://theprint.in/health/study-shift-workers-cant-all-adjust-to-night-shift/1049763/

Journal

Medscape

Titre

FOR CANCER PREVENTION, NOT ALL PLANT-BASED DIETS ARE EQUAL

Following a diet rich in healthy plant-based products may lower one's risk of breast cancer, but not if that diet happens to be high in unhealthy foods, researchers have found.

The study of more than 65,000 people showed that plant-based diets that were high in whole grains, fruits, and vegetables appear to be more protective against breast cancer than diets rich in processed plant-based products, such as juice and chips.

https://www.medscape.com/viewarticle/975552?src=mkm_ret_220630_mscpmrk_BC_top10&uac=50597MX&impID=4380143

Journal

TECH TIMES

Titre

MULTICOLORED MARS: RESEARCHERS USE MACHINE LEARNING TO MAP SOURCE OF ANCIENT MARTIAN METEORITES

Mars was struck by an asteroid between five and ten million years ago. It produced a huge crater and launched a fresh meteorite made of ancient Martian crust into space, which finally plummeted into Africa.

Thanks to a supercomputer-powered technique that enabled scientists to study the geology of planets without leaving the planet, the meteorite source was located.

https://www.techtimes.com/articles/279268/20220817/multicolored-mars-researchers-use-machine-learning-map-source-ancient-martian-meteorites.htm

Keywords

Agro Paris-Saclay Campus – Henri Moissan Site – PASS course at Kremlin-Bicêtre

Title

First academic year on the Agro Paris-Saclay campus

This new campus on the Saclay plateau is home to AgroParisTech's life and environmental sciences students and its administrative, technical and research staff.

After the premises had been delivered in the spring, followed by a gradual move of staff, services and laboratories during the summer, the Agro Paris-Saclay campus is now welcoming its students. "*Our arrival on the Saclay plateau opens a new page in the history of our institution. This new academic year is a time of reunion between our different classes, the school's disciplines, but also teaching, research and innovation. This new location provides exceptional collaboration opportunities with the whole range of stakeholders on the plateau, on various topics,*" comments Laurent Buisson, AgroParisTech's General Director.

Located in the Corbeville district in Palaiseau (Essonne), at the heart of the Université Paris-Saclay ecosystem, the campus brings together on a 4.2 hectare site the AgroParisTech/INRAE research teams and its student community previously located on four sites in Île-de-France (Paris 5th and 15th districts, Thiverval-Grignon and Massy). Designed by architects Marc Mimram and Jean-Baptiste Lacoudre/Patriarche in association with the TER landscape agency, it comprises a group of eight buildings – all HEQ certified – with a total surface area of 66,000 m^2 and set around a tree-lined park of almost two hectares. Training, research and administration are equally divided among the facilities.

"*The building dedicated to practical work and experimental projects is the result of ten years of work,*" comments the lecturer Marie-Noëlle Maillard, from the Food and Bioproducts Sciences and Processes Department, and the SayFood laboratory. "*The premises had to meet educational challenges, in order to offer courses that put the experimental approach at the heart of the curriculum, which is essential for our future engineering and master's graduates. We had two imperatives: an organisation by thematic zones with facilities and equipments that were specific to each discipline, and the need to facilitate the development of cross-disciplinary teaching, with a relative porosity between the zones. The result is as good as we expected.*"

As for the students, although some of them underline the aerial and artificial aspect of the premises, or their size and modernity, they all express the desire to make them their own.

© AgroParisTech-Christophe Dao

© AgroParisTech-Bastien Croutsdepaille

© AgroParisTech-Bastien Croutsdepaille

© AgroParisTech-Bastien Croutsdepaille

Title

The Henri Moissan site opens its doors!

© Yves Chanoit

The second site of the Biology – Pharmacy – Chemistry centre (BPC) of Université Paris-Saclay, which covers 74,000 m^2, incorporates six buildings in the heart of the Moulon area in Gif-sur-Yvette (Essonne) and is located in front of the future Orsay-Gif station of the Grand Paris Express metro line 18, now houses the Faculty of Pharmacy, the Orsay Institute of Molecular Chemistry and Materials (ICMMO) and Université Paris-Saclay Master's courses in Chemistry and Biology. This involves about 3,300 students and 1,000 members of staff.

This multidisciplinary site aims to act as a link between teaching and research, to encourage the mixing of students, to strengthen the cohesion of the institution's departments and to improve working conditions for all.

The heart of the site is also a reception area and a meeting place for all types of visitors, including staff, students, and visitors who have come for a particular event. It will help to revitalise the area.

Title

A PASS on the doorstep of Paris(-Saclay)

At the start of the 2022/2023 academic year, the Faculty of Medicine at Paris-Saclay welcomed for the first time students in their first year of health training. About a hundred of the 500 students enrolled in the Specialist Health Course (PASS) joined the Faculty's campus located at Kremlin-Bicêtre (Val-de-Marne). The other 400 will are attending the Orsay Faculty of Science campus (Essonne). As with all health courses, the PASS course prepares students for the entrance examinations for medicine, midwifery, dentistry, pharmacy and physiotherapy studies.

This new arrangement is linked to the relocation of the Faculty of Pharmacy to the Plateau de Moulon campus in Gif-sur-Yvette and is coinciding with the completion of the new medical school building. Université Paris-Saclay is continuing to put down its roots in the area by creating a teaching site for the PASS course near Paris.

WE WERE THERE

JUNE

Date	Location	Host
2	ENS Saclay	GS Research and Higher Education Univ. Paris-Saclay

Title

MULTIDISCIPLINARY JUNIOR CONGRESS

Description

The Graduate School (GS) Research and Higher Education organized the first edition of its multidisciplinary Junior Congress. On the program, a series of presentations, posters and more than ten awarded projects!

https://www.universite-paris-saclay.fr/gs-mres-congres-junior

DON'T MISS

SEPTEMBER

Date	Location	Host
15	University sports complex of Moulon	SUAPS Univ. Paris-Saclay

Title

DÉFI 2024 KM

Description

To celebrate the arrival of the Olympic and Paralympic Games in Paris in 2024, the University Service of Physical and Sports Activities (SUAPS) of Université Paris-Saclay is organizing a great day of sports in the brand new university sports complex of Moulon!

https://www.universite-paris-saclay.fr/evenements/defi-2024-km

Date	Location	Host
from 15	all UVSQ campuses	UVSQ

Title

THE UVSQ'S CLIMATE WEEK

Description

From September 15, UVSQ will organize on all its campuses fun "Climate Fresco" workshops aimed at learning and exchanging around the issues of ecological transition and sustainable development.

https://www.uvsq.fr/luvsq-organise-ses-rentrees-climat-1

Date	Location	Host
19	Centrale-Supélec Bouygues building	AllCan

Title

ALLCAN RESEARCH SEMINAR

Description

AllCan, the interdisciplinary initiative bringing together research laboratories of Université Paris-Saclay around the objectives of sustainable development, is organizing its first research seminar. It's open to all publics!

https://www.universite-paris-saclay.fr/evenements/seminaire-de-recherche-allcan

Date	Location	Host
21	Garden of the Évry University library	Univ. d'Évry

Title

FAIR OF STUDENT ASSOCIATIONS

Description

To celebrate the beginning of the academic year 2022, the student associations of Université d'Évry are organizing a big fair with dozens of stands to present their numerous projects and activities.

https://www.univ-evry.fr/evenements/agenda-des-evenements-vie-etudiante/rentree-2022/kermesse-des-associations-etudiantes.html

OCTOBER

Date	Location	Host
2 to 7	Aussois	LPS

Title

XFEL SCHOOL FOR CONDENSED MATTER, PHYSICS UNDER EXTREME CONDITIONS AND DENSE PLASMAS

Description

The Solid State Physics Laboratory (LPS – Univ. Paris-Saclay, CNRS) is taking part in the organization of a school in Savoie dedicated to free electron lasers emitting in the X-ray regime (XFEL), for the study of condensed matter.

https://xfelshool2022.sciencesconf.org/

Date	Location	Host
3 to 5	MAPS	CPAM – Univ. Paris-Saclay

Title

WEBINAR "ACCESS TO HEALTH RIGHTS – EVERYTHING YOU NEED TO KNOW"

Description

The University Health Service (SSU) is launching its awareness campaign on access to health rights and care. This campaign aims at informing and accompanying students on administrative procedures. It includes a webinar and an escape game.

https://www.universite-paris-saclay.fr/evenements/acces-au-droit-la-sante-tout-savoir

Date	Location	Host
6	Télécom Paris	LabEx Digicosme

Title

JWOC 2022, THE JUNIOR CONFERENCE ON WIRELESS AND OPTICAL COMMUNICATIONS

Description

LabEx DigiCosme is organising the 4th edition of the Junior Conference on Wireless and Optical Communications (JWOC). This conference gives students the opportunity to present the results of their research work in the field of optical and wireless communications.

https://digicosme.cnrs.fr/jwoc-2022-la-conference-junior-sur-les-communications-sans-fil-et-optiques/

Date	Location	Host
13	Online	Univ. Paris-Saclay

Title

VIRTUAL FORUM ON STUDENT MOBILITY 2022

Description

For its third edition, the virtual forum of student mobility aims to allow those curious about international experiences to learn more about it, to listen to testimonies of students who have already gone abroad, and to promote their own experiences.

https://forum-mobilite-etudiante-upsaclay2022.fr/fr universite PARIS-SACLAY

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READING HIGHLIGHTS
THE CONVERSATION

'Narcissistic Perverts': why does this term give the impression that they are everywhere?

Marc Joly, sociologist at the Professions, Institutions, Temporalities laboratory (PRINTEMPS – Univ. Paris-Saclay, UVSQ, CNRS) reports on a sociological investigation into the use and dissemination of the term 'narcissistic pervert' and looks back at the genealogy of this clinical psychopathology concept.

https://theconversation.com/pervers-narcissiques-pourquoi-ce-terme-donne-limpression-quils-sont-partout-184961 (in French)

What is to be learned from the Curiosity mission after ten years on Mars

Cyril Szopa, professor and exobiologist at the Laboratory of Atmospheres, Modelling and Space Observations (LATMOS – Univ. Paris-Saclay, UVSQ, CNRS, Sorbonne Univ.), and collaborators from the CNES (French National Centre for Space Studies), on the occasion of the tenth anniversary of the landing of the Curiosity spacecraft on Mars, draw up a technical and scientific assessment of the mission and discuss the discoveries made by the on-board instruments.

https://theconversation.com/ce-quil-faut-retenir-de-la-mission-curiosity-apres-dix-annees-sur-mars-188034 (in French)

INTERDISCIPLINARY INITIATIVES AT UNIVERSITÉ PARIS-SACLAY (2/3)

Hub PASREL

'Paris-Saclay research & hospital education' aims to develop the relationship between the 'technology for health' community and hospitals in Paris-Saclay. It focuses on technologies for medical research, including the combination of imaging and artificial intelligence, and technologies for organisational innovation in health. It is committed to the '4Ps' in medicine (predictive, preventive, personalised and participative) and is intended to be a model for the 'hospital of the future'.

The GS involved: Computer Sciences; Economics & Management; Engineering and Systems Sciences; Health and Drug Sciences; Life Sciences and Health; Sociology and Political Science.

Metabiodivex

The aim of Metabiodivex is to explore and develop natural resources for health, agriculture, food and the environment. It involves research on natural substances and their applications and in particular on the specialised metabolites of living organisms (plants, animals, microorganisms) in relation to the environment, agrosciences and health.

The GS involved: Biosphera; Chemistry; Computer Sciences; Health and Drug Sciences; Life Sciences and Health.

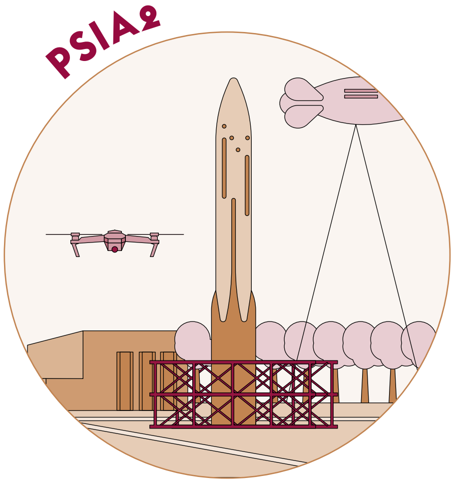
MICROBES

The aim of MICROBES is to become the University's interdisciplinary centre for microbial sciences. It operates at the interface between biology, ecology, chemistry, medicine, pharmacology, physics, applied mathematics, computer science and engineering. It seeks to improve the fundamental understanding of microbial organisms and to relate it to health, the environment, climate, energy, biodiversity, agriculture, food and industrial renewal.

The GS involved: Biosphera; Chemistry; Computer Sciences; Engineering and Systems Sciences; Health and Drug Sciences; Life Sciences and Health; Physics.

The aim of Interdisciplinary Initiatives is to be able to carry out research, training and innovation activities across several of the University's Graduate Schools (GS).

PSIA2



'Paris-Saclay Institute of Aeronautics and Astronautics' brings together and raises the profile of scientific activities relating to aerospace and its impacts. Its key areas of focus are structured around the modelling of aeronautical and space engine systems, their design, properties and flight mechanics. Areas also include the development of innovative modes of propulsion with lower environmental and climate footprints.

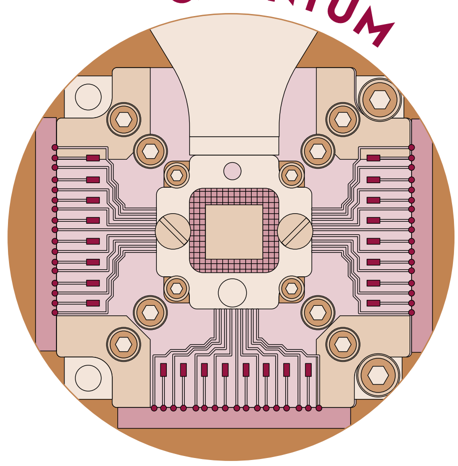
The GS involved: Chemistry; Computer Sciences; Economics & Management; Engineering and Systems Sciences; Geosciences, Climate, Environment, Planets; Law; Mathematics; Physics; Research and Higher Education.

PSiNano

PsiNano is involved in the field of nanoscience. The main areas are nanophotonics and spin nanoelectronics for the emergence of quantum technologies, nanochemistry and nanomaterials for optoelectronics, nanomedicines and nanosystems for the diagnosis of severe diseases, and nano-objects for energy control and recovery.

The GS involved: Chemistry; Health and Drug Sciences; Institute for the Sciences of Light; Physics.

QUANTUM



QUANTUM covers the very broad field of quantum science and technology. It is investigating many platforms for the development of quantum functionalities, ranging from massless and non-interacting particles such as photons, single isolated or interacting atoms, to electronic mesoscopic systems based on semiconductors or superconductors.

The GS involved: Chemistry; Computer Sciences; Engineering and System Sciences; Institute for the Sciences of Light; Mathematics; Physics.