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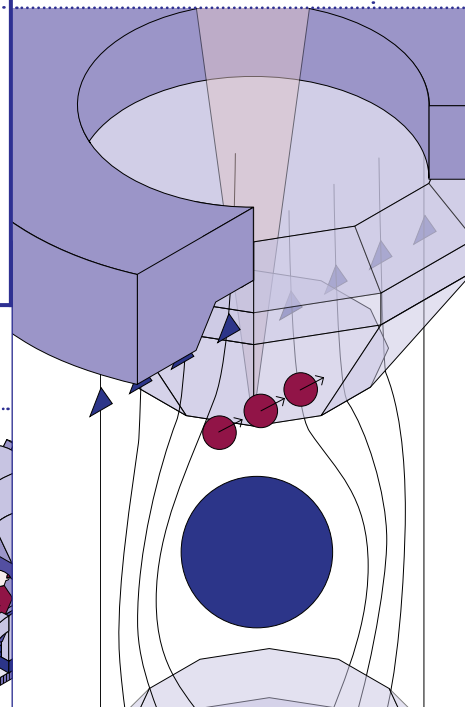
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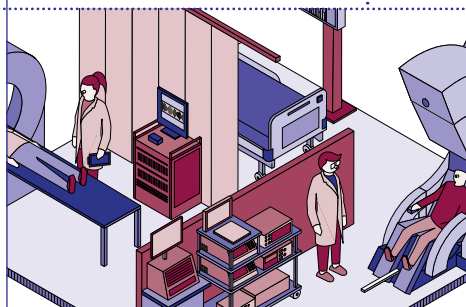
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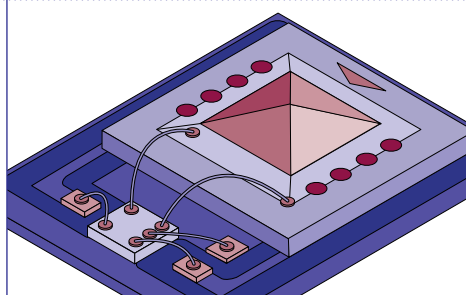
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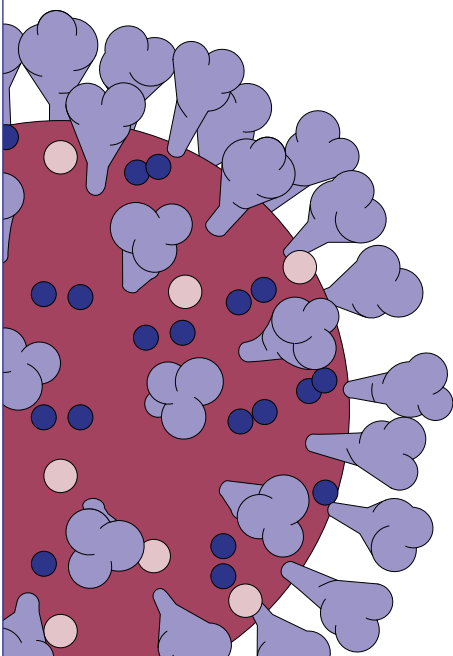
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Title

CAMPUS LIFE IN THE COVID ERA

université PARIS-SACLAY

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RESEARCHERS

The French University Institute (Institut Universitaire de France – IUF) has appointed four professors from Université Paris-Saclay as **junior members** and two professors as **senior members**:

Sylvain Arlot from the Orsay Mathematics Laboratory (LMO – UPSaclay, CNRS) was appointed as junior member. His field of research is at the junction between mathematical statistics and machine learning.

Sylvain Bouley from Paris-Saclay's Geosciences laboratory (GEOPS – UPSaclay, CNRS) was appointed as junior member. He specialises in Mars and impact craters.

Nicolas Delpierre from the Ecology, Systematics and Evolution laboratory (ESE – UPSaclay, CNRS, AgroParisTech) was appointed as junior member. His research focuses on the environmental and biological determinants of the processes for the acquisition and use of resources by trees in forests, such as carbon, water and nutrients.

Quentin Mérigot from the Orsay Mathematics Laboratory (LMO – UPSaclay, CNRS) was appointed as junior member. His research focuses on optimal transport and its applications, reverse problems, discretization of partial differential equations and geometric methods for data analysis.

Elisabeth Gassiat from Orsay Mathematics Laboratory (LMO – UPSaclay, CNRS) was appointed as senior member. She specialises in statistics and information theory.

Yannis Manoussakis from the Computer Science Research Laboratory (LRI – UPSaclay, CNRS) was appointed as senior member. His research focuses on discrete mathematics and the foundations of computer science.

Nicolas Elie, specialist in chemical analysis techniques at the Institute of Natural Products Chemistry (ICSN – UPSaclay, CNRS), and **Farah Savina**, specialist in chemical synthesis at the Orsay Institute of Molecular Sciences (ISMO – UPSaclay, CNRS), received the **2020 CNRS Crystal Medal**.

Christophe Laux from the Macroscopic and Molecular Energy, and Combustion Laboratory, (EM₂C – UPSaclay, CNRS, CentraleSupélec) received the **2020 Fellowship Award from the American Institute of Aeronautics and Astronautics (AIAA)**.



© F.Rhodes – CEA

Valérie Masson-Delmotte from the Laboratory for Sciences of Climate and Environment (LSCE – UPSaclay, CNRS, CEA, UVSQ) was awarded the **2020 Milutin Milankovich Medal** for her contribution to long-term climate change research and for leadership in international efforts to translate science to society.

Anaëlle Maury from the Department of Astrophysics – Irfu (DAP – UPSaclay, CEA) won the **2020 Young Researcher Award from the French Society of Astronomy and Astrophysics (SF2A)** for her scientific work and service to the astronomical community.



© CNRS

Yves Meyer, mathematics professor emeritus at ENS Paris-Saclay and researcher at the Borelli Centre (CGB – UPSaclay, CNRS, ENS Paris-Saclay), was awarded the **2020 Princess of Asturias Foundation award for scientific and technical research** for his important advances in mathematical wavelet theory.

STUDENTS

Olga Bragoi, Lamine Dia, Yanis Djouder, Adrien Laoufi, Abraham Le Guen Yeganeh-Cary and **Clara Martin**, students at the Université Paris-Saclay's Faculty of Law, Economics and Management and members of the "Révolte-toi Jean Monnet" (Rise up Jean Monnet) debate club, won the **2020 final of the French debate championships**

Yoann Launay, student engineer at Centrale-Supélec, won the prize for the **best communication in poster form** at the international online conference *Quantum Crystallography Online Meeting 2020*.



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Léa Bonnefoy, PhD student at the Atmospheres, Environments, Space Observations Laboratory (LATMOS – UPSaclay, UVSQ, CNRS, Sorbonne Université), **Charlotte Canet-Jourdan**, PhD student at the Tumour Cell Dynamics Laboratory (TCD – UPSaclay, Inserm, Institut Gustave Roussy), **Élodie Hinnekens**, PhD student at the Complexity, Innovation, Motor and Sports Activities Laboratory (CIAMS – UPSaclay), and **Solène Marie**, PhD student at the Paris-Saclay Multimodal Biomedical Imaging Laboratory (BIOMAPS – UPSaclay, CEA, CNRS, Inserm) are winners of the **2020 France L'Oréal-UNESCO Young Talent Award for Women in Science**.

COMPANIES/ PROJECTS

DAMAE MEDICAL

DAMAE Medical, linked to the Charles Fabry Laboratory (LCF – UPSaclay, IOGS, CNRS), **won the call for projects by the Health Data Hub** co-organised with the "AI and Health" challenge and supported by Bpifrance. They propose new technology for diagnosing skin cancer using optical imaging.



Eight **winners of the 2020 I-Lab National Innovation Competition**, including a Grand Prix, are from Université Paris-Saclay laboratories or led by alumni of the University:

CERES BRAIN Therapeutics, led by Thomas Joudinaud, is a spin-off of CEA that develops patents from the Pharmacology and Immunology Unit (SPI – UPSaclay, INRAE, CEA) and the Molecular Labelling and Bioorganic Chemistry Unit (SCBM – UPSaclay, CEA). They are developing a nasal drug to treat genetic autism in children.

ELPIS, led by Philippe Chambon, promotes patented technology and work initiated in the Neuromuscular Disability: Pathophysiology, Biotherapy and Applied Pharmacology research unit (END-ICAP – UPSaclay, UVSQ, Inserm) and AP-HP. They aim to develop gene therapy to treat urinary disorders.

FinX, led by Harold Guillemin, former student of CentraleSupélec, is developing the first electric boat motor with a fin.

IMESCIA, led by Tanguy Boissenot and organised by the Paris-Saclay Galien Institute (IGPS – UPSaclay, CNRS), aims to develop high-activity anti-cancer drugs with subcutaneous application.

InBolt, led by Rudy Cohen, a former ENS Paris-Saclay student, aims to improve the traceability and reliability of manual processes in the industrial sector.

I-Ris, led by Sami Kraiem from the VEDECOM Institute, of which UVSQ is a founding member, aims to understand the mobility of people to optimise transport services.

Mangrove, led by Emeric Lemaire, former ENS Paris-Saclay student, runs a decentralised platform for the use of health data.

PROQUIRE, led by Georges Reymond and organised by the Charles Fabry Laboratory (LCF – UPSaclay, IOGS, CNRS), is developing a quantum processor with Rydberg atoms to scale. **Grand Prix**.

EDITOR'S LETTER



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On the 15th of August, Université Paris-Saclay ranked French research in the top 15 worldwide. Our university was ranked 14th in ARWU's Shanghai ranking. We are immensely proud of this recognition, but we are also aware of the important responsibility it implies.

Firstly, responsibility to our students who are suffering from the restrictions we are obliged to impose on them in our faculties, our University Institutes of Technology (IUT) and schools, making their studies and lifestyle less carefree than before. But their health – and the health of their loved ones – is at stake.

Also, responsibility to our academic staff who have a two-fold challenge. They must pursue their usual activity with excellent standards while dealing with conditions imposed by the French and global pandemic: organising hybrid educational programmes, reinventing international mobility, developing knowledge and supporting decisions by public authorities. This issue features many examples. Since the beginning of the Covid-19 epidemic, many scientists from Université Paris-Saclay have participated in the fight against the disease and included it in their research. As a result of the pandemic and lockdown, they are developing tools for caregivers, working on new drugs and analysing health data.

We also have responsibility to our staff who continue working in the wings to ensure the university's administration and operation so we continue to meet international standards.

Finally, we have responsibility to the society at large – citizens, elected officials and our partners. They can – and should – expect us to continue sharing knowledge and transferring it to the economic network that needs the innovations developed by our teams and young researchers more than ever.

The effects of the pandemic have made us all feel insecure, but the university remains a solid reference for our society due to its unwavering commitment to education the young population and its characteristic solidarity. The thousands of students who joined us this year – either starting or continuing their courses – benefit from this commitment constantly. And I know that this year too, we are going to make their eyes shine!

I hope you enjoy this new issue of our journal.

“Let's remain cautious and united together.”

Sylvie Retailleau,
President of Université Paris-Saclay

Members of Université Paris-Saclay



Title

Combining classroom and distance learning: a hybrid solution



© Christophe Peus – UPSaclay

Marked by the persistent Covid-19 pandemic, the 2020-21 academic year at Université Paris-Saclay will be hybrid with a combination of classroom and distance learning. This new combination of methods had to be prepared during the summer break, both to compensate for unexpected events and to reinforce programmes.

Preparation for this academic year was completely different due to the uncertainty of current health conditions. *“The guidelines in this area, developed with Université Paris-Saclay faculties, its component institutions and member-associated universities, focused on hybrid programmes to ensure physical distance wherever possible,”* explains Isabelle Demachy, Vice-President of Courses, Educational Innovation and Student Life at the university. Classroom learning is central to education programmes: *“the experience of lockdown confirmed that it is essential to the transmission of knowledge and skills”*. However, the recommendation given before summer leave was to include distance learning in the programme.

The goal for professors, academic staff and course managers was to pass on essential concepts in classroom conditions and reinforce their courses with distant sessions, synchronous or asynchronous, to limit the flow of students on campus. *“The aim is to be able to quickly switch from majority to minority attendance should the epidemic accelerate or should a cluster force the establishments to close.”* On campus and in closed areas, wearing the mask is compulsory and physical distancing obligation whenever possible.

Assistance with developing new teaching methods

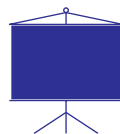
To help teachers to adapt to this restricted context, recommendations and tutorials produced by education specialists and project managers in Education Innovation were hosted on a specialised website. *“Given the diversity and number of courses, audiences, and timetables, it is not possible to apply the same approach to them all. That leaves room for freedom,”* says Isabelle Demachy. What’s more, classroom and distance learning practices since the beginning of the academic year have contributed to reflection about new hybrid courses and about how to make time

for exchange at faculty-level for discussing problems.

The university has also committed a €600K budget for computer and audiovisual equipment and has responded jointly with Évry and Versailles–Saint-Quentin-en-Yvelines universities to a call for projects launched by the government entitled “Hybridisation of Higher Education Courses”. A total budget of €1.5 million will fund equipment for the campuses and sustainable hybrid programmes chosen by certain education teams. *“For example, we will buy tablets, microphones, headsets and mobile receivers to produce short videos to complement courses. As the situation returns to normal, these distance learning tools and resources will still be relevant, as they can be used to help students, particularly students with a job, with disabilities or returning to study,”* says Isabelle Demachy.

Special cases

We have also paid close attention to first-time students for this new academic year, particularly students just out of secondary school. *“Going from secondary school to university is a big step, so classroom learning is important, especially during the first few weeks of the*



course. Teaching staff are aware that knowledge usually acquired at the end of secondary school may have been compromised this year. Students with difficulties or requesting support in science subjects will be provided help via distance resources and PhD students,” explains the Vice-President.

International courses, with a majority of foreign students, began to prepare for the beginning of the academic year very early. They are conducted entirely using distance learning, whether students are here or not, or in hybrid mode, combining distance and classroom learning. One-quarter of them, roughly 30, pledged to complete the first semester remotely.

We can be sure of one thing, regardless of the uncertainty generated by the health crisis: continuous assessment will start early in the year and the proportion will be increased, especially for first-year students. Exams will also be organised in the classroom as a complement.

www.persay.universite-paris-saclay.fr

Title

Ensuring the pursuit of education during lockdown

With the sudden application of general lockdown in France in march, the university's management, staff, constituents and members were obliged to experiment with innovative educational solutions.

“Given the lack of forewarning, the whole faculty has been exemplary, showing reactivity and their capacity to adapt, and the courses were completed for the period,” stresses Isabelle Demachy, Vice-President Courses, Education Innovation and Student Life at Université Paris-Saclay. A survey shows that the vast majority of teachers and academic staff were not isolated. They used the tools quickly made available by the university such as the virtual Collaborate classroom for distance learning. They also discussed other resources and methods amongst themselves and passed on the remaining learning to their students. Actions by the teaching staff and staff in the Courses, Education Innovation and Campus Life departments ensured courses were pursued and links with students were maintained. SMS campaigns were used to identify students in difficulty and track them remotely, and nearly 500 students benefited from hardware donations, such as computers or connection equipment.

Course formats are changing

At CentraleSupélec, the teaching department offered individual interviews to help teachers to adapt distance learning for their courses. *“They were advised to avoid long synchronous sessions where students are passive for too long. On the contrary, the recommendation was to let students view distance learning resources at their own pace in advance, and then do synchronous exercises with the teacher. That kept students active,”* explains Françoise Berthoud, who has now joined the Education Innovation department at Université Paris-Saclay. *“We also need to use short videos with a maximum of one or two learning objectives, to keep students' attention. Distance learning is not as fast. We must accept less progress.”* In fact, some “lockdown” course formats were very popular with students, being received with satisfaction both remotely and in the classroom.

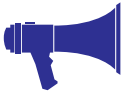
Digital as a medium

At the INSTN Saclay, digital transformation has been underway for two years, and the methods have been integrated into continuous education and graduate training programmes. *“With digital tools, teaching sequences are structured differently and cut into short sessions. We don't count course hours, but modules aligned with the intended competencies. They feature diverse activities including filmed courses, powerpoints, with or without voice-over, and tests to verify whether the competency is acquired,”* remarks Vincent Minier, head of digital transformation for the institute. When lockdown was announced, Instart Learning, the organisation's distance learning platform took over and centralised information, providing the means for teachers to post course materials.

Successful remote assessment

It was a tricky issue. The organisation and follow-up of remote examinations has resulted in completely original assessment systems. *“With first-year classes of 900 students at CentraleSupélec, the method chosen as the least intrusive, was to take a photo of the student and their ID with their computer's camera and then other photos at regular intervals,”* recalls Françoise Berthoud. 9,000 examinations sessions, using MCQ among other methods, were conducted in two months. *“At INSTN, this began with a hardware test and student-identity check. The exam was filmed via the student's computer webcam and screen sharing mode. Their mobile phone or touchscreen tablet were used to film their hands. At the end of the exam, the papers were downloaded,”* tells Vincent Minier. 70 students sat about 10 exams of 3-hours with this method. The INSTN team had previously tested with them these methods during mock exams.

The general view is that lockdown has boosted and accelerated digital transformation. *“Many teachers realise the potential for their courses,”* says Vincent Minier. The challenge for the future is interoperability: combining all these methods with flexibility, while rationalising digital practices.



Title

Lockdown Lectures: science infiltrates the home



© La physique autrement

During the recent general lockdown in France due to the Covid-19 pandemic, researchers of Université Paris-Saclay infiltrated social media with videos of “lockdown lectures”. Presenting science and experiments for the home, these initiatives are being pursued in new formats.

The challenge required researchers with strong motivation. “Our challenge was to avoid

the typical form of lectures for popularising science,” explains Julien Bobroff from the Laboratory of Solid Physics (LPS – UPSaclay, CNRS). He put videos online about current research and physics experiments to be done at home, such as measuring the Earth’s gravity. For Hervé Dole from the Institute of Space Astrophysics (IAS – UPSaclay, CNRS), the bonus was interactivity: “I asked the public questions about astrophysics, for which they voted, and I saw their results live. As a result, we were able to have live discussions.” Finally, Benjamin Brigaud and Cécile Quantin, from the Paris-Saclay Geosciences laboratory (GEOPS – UPSaclay, CNRS) posted short videos about rocks. “Our goal was to popularise mineral samples and what they can tell us.”

Technical and logistic problems complicated their undertakings, but the public was very enthusiastic. “Many people wrote to me to say they were grateful for my videos,” tells Bobroff.

“Scientists are often considered to be distant characters,” adds Hervé Dole. “Presenting in an interactive, simple and accessible way is very popular.”

These initiatives have not been forgotten. On the contrary they have stimulated future action. “We continue posting new rock videos online,” exclaims Cécile Quantin. Julien Bobroff, with his team and the French education department, developed lab work that can be conducted remotely for secondary-school physics teachers. Finally, Hervé Dole launched an annual online festival combining astrophysics and jazz: “From Big Bang to Big Bands”.

www.ias.u-psud.fr/dole/conferenceconfineeastro2020.php
www.hebergement.u-psud.fr/supraconductivite/projet/confarences_confinaes/
www.youtube.com/channel/UCXs9Q2DG8_QMWDY-h_mRyEA/videos?view=o&sort=p&shelf_id=2

Title

Come the night, toll the hour: time running out in confinement

Were your days endless during lockdown, or did it go by in a flash? Was your relationship with time completely disturbed? To understand why, in early April, a team from the Cognitive Neuroimaging unit (UNICOG – UPSaclay, Inserm, CEA) from Neurospin launched a participatory online survey entitled Lockdown Time (Temps Confiné). It was distributed in 17 countries, each with nearly 100 participants. This experimental psychology and chronobiology study focuses on the impact of lockdown on rhythms of awakening and sleeping and the perception of duration, among other things. “The participants are making a superb contribution in time and energy to participatory sciences,” said Virginia van Wassenhove, head of the Cognition & brain Dynamics team. They will soon be recruiting new participants: stay tuned!

www.brainthemind.com/temps-distanciation-sociale

Title

CEA at the Cannes Games Festival



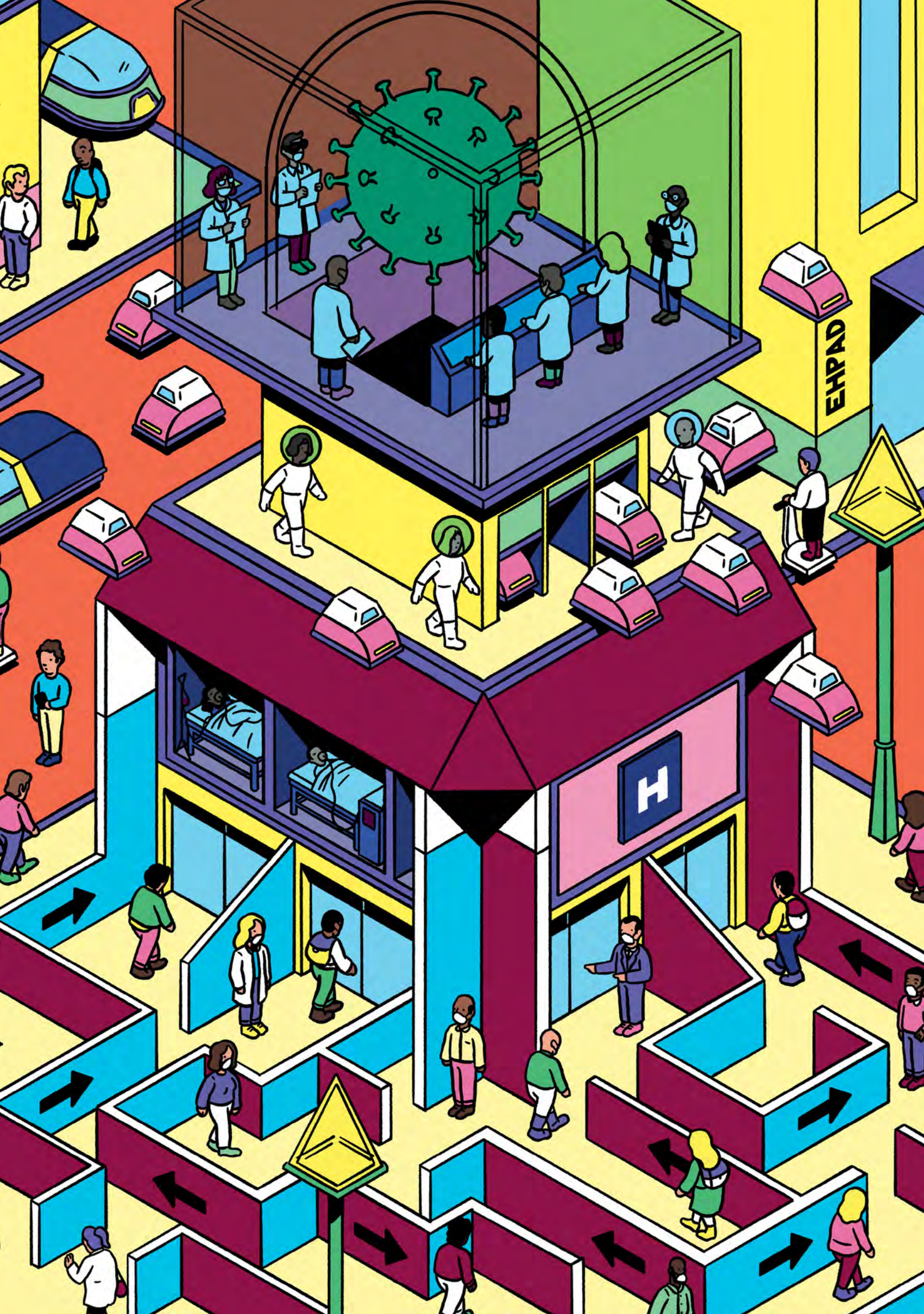
© CEA

From 21st to 23rd February 2020, the CEA participated in the Cannes International Games Festival, the largest French-speaking game event.

Get ready to play! An exclamation that must have resonated strongly for the CEA. The researchers, who have developed five games to communicate about scientific culture, presented them at their first festival. Several of the games were funded by Diagonale Paris-Saclay. The objective of the range, which includes a video game (*Le Prisonnier Quantique – the Quantum Prisoner*), board games (*Climatic Tac*, *Exoplanètes: le jeu* et *Astro chronomaître* –

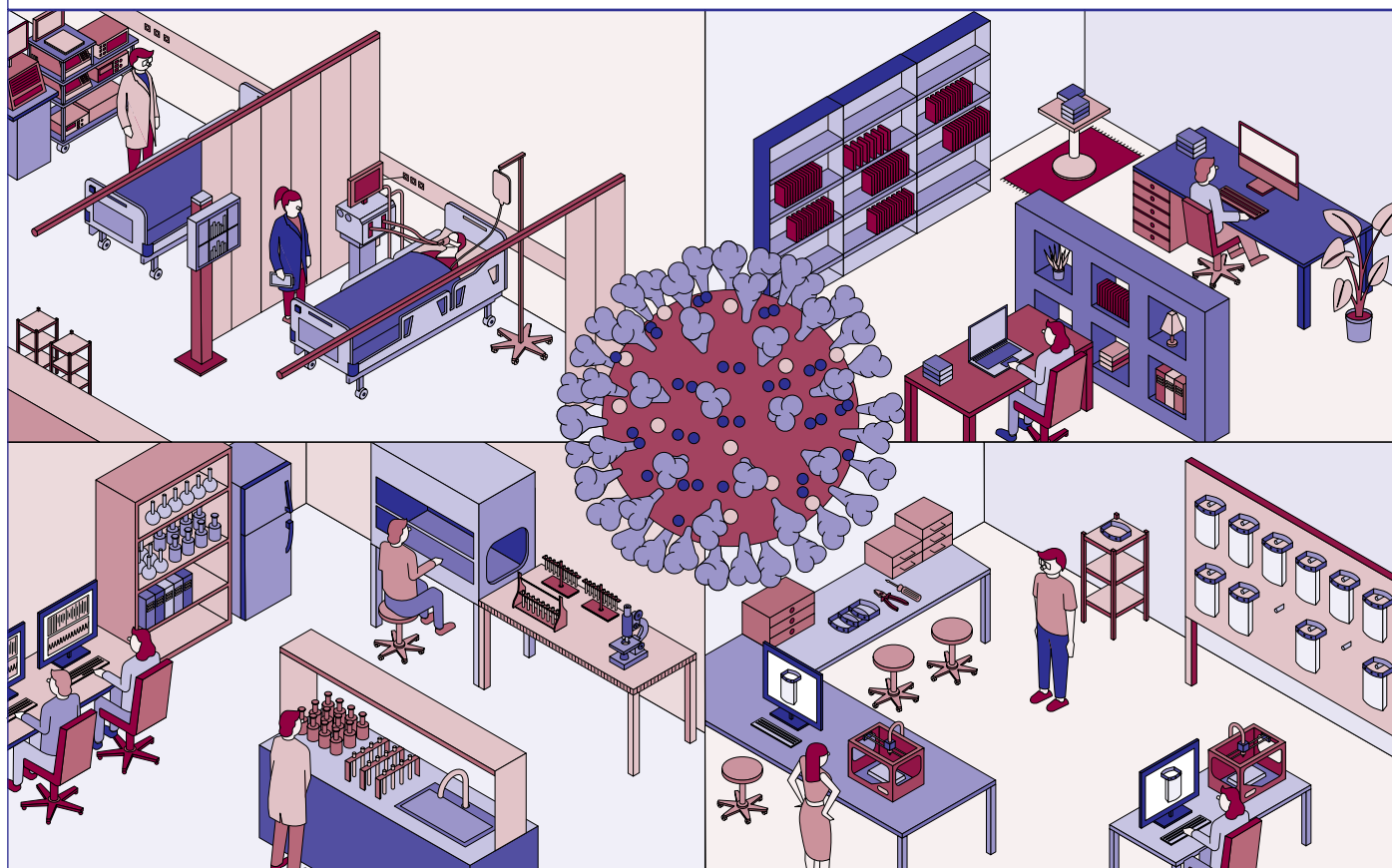
Climatic Tock, *Exoplanets: the game*, *Astro chronomaster*) and a mobile application (*Climarisk*), was to talk to the general public about science. “Games are a great way to stimulate exchange and encourage richer dialogue,” explains Céline Lipari, editorial manager of the CEA website. “The games were very popular. Festival visitors asked a lot of questions, pursuing discussion further and asking about the research carried out within the CEA. They even wanted to buy the games to take home with them!”

www.prisonnier-quantique.fr



Title

Covid-19: Université Paris-Saclay – a project hub



Many scientists from the faculties, component institutions, member-associated universities and partners of Université Paris-Saclay began contributing to the fight against the Covid-19 epidemic since it began, including Covid-19 in their research. The pandemic and lockdown have led them to develop tools for caregivers and to study medication and health data. Read on for a short and non-exhaustive overview.

PCR tests may be the entry point for detecting SARS-CoV-2 infection, but the start-up MORPHEE+, from the SONDRALABORATORY (UPSaclay, CentraleSupélec, ONERA), plans to identify symptoms associated with the disease using micro-radar. The start-up originally introduced a real-time drop detection device based on the same system. “A radio wave is sent into a room where it propagates. As soon as it encounters an object, part of the wave returns,” explains Sylvain Azarian, director of MORPHEE+. The tool has been slightly modified to detect respiratory distress symptoms associated with Covid-19. “We use the same sensor, but we still need

to change some algorithms to accurately detect respiratory rhythm,” says Sylvain Azarian. The team hopes to be able to use this system to detect Covid-19 symptoms by the end of the year.

Characterising and treating Covid-19

Artificial intelligence (AI) has also been used for Covid-19 research, thanks to the ScanCovid project led by the OPIS joint team (Inria, CentraleSupélec), in partnership with the Institute Gustave Roussy, the Bicêtre Hospital (AP-HP) and the start-up Owkin. “The team’s challenge was to analyse chest CT images of Covid-19 patients to locate and quantify the extent of lesions suspected to be factors of disease severity. We used AI methods to learn to automatically predict the volume of each lesion for each patient,” explains Émilie Chouzenoux, member of the OPIS joint team and project leader. Results show that deep learning methods using chest scanners are capable of revealing the severity of the disease, improving predictions about how it will develop.

Finding treatments for SARS-CoV-2 is another major issue for research. Antiviral drugs are obviously among the therapeutic molecules studied, but molecules capable of combating

powerful inflammation sometimes triggered by infection, also called “cytokine storms” are also being investigated. The Immunology Laboratory for Viral, Autoimmune, Hematological and Bacterial Diseases (IMVA-HB – UPSaclay, Inserm, CEA) is researching antiviral solutions and has conducted various preclinical tests: “We tested several molecules on cynomolgus macaques, which are known to be infected with SARS-CoV-2 similarly to humans. The pathology is very similar in the early stages,” explains Roger Le Grand, director of the laboratory. Hydroxychloroquine, the association of lopinavir/ritonavir, or ivermectin were tested.

“We used AI methods to learn to automatically predict the volume of each lesion for each patient.”

Émilie Chouzenoux

The Coriumuno-19 study, carried out by the AP-HP and REACTing consortium, with

hospital-university staff from the Université Paris-Saclay medicine faculty, examined the effect of different immunomodulators on the frenetic immune system observed in some patients. This set of clinical trials, including about 700 patients, tested inhibitors of molecules that cause inflammation. One has produced promising results and will soon be published. Xavier Mariette, President of the Scientific Council of the Faculty of Medicine of Université Paris-Saclay and principal co-investigator of the Corimuno-19 study, says: “Some tests will probably be negative, but they are almost as important as positive results. The scientific community needs to know when a drug is not effective in treating this disease.”

“The scientific community needs to know when a drug is not effective in treating this disease.”

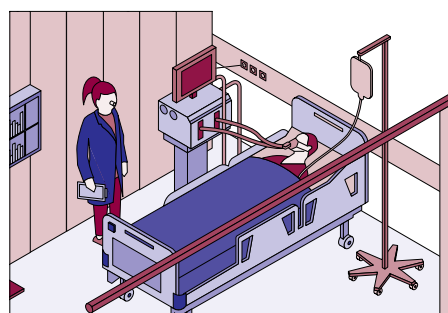
Xavier Mariette

All of these molecules may help in the fight against the virus, but “it’s important to know your enemy to fight it effectively,” says Agnès Delaunay-Moisan, researcher at the Institute of Integrative Biology of the Cell (I2BC – UPSaclay, CEA, CNRS) and head of the Ped-Covid programme. Conducted with the company NG Biotech, the Pasteur Institute, the Necker Institute and the National Centre for Research in Human Genomics (CNRGH – UPSaclay, CEA), the study seeks to develop knowledge about immunoprotection of children infected with SARS-CoV-2. “The most important issue is seroprevalence: have children been in contact with the virus and how do we know it, for example, by searching for antigens,” explains Agnès Delaunay-Moisan. The study examined the potential for immunity due to past seasonal coronaviruses and demonstrated no cross-immunity. The follow-up will focus on the circulation of the virus among children, diagnosed with PCR tests, and their immunoprotection long term.

Quickly build operational tools for hospitals and health professionals

During lockdown, other research teams put in place measures to assist Covid-19 caregivers or victims. They include applications to help cope with the large influx of patients to intensive care. In the Paris area, the AP-HP health

data warehouse (EDS – *Entrepôt de Données de Santé*) was used to visualise and analyse flows. Further to a request by the AP-HP, several Inria Saclay teams developed the ScikitEDS viewing tool. “The EDS indicates numbers of admissions and describes patient flows, providing information about age, medical history, etc. Thanks to ScikitEDS, we summarised all the indicators for AP-HP general management in a graphic presentation,” explains project leader Alexandre Gramfort from the Parietal project team (UPSaclay Inria, CEA). “We produced a web page featuring interactive graphics on a daily basis to help the AP-HP crisis taskforce to understand the changing needs of hospitals.”



Other regions had the same needs. “In the Grand-Est region, intensive-care staff required regular exchanges of up-to-date information about the number of available beds,” explains Julie Josse from the XPOP project team (École Polytechnique, Inria) and co-leader of the ICUBAM project with Alexandre Gramfort. The ICUBAM application formalised and secured this exchange of information for intensive-care staff. It was quickly adopted in the region. Medical staff were able to use the application to update and view the number of available beds and patient flows in real time. Data collected and analysed by ICUBAM and ScikitEDS was deposited on the Health Data Hub for use by the scientific community and other research projects, including for epidemiology or biomedical research.

“We produced a web page featuring interactive graphics on a daily basis to help the AP-HP crisis taskforce to understand the changing needs of hospitals.”

Alexandre Gramfort

The influx of patients has also had an impact on the interaction between patients’ families

and caregivers. “Families and caregivers usually communicate by phone. In mid-March, seeing the increasing influx of patients, AP-HP’s intensive-care services knew that they would no longer be able to keep families informed,” explains Nicolas Anciaux, head of the PETRUS team, a joint project team between Inria Saclay and the Data and Algorithms Laboratory for a Smart and Sustainable City (DAVID – UPSaclay, Inria, UVSQ). With Dominique Chapelle and Céline Grandmont from Inria, and in partnership with Hippocad, they created PréLiFa, a platform for intensive-care staff for staying in touch with patients’ families. According to Nicolas Anciaux, “PréLiFa demonstrated a real need. All the caregivers treating a patient were able to update the family. Families were reassured to see that a whole team was taking care of their loved one.”

Another joint project between the research community and health-care providers was developed due to the fear of a shortage of respirators. The CLEAR project, led by the LIST Institute (UPSaclay, CEA) and the Frédéric Joliot hospital department (SHFJ – UPSaclay, CEA) aimed to improve emergency respirators, which are available in large quantities. “The CLEAR project comprises two actions,” explains Gregorio Ameyugo from the LIST Institute. “The CLEAR-R insufflator was originally designed to manually inflate patients. We then made it automatic. Meanwhile, the CLEAR-M device was designed to monitor patients with Covid-19. Connected to emergency ventilators, it provided the necessary flow and pressure information to ventilate these patients. CLEAR-M succeeded in turning a Twingo into a Ferrari,” says Vincent Lebon, head of department at the SHFJ.



“Makers” also spurred into action during lockdown, manufacturing protective plastic visors for example. Sociologist Volny Fages from the ENS Paris-Saclay Department of Social Sciences has been studying their practices for several years. “During lockdown, there was increased activity in the maker community to help fight the virus. We decided to investigate,” says the researcher. With his team, he analysed makers’ profiles and how they organised their activity during lockdown. Deprived of

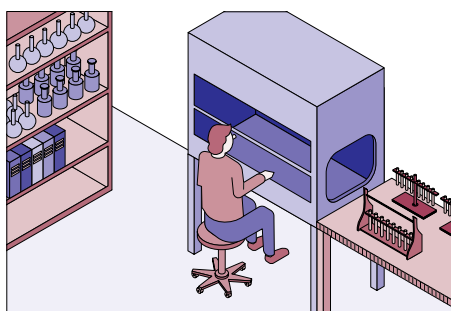


field studies to begin with, the team conducted remote interviews and distributed a social-network questionnaire. This played a crucial role in establishing the impetus for cooperation among makers and their generous actions.

“It’s important to know your enemy to fight it effectively.”

Agnès Delaunay-Moisan

Many scientists involved in the fight against Covid-19 report that such initiatives have generated new working partnerships and methods. “At Inria and AP-HP, we acted on an intention that has existed for several months – even years – and signed a convention that provides an institutional framework for working in partnerships,” says Alexandre Gramfort. Émilie Chouzenoux and Volny Fages noted the involvement of their students, respectively graduate and third-year students: “I’m fascinated by their commitment. It was a real exercise for them, and it turned the educational relationship into something more egalitarian,” enthuses the sociologist. Others highlight the impact of the pandemic on the temporality of research, for example for clinical trials: “There is usually at least four to six months between writing a protocol and application on the first patient. In this case, we received authorisation within ten days,” says Xavier Mariette.



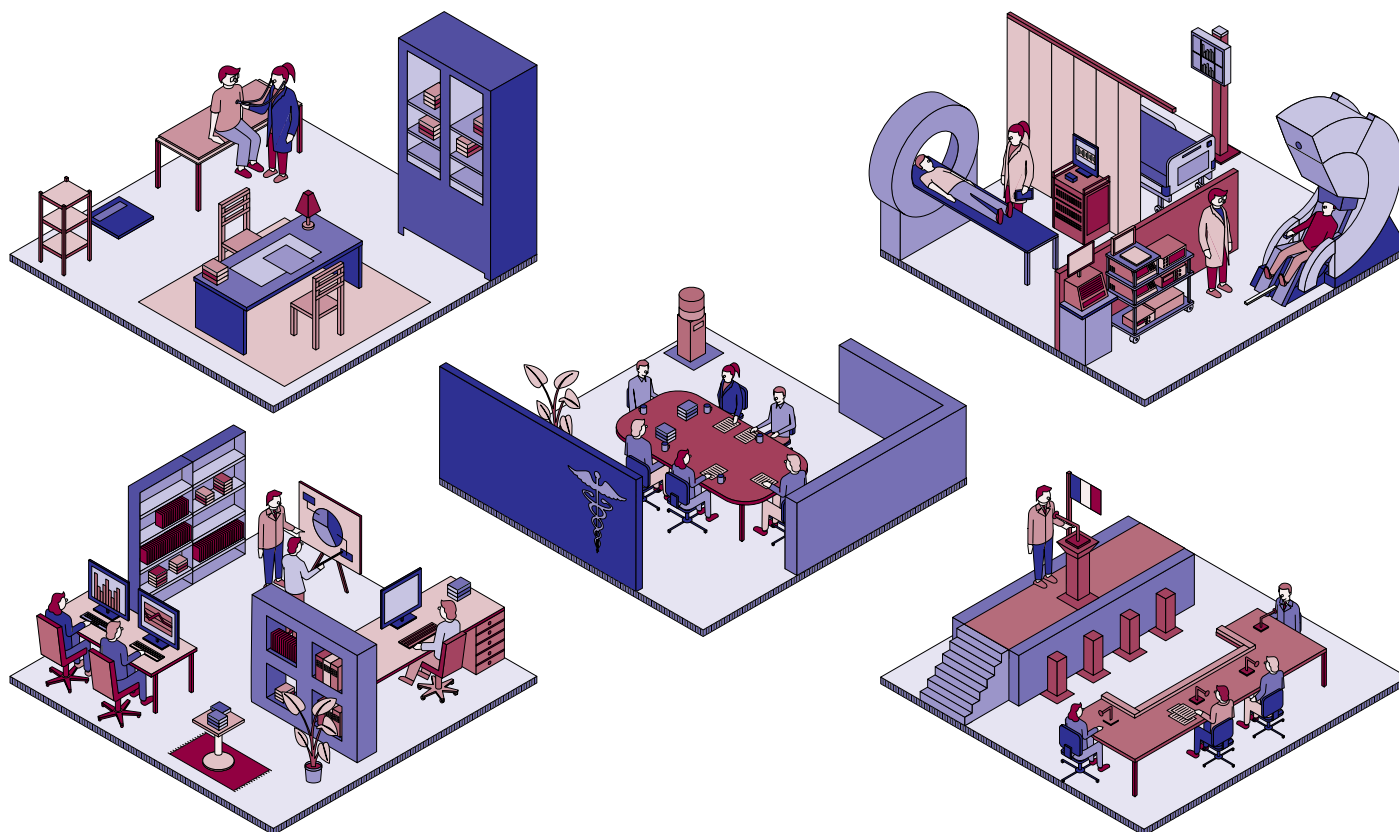
It will be interesting to examine the future. To see the outcome of these projects, and to understand the effects of this particular period on scientific research.

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Title

Organisation and Management in Healthcare Facilities



Université Paris-Saclay's researchers in management sciences, health economics, engineering and organisational ethics, are examining the organisation of the French health system to improve coordination of patient care.

The French healthcare system, put under pressure by the Covid-19 pandemic, is still under scrutiny. It is often criticised for being overly complex with a diversity of players and interested parties including hospitals, but also general practitioners, specialists, medico-social institutions, and hospital services in the home. While organisation and orientations are obviously dictated by medical, health and social issues, organisational, managerial, economic and even ethical subjects also require special attention. Université Paris-Saclay is currently conducting research into these issues. "Organising such a multi-faceted system requires structural division with coherent and flexible operations to adapt to changing needs," explains Annie Bartoli, Director of the Larequoi Management Research Laboratory (UPSaclay, UVSQ).

With longer life expectancy and the onset of chronic disease, health-care facilities are required to address new needs. For example, a patient with polyopathologies may need assistance in daily life or reintegration into school or university. Such social, educational and professional needs are still poorly coordinated with medical or health practices. "There are different ways to enter the health system – via a GP or attending hospital or through a specialist consultation," says Annie Bartoli. "However, each institution is highly specialised to meet particular needs. The link between health and medical services on one hand and medicosocial issues on the other is often insufficient. As a result, the care path for patients is chaotic. Particularly if their pathology requires intervention by multiple carers."

In recent years, several national plans and public health policy reforms have been undertaken to improve the system. While many health management specialists and health professionals agree on the solutions, they often differ about the right direction for change. "The obstacles are cultural and due to hyperspecialisation in medical professions, which is also necessary. Every specialist needs to be open to other disciplines. An interdisciplinary and cross-

cutting approach is essential if solutions are to be optimised," says Annie Bartoli.

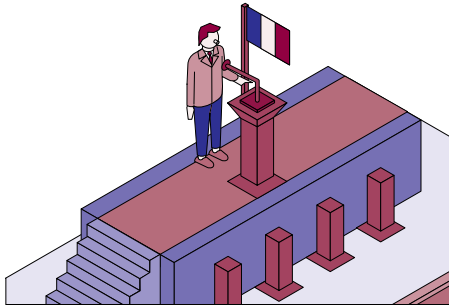
“Organising such a multi-faceted system requires structural division with coherent and flexible operations to adapt to changing needs.”

Annie Bartoli

Supporting and promoting organisational initiatives

Political impetus with national or regional motivation are required to drive change, as are the means for facilitating its application whenever the motivation presents itself. This requires improving what already exists or creating appropriate structures. "They coexist locally and are complementary," says Annie Bartoli. "For example in mental health, specialised entities with psychiatric healthcare professionals in regional hospitals coordinate services adapted to patients both during their

hospitalisation, but also when they return home. New customised services are being created to take care of patients without hospitalisation or accommodation. According to their needs, ergonomists, addictologists, and psychologists support them in their home and help them to reintegrate.”



In some cases, the services themselves initiate change when they realise the same patients have returned at regular intervals. “They consider that by applying systems that anticipate and correct malfunctions, additional means will not be required, and the outcome is generally positive,” says Bartoli. “A form of participatory management becomes the norm and a key to change.”

There are also innovative forms of organisation, such as PREPSY in Île-de-France, which focuses on schizophrenia among young people aged 18 to 25. A hybrid system with a central structure, PREPSY unites diverse skills necessary for overall care – psychiatrists, psychologists, ergonomists, dieticians, professional and school-based integration officers – professions which do not usually work together. What’s more, other local actors such as schools close to the patient’s place of residence can also be included. A designated contact or coordinator – often a caregiver or social worker – is responsible for following the patient’s case. They assist them in their home and community to help them refamiliarise themselves with their environment and recover their level of independence. Particularly developed in Anglo-Saxon countries, such case management schemes are now spreading gently in France, for mental health, cancer and geriatric patients. “These methods are particularly suitable for patients with complex and chronic conditions who must adapt their lifestyle to their condition,” says Bartoli.

New organisational models are also currently emerging in primary care with the creation of multidisciplinary clinics in towns where doctors work together. These models lead to changes in professional practices and new forms of remuneration. Practitioners are employees and are no longer paid by the consultation.

Healthy resource management

Solving organisational problems also means optimising the use of existing resources – financial, material and human. Resources that are crucial, yet so frequently limited. “Efficient resource allocation is the fundamental issue in health economics,” says Nathalie Pelletier-Fleury of the Centre for Research in Epidemiology and Population Health (CESP – UPSaclay, UVSQ, Inserm), who uses tools such as cost-effectiveness, cost-utility and cost-benefit analysis. These tools help to assess the effectiveness of new health programs or public policy mechanisms taking into account resources required. “Costs are associated with health outcomes, measured in quality-of-life-adjusted life years (QALY), or benefits measured in monetary units. For example, cost-utility analysis compares the additional costs for an additional QALY with the implementation of a new health programme. The question is how much the community wants to invest and how much, knowing that because resources are limited, creating new programmes means abandoning existing programmes,” explains the health economist.

“Efficient resource allocation is the fundamental issue in health economics.”

Nathalie Pelletier-Fleury

With her colleagues, she recently conducted an international study to measure preferences for funding new health programs. “In an online questionnaire, we asked a thousand people in the general population to make choices between different solutions which added years of life for different costs.” Researchers used econometrics to define a utility function: the value individuals place on improved effectiveness compared with monetary cost to the community. “For the time being, this remains methodological research and our results are not yet applicable for evaluation. Unfortunately, research does keep up with decision-makers,” says the researcher.

At the Laboratory of Industrial Engineering (LGI – UPSaclay, CentraleSupélec), the Health Systems Engineering group adapts approaches normally used in industrial engineering for use in health systems. The objective is to develop new methods and tools for managing and organising health systems. The group is particularly interested in the integration of new technologies, such as telemedicine and the Internet of Things, to improve the patient

journey and care, reduce waiting times, and improve drug production and traceability. “Interviews and field observations are combined with digital simulations incorporating scenarios and indicators: resource configuration, patient numbers of patients, treatment methods, etc. Recommendations are then made to create value for the entire health care system,” says Marija Jankovic of the LGI.



As part of the Autonomie (autonomous) project, she worked with Dr. Laure Gatin of Raymond-Poincaré Hospital in Garches, to investigate the feasibility of orthopedic surgery on the elderly as outpatients. “The idea was to create a mobile unit that carries out surgery in care homes to relieve disabilities. Firstly, we attempted to clearly identify the types of patients being treated and the severity of their operation and the associated risks. We identified a dozen scenarios which we measured qualitatively or quantitatively using field surveys and simulation models. The goal was to identify patients conducive to surgery depending on medical criteria and available resources.” One of the scenarios is currently being implemented.

Organisational Ethics: the key to well-being?

Ethics – called a “form of awakening” by Alexia Jolivet from the Laboratory of Science and Techniques (UPSaclay) are yet to find their place in the complex French health system. Since the law dated 4 March 2002 for patient rights and the quality of health systems, each institution has had to undertake reflection about the subject, if it was not already the case. Formats and organisation vary depending on institutions, but due to the introduction of certification, most hospitals have created ethics services with a purely advisory role.

“Ethics are questions for our conscience, such as the consequences of our actions or the values at stake. Ethics often generate dilemmas. For example, physical restraint – attaching a person to a hospital bed – opposes two attitudes: are we protecting the patient person from a fall or themselves? or depriving them of their freedom of movement, and hence their autonomy? The creation of an ethics service transforms this

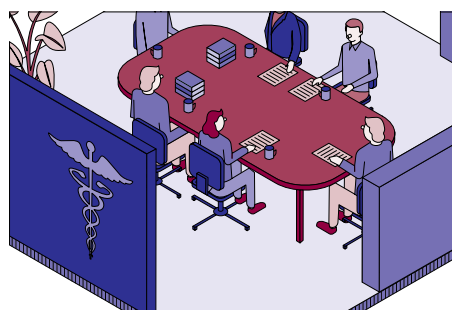


dilemma into a generalised problematisation. Using a multidisciplinary approach including all professions, we are going to try to analyse, understand and elucidate it together,” reports Alexia Jolivet.

“The role of an ethics service is to deconstruct, not to impose, because ethics emerge from the confrontation of the expected with the singularity of a situation.”

Alexia Jolivet

Ethics services are completely new to this extremely hierarchical health system. They are not concerned with power or domination. Discussion and exchange are the priorities. “Each point of view is of equal importance,” the researcher insists. The goal is not to make decisions, nor to decree absolute truths. The goal is to allow time to play its role. “The role of an ethics service is to deconstruct, not to impose, because ethics emerge from the confrontation of the expected with the singularity of a situation.” Ethics provide solutions. And by reinstating doubt, ethics services make it a constitutive part of practices and allow it to be taken into account collectively. Doubting is no longer one person’s problem. Benefits are felt by patients and staff who become more caring with practices that are more relevant.



Ethics can stimulate health organisations, but the reverse is not always true. The real challenge for ethics services is legitimacy. “The law has helped, but generally, health organisations are not very conducive to ethics due to insufficient time and means. Those involved are volunteers who work outside their official working hours. They are in danger of running out of steam. More training is needed. Ethics is still a minor part of the curriculum for healthcare professionals,” says Alexia Jolivet.

But ethics are essential. During the recent widespread lockdown in France, many ethics services were quick to offer their support and went into the field to help adapt general health guidelines for the Covid-19 pandemic. Their functions were to assist and to alert. For example, via the national ethics council, they alerted to difficulties for mourning Covid-19 victims. “Instructions were to refuse access to loved ones of the deceased, but ethics services warned of the moral suffering this caused,” explains Alexia Jolivet.

Clearly, possibilities for transforming health systems abound. “Overall, things are moving in the right direction, but there is still a long way to go. Organisational innovation deserves more encouragement and recognition,” concludes Annie Bartoli.

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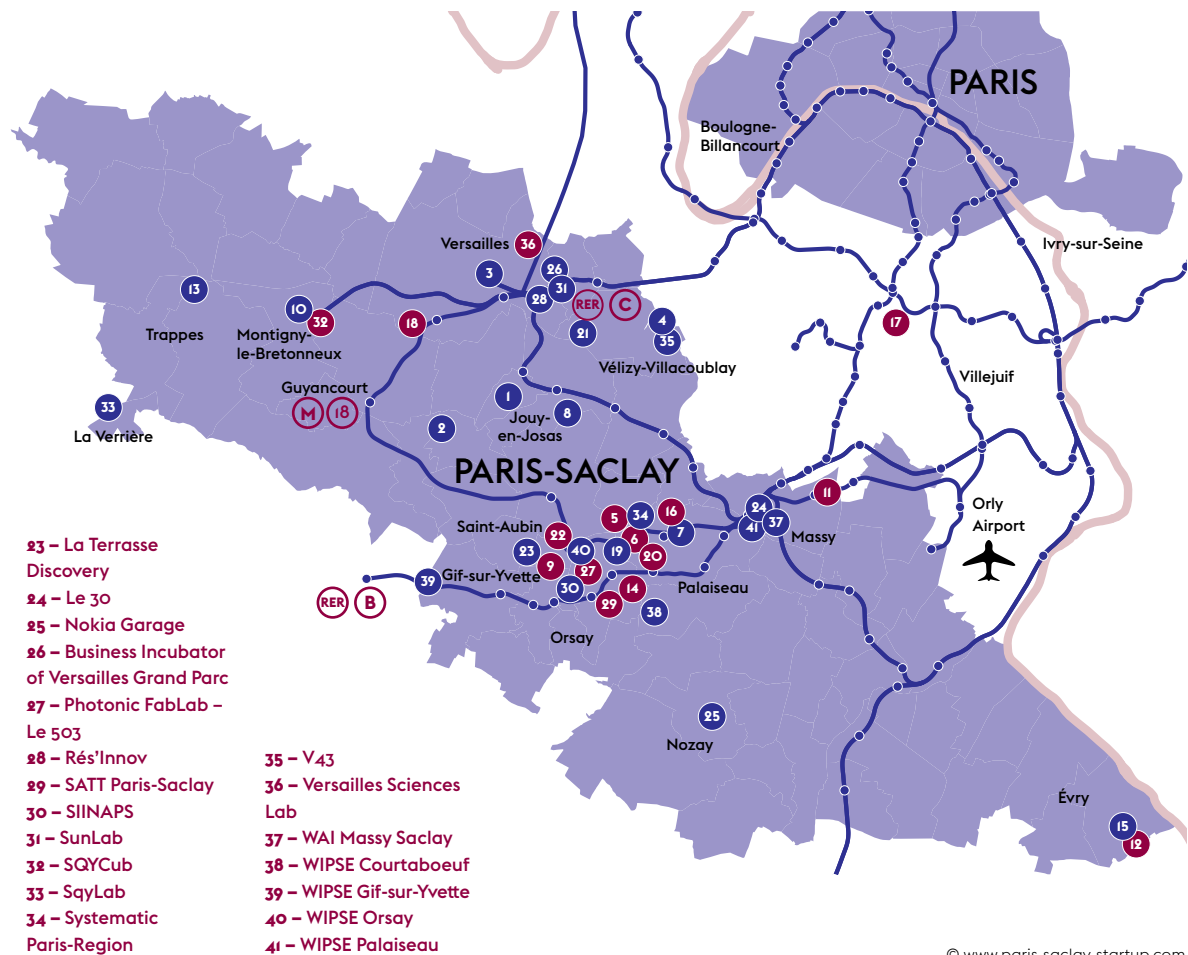
Title

Hubs of innovation at Paris-Saclay

Paris-Saclay's innovation ecosystem abounds with coworking and prototyping spaces, connectors, office space and other support services. This ecosystem trains students, PhD students, academic staff and researchers in entrepreneurship and promotes technology transfer from laboratories to businesses.

- Linked to Université Paris-Saclay
- Outside Université Paris-Saclay

- 1 – ACCELAIR by Air Liquide
- 2 – Innovative Aerodrome Paris Versailles Saclay
- 3 – CCI of Versailles-Yvelines
- 4 – Dassault Systems /3D EXPERIENCE LAB
- 5 – Design Spot
- 6 – DIGI-HALL
- 7 – Drahix Novation Center
- 8 – eLab HEC
- 9 – Fablab Digiscope – Université Paris-Saclay
- 10 – Fablab ESTACA
- 11 – Food'Inn Lab
- 12 – Genopole
- 13 – HeXplora
- 14 – IncubAlliance
- 15 – Incubator IMT Starter
- 16 – Business Incubator – Business Park (IPHE) starting 2021
- 17 – Innov'Lab
- 18 – Institut Vedecom – mobiLAB
- 19 – IPVF
- 20 – IRT System X
- 21 – IZYLAB
- 22 – The Factory and The Incubator of CentraleSupélec



- 23 – La Terrasse Discovery
- 24 – Le 30
- 25 – Nokia Garage
- 26 – Business Incubator of Versailles Grand Parc starting 2021
- 27 – Photonic FabLab – Le 503
- 28 – Rés'Innov
- 29 – SATT Paris-Saclay
- 30 – SIINAPS
- 31 – SunLab
- 32 – SQYCub
- 33 – SqyLab
- 34 – Systematic Paris-Region
- 35 – V43
- 36 – Versailles Sciences Lab
- 37 – WAI Massy Saclay
- 38 – WIPSE Courtaboeuf
- 39 – WIPSE Gif-sur-Yvette
- 40 – WIPSE Orsay
- 41 – WIPSE Palaiseau

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7 000

students learning about entrepreneurship each year

100

start-ups created each year

6

operating fablabs

6

incubators, including 3 constituent-faculty incubators

A design centre:
The Design Spot

A network of young entrepreneurs from the Paris-Saclay area:
PÉPITE PEIPS

A Technology Transfer Accelerator Office: SATT Paris-Saclay

Support and promotion schemes run by the university's research partners

Funding solutions of the University to support technology transfer and business creation:

Awareness:
– Programme Maturaction, Université Paris-Saclay
– Training programme Doctor'Preneuriales, Université Paris-Saclay
– Lab2Biz with HEC Paris
– Genesis Light with IncubAlliance

Proof of Concept (POC):
– Call for projects Prématuration POC in labs Université Paris-Saclay

– Call for projects POC'UP by SATT Paris-Saclay
– Call for projects POC Jeune Docteur (Young Doctor) by SATT Paris-Saclay

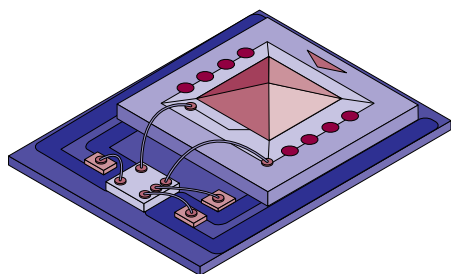
Maturing:
– Call for projects Maturaction by SATT Paris-Saclay

Start-up grants:
– French Tech Seed Paris-Saclay Fund
– Paris-Saclay Seed Fund

Incubators
– Programme Genesis Lab with IncubAlliance



From piezoelectric resonators to industrial applications



Young PhD graduates of Université Paris-Saclay are going on to create their own companies after presenting their thesis. Paul Chapellier, from the Physics, Instrumentation, Environment, Space Departement (DPHY) of ONERA Châtillon, has chosen that path. *“I work on piezoelectric MEMS. They are very small quartz resonators with unvarying vibration frequency over time. During my thesis, I made interesting findings that pave the way for valuable applications in industry,”* explains the new graduate.

These very small resonators are ideal where miniaturisation is required, such as in the space industry and the communications and automotive sectors. The first step in the project was to adapt the results of the thesis to concrete applications. To make it, in addition to technical support from ONERA, Paul Chapellier received a 12-month support programme with SATT Paris-Saclay, which trains new entrepreneurs to meet market expectations. *“It helped me structure the project and to clearly understand potential applications which my thesis results had suggested,”* explains Paul Chapellier.

<https://www.onera.fr/fr/dphy>
<https://satt-paris-saclay.fr>

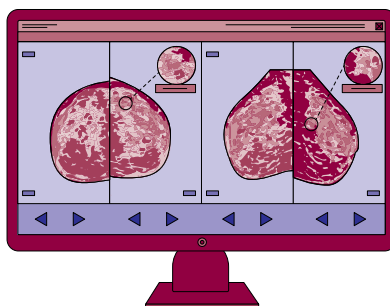
Companies with high technological potential

“Transferring our technological and scientific know-how to industry has always been a priority,” says Corinne Borel, Director in charge of spin-off at CEA Saclay. For over 20 years, the CEA has put in place a comprehensive system to promote company creation, both by funding their employees, but also with training, expert advice and assistance with networking in the industry. *“Of the approximately 220 companies that have been created and supported, 7 are now listed on the stock market and 70% are still operating,”* says Borel.

Most start-ups are in the microelectronics and digital, energy, and health sectors. Among listed companies, Kalray, founded in 2008, develops new intelligent microprocessors that will power future servers and vehicles. Theranexus, founded in 2013, is specialised in the field of nervous system therapy. It develops molecules that increase the efficiency of some existing psychotropic substances, in order to reduce prescribed doses. CEA Saclay works with all the services that support innovation in the virtuous ecosystem of which Université Paris-Saclay is a part.

<http://www.cea.fr/pages/le-cea/les-centres-cea/paris-saclay.aspx>

Start-ups designing digital tools for the future



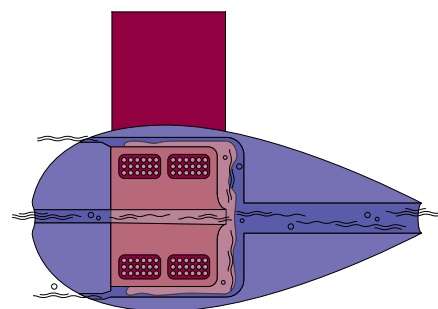
Inaugurated a year ago, the Inria Startup studio is the result of a 35-year programme which has created over 120 companies. Entrepreneurs receive technical and operational support, and unlike many existing support schemes, project holders are employees of Inria. *“We give opportunities to employees who want to create a deeptech company. People are our focus because they are the driving force behind these projects,”* explains Sophie Pellat, co-director of Startup Studio.

Among the companies created, Therapixel, founded in 2013 by researchers from Inria Paris-Saclay centre and Inria Sophia Antipolis-Méditerranée centre, develops an algorithm that facilitates the detection of tumours in mammograms. It assists radiologist with diagnosis.

Cryptosense is another start-up born in Saclay in 2013. Cryptosense develops software that detects vulnerabilities in cryptographic systems. Thanks to Inria Startup Studio, and support from eight Inria centres in France including Paris-Saclay’s, many equally innovative companies will have the opportunity to be created.

<https://www.inria.fr/fr/inria-startup-studio>

Cryptocurrency and boat propellers



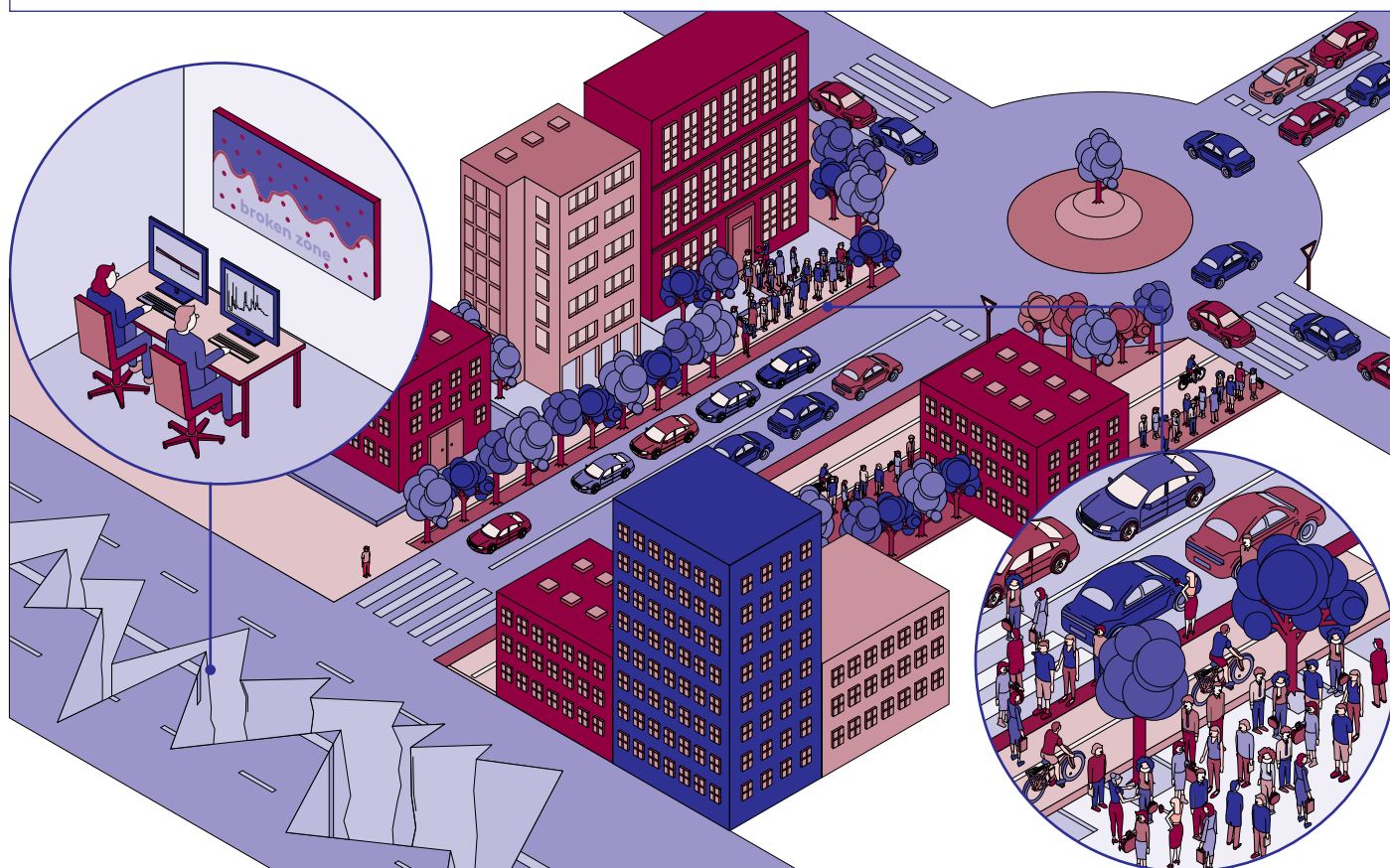
The CentraleSupélec start-up incubator offers two years of support to people wishing to develop a scientific or technological company. *“Entrepreneurs benefit from personalised, individual workshops and group workshops to foster mutual assistance and networking,”* explains Marie Duris, in charge of communication for the CentraleSupélec Entrepreneuriat team.

Since creation of the incubator in 2001, around one hundred companies have been created, creating 720 jobs. 75% of all the assisted start-ups are still active five years after their creation. The incubator is currently assisting around a dozen companies. Among them: be-cube.ai, winner of the 16th edition of the Graines de Boss competition (2020) which aims to make cryptocurrency trading simpler and more profitable. FinX is an original start-up which designs boat engines without a propeller, making them silent and more environmentally friendly. More recently, several start-ups developing solutions related to the problems raised by the Covid-19 crisis were selected in a call for projects to be accelerated by CentraleSupélec teams.

<https://www.centralesupelec.fr/fr/lincubateur>

Title

(Fore)seeing the world with statistical physics



Predicting material breakage, earthquakes, traffic jams or crowd movements. Statistical physics covers an eclectic range of fields at Université Paris-Saclay

This branch of modern physics emerged in the middle of the 19th century with the kinetic theory of gases and the first models describing matter and its properties at atomic scale. Since, it has been attempting to predict the behaviour and development of a macroscopic system using the characteristics of an elementary constituent or known microscopic processes. “Statistical physics presumes that not all microscopic details are important for understanding what is happening on a large scale. Only some are responsible for macroscopic behaviour,” explains Marc Barthelemy of the Institute of Theoretical Physics (IPhT – UPSaclay, CNRS, CEA). “We develop a simple mathematical model which we confront with reality and improve if necessary. That is how we have progressed from describing the atom to quantum mechanics,” says the researcher. These days, many physicists apply the same methods to studying complex systems in

more unexpected disciplines, such as sociology, biology, neuroscience, networks, and urban systems.

Calculating breakage

When will material break? And how and why? It is impossible for a physicist to answer these questions in a predictable manner “because the problem of rupture is inherently statistical,” explains Daniel Bonamy of the Condensed Matter Physics laboratory (SPEC – UPSaclay, CEA, CNRS). “Material is never perfect. Tiny defects or impurities created during manufacture are possible starting points of fractures that vary due to demands on the material. Their size and capacity for propagation are also very variable,” adds his colleague from the Laboratory of Theoretical Physics and Statistical Models (LPTMS – UPSaclay, CNRS), Alberto Rosso. “Such flaws are the origin of a cascade of events called an avalanche. The tips of the fracture front work as a team, advancing in blocks larger than microscopic defects.” The rupture becomes a macroscopic manifestation of the distribution of existing microscopic defects. It is also dependent on extreme events. The worst microscopic defect in matter – its weakest point – determines macroscopic behaviour in rupture.

The aim is to describe the spread of cracks simply and correctly. “The goal is to understand complex systems, in this case faults or interfaces, that are essential for producing the observed phenomena and statistics,” explains Alberto Rosso. “Our models will explicitly take into account that disorder exists in the microstructure of material, so we can analyse statistics obtained on a macroscopic scale,” adds Daniel Bonamy. The models include parameters such as the type of material, its tenacity, its homogeneity, the nature and size of manufacturing flaws, and the design and geometry of the object being analysed.

“The problem of rupture is inherently statistical.”

Daniel Bonamy

Fracture research is fundamental to construction and earthquake research. “In fact, we don’t know much about what is going on under our feet in the faults. Yet the heterogeneity in a fault explains the great diversity of earthquakes,” remarks Alberto Rosso who studies these gigantic avalanches.

Earthquake statistics



Earthquakes are seismological events characterised by the presence of aftershocks, “yet some statistical models do not predict them,” says Alberto Rosso. Working with geophysics researchers, he created a computer model that predicts aftershocks: “We introduced viscoelastic and ductile areas.” With François Landes from the Computer Science Research Laboratory (LRI – UPSaclay, CNRS), they used machine learning methods to confirm that computer-produced avalanches and aftershocks resemble real earthquake activity, particularly for strength and gravity.

“Yet the heterogeneity in a fault explains the great diversity of earthquakes.”

Alberto Rosso

Foreshocks – the rare signs that announce earthquakes – are still insufficiently detected by seismic sensors. Researchers hope that by better characterising their statistics for time and size, they will be able to better identify these signs and predict earthquakes more effectively. In the laboratory, Daniel Bonamy and his colleagues have developed a model experiment that duplicates earthquake dynamics which they use to qualify their statistical models for ruptures. “We created artificial rocks by compressing and heating polymer beads and controlled their porosity and sequencing. By pushing a steel wedge against them at constant speed, a crack was created that we measured at different degrees of progression.” Using acoustic sensors placed on the sample, the researchers also detected acoustic pulsations – similar to seismic tremors – generated by microcracks. Using triangulation, they were then able to locate the source in the sample. This experiment showed that the intermittent dynamics of microcracks present similar statistics to earthquake statistics, and that the mechanical energy dissipated by the system at each moment is proportional to the surface created by microcracks.

Using science for cities

The science of cities would be the first field to benefit from this wealth of digital data for statistical analysis. Data is flourishing and fuelling research. “For example, GPS data, mobile phone data and public-transport passes can provide a comprehensive image of human mobility in an urban area. And we can analyse the phenomenon of gentrification using socio-economic data, such as average income,” explains Marc Barthelemy from the IPhT. “The influx of data – which did not exist 15 years ago – is impressive. Unprecedented information is available, making quantitative study of cities possible without putting people into equation,” continues the urban specialist who often uses data from abroad for his work. “French public authorities are not ready to share their data with researchers. It’s unfortunate, because it’s holding back research. Data is often what drives research,” regrets the researcher.

“Unprecedented information is available, making quantitative study of cities possible without putting people into equation.”

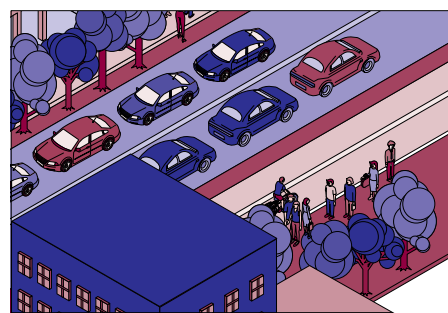
Marc Barthelemy

Once it has been compared with population numbers, data provides strong indicators for a city’s economic, cultural and technological development. Quantities are either linear, such as water consumption, and proportional to the number of inhabitants, independent of the size of the city; or non-linear, and not proportional to the number of inhabitants, but their per capita value increases or decreases with the size of the city. “Quantities with an exponent greater than one, such as the number of patents, CO₂ emissions, or traffic congestion, are due to numerous interactions or fertilising ideas that create a runaway effect. Those with an exponent less than one, such as the total length of electrical cables or distribution systems, are explained by mutualising and economies of scale.”

Decongesting urban traffic

Depending on the aspect studied, non-linear empirical behaviour can be a precious guide for identifying important mechanisms and help to build a simplified but realistic statistical model. “For example, to reduce urban congestion and calculate the proportion of people who will take their cars to work and hence, the amount of

CO₂ emitted, we investigate dominant processes and how they can be used as leverage, such as access to another means of transport nearby or time lost in traffic,” explains Marc Barthelemy. He recently developed a statistical model that predicts the quantity of motorists, the amount of CO₂ emitted by cars and average journey time with good approximation. “We checked our predictions against real data from 25 cities around the world. They are quite convincing about the model’s reliability, with some inevitable fluctuations due to historical, topological, topographical, or socio-economic particularities of cities.”



The researcher’s model also showed that the proportion of motorists only depends on the probability of being less than one kilometre from a public transport station. His statistical approach confirms that the solution to reducing traffic-related CO₂ emissions is not to increase urban density, but to increase the density and accessibility of public transport.

Crowd density and grain movement

Car congestion is a problem, but so is human congestion. However, identifying the best place for arrival and departure signs in stations or how to prevent accidents due to a movement of panic in theatres requires powerful predictive models. At the Irène Joliot-Curie Physics of Two Infinities Lab – (IJCLab – UPSaclay, CNRS), Cécile Appert-Rolland studies include the movement of pedestrians.

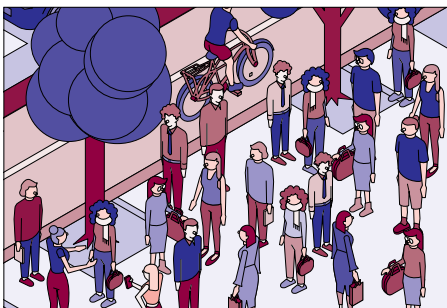
“In the past, research has focused heavily on low and intermediate crowd density. We have recently investigated higher density where it is often assumed that crowd behaviour resembles grain movement. We decided to test this hypothesis,” tells the researcher. Her team drew on a standard test traditionally used with granular media. “The experiment involved placing a person in a cylinder and asking him or her to pass through a crowd of 2, 4 or 6 people/m². The latter is practically the density in the Parisian metro at peak times. The crowd is so dense that people touch each other and it is very difficult to pass between them with the cylinder,” explains Cécile Appert-Rolland.

In normal granular medium, a grain pushed by a cylinder moves in the same direction as



the thrust. Pedestrians, unlike grains, can anticipate. “They anticipate the cylinder, stepping aside to let it pass. Anticipation is so innate. The only way to achieve results similar to grain behaviour was to ask people to turn their backs and not anticipate the approaching cylinder.” Due to their capacity for self-propulsion, pedestrians can also apply their own avoidance strategy, moving in a different direction to where they are pushed. But, regardless of whether density is medium or high, they use the same strategy: “Pedestrians accept temporary discomfort in very crowded conditions, because they know they will eventually be released when the cylinder passes.”

Modelling anticipation



Working with Denis Ullmo’s LPTMS team, Cécile Appert-Rolland has built a statistical model capable of reproducing pedestrian anticipation. Based on game theory, the model assumes that each person applies a strategy to minimise their journey and the density of people encountered. “It is a compromise between not moving too much and not approaching areas where density is too high. This requires cognitive participation.”

“Pedestrians are human beings, not machines. It is estimated that between 70% and 80% of them will respond to the model.”

Cécile Appert-Rolland

the person in front of them, but estimating and changing speed takes longer. “We added this parameter to our model.”

Despite high performance, these models will never be able to describe all behaviour. “Pedestrians are human beings, not machines. It is estimated that between 70% and 80% of them will respond to the model, but the remaining 20% to 30% will not. Nevertheless, our aim is to try to correctly identify the behaviour of the majority and to make deductions for macroscopic effects, such as the formation of slow zones or traffic lanes,” Cécile Appert-Rolland concludes. That is the ultimate aim of statistical physics.

Publications

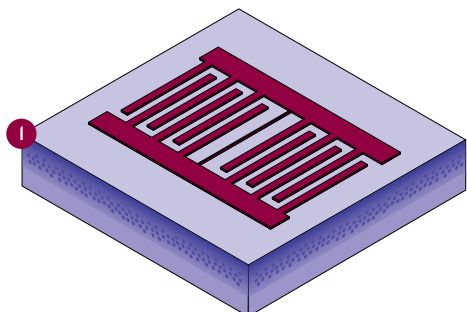
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Using another experiment, the researcher developed tracking models that describe how pedestrians deviate from a preferred path to avoid collision. “We asked people to walk on a line without overtaking to see how they adapt their speed to the person in front of them.” Results show that people almost instantaneously assess the distance separating them from

Title

Different states of condensed matter

EXPERIMENTAL DEVICES AND MAGNETIC STATES



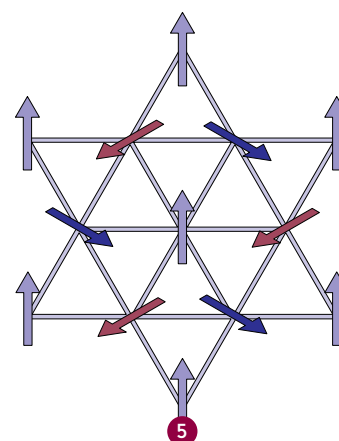
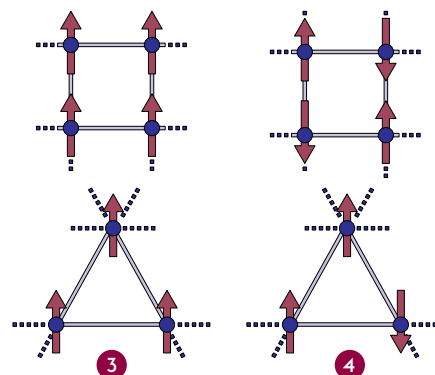
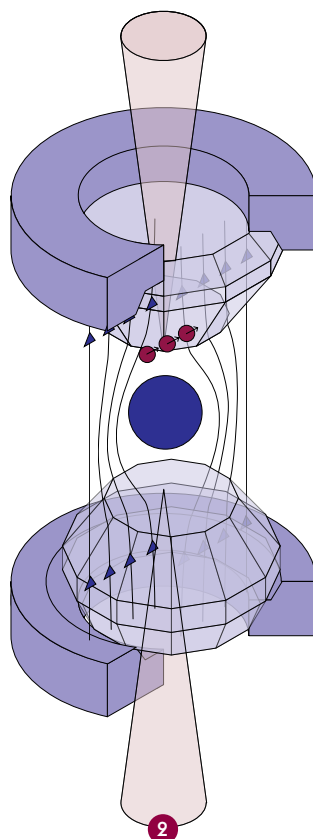
1 – Resonant microwave cavity placed on a silicon matrix where bismuth atoms are implanted.

2 – Diamond anvil cell. The top one incorporates NV centres. The applied magnetic field is expelled out of the ball when this becomes superconducting and is optically detected by the laser-excited NV centres.

3 – Ferromagnetic interactions of spins in square and triangular arrays.

4 – Antiferromagnetic interactions of spins in square and triangular arrays.

5 – Spin interactions in a kagome lattice.



Physicists of condensed matter at Université Paris-Saclay set out to conquer new electronic and magnetic properties of matter.

“Oh! endless collage, shifting planes, the bleeding sun, the deep sea scattered with sloping sails. Matter upon matter...you could dissolve in it,” exclaimed painter Paul Klee. This description of the artist’s pictorial quest also evokes a beautiful and lyrical metaphor for current research into condensed matter physics – a field of research that explores matter in a state where atoms are spatially correlated.

Some materials – both natural or artificial – and behaviours discovered in recent years have such original and unexpected microscopic and macroscopic properties that physicists are once again stirred into action. Properties such as superconductivity, ferromagnetism and antiferromagnetism have challenged many accepted representations, and researchers at Université Paris-Saclay are striving to understand them. *“Oh perfect kagome lattice of spins, frustrated geometry, microwave photon cooling, diamond-encased magnetometers. Magnetic field and pressure on matter; until it melts.”* would be an apt declaration by specialists.

Magnetic behaviour under pressure

On a scale smaller than the atom, matter consists of atomic nuclei (composed of protons and neutrons) and electrons which participate in a concert of interactions. They are associated with various characteristics, such as mass or electrical charge. But it is their spin, a kind of internal mini-magnet, and its interactions with neighbouring counterparts, that are responsible for some of the most remarkable properties of matter. When placed in an external magnetic field, the electronic spins of some metallic materials – such as iron, nickel, or cobalt – are parallel. They develop strong magnetic properties, called ferromagnetism.

Jean-François Roch from the Light, Material and Interfaces Laboratory (LUMIN – UPSaclay, ENS Paris-Saclay, CNRS) and his colleague Thierry Debuisschert from Thales R&T investigated the magnetic behaviour of iron under high pressure. *“The metal loses its magnetism between 15 and 20 GPa. The crystalline phase changes and the magnetic order that determines spin organisation disappears,”* explains the researcher. Working with Paul Loubeyre, affiliate professor at ENS Paris-Saclay and researcher at CEA-DAM, his team has

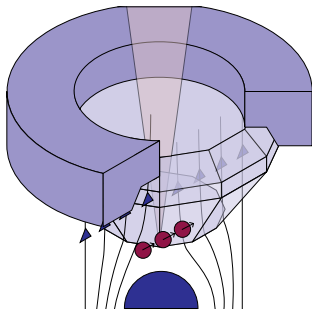
developed a new, more sensitive method for detecting the phenomenon, making it possible to visualise magnetic properties using optical and spectroscopic measurements, and crystallographic ones by X-ray diffraction measurements.

The method uses a press with two diamond anvils sharpened into tips. On one of the tips perfectly controlled flaws, called nitrogen-vacancy (NV) centres, are distributed. Inserted into the diamond using a focused ion beam microscope, these NV centres act as atomic size magnetometers, capable of measuring magnetic resonance of sample spins.

“In the experiment, a magnetic field attracts an iron ball placed between the two anvils. As pressure is increased, the magnetic transition of the iron is observed: the higher the pressure, the more the magnetic field detected by the NV centres decreases, until it disappears,” says Jean-François Roch. *“When pressure is lowered, magnetisation returns, displaying a hysteresis. The delay is due to the gradual switching of the magnetic domains in the iron ball.”*

New metal superconductors

One of the major challenges in research into materials under high pressure is the emergence



of superconductivity. This is due to the loss of electrical resistivity of materials, which begin to expel an applied magnetic field. This is called the Meissner effect. Thanks to their technique, Jean-François Roch and his team have detected this characteristic distortion of field lines when in the vicinity of a superconductor. “We used magnesium bromide (MgB_2), a known superconductor, and tracked its superconductivity transition: at 7 GPa of pressure, superconductivity disappeared when the temperature exceeded 30 K.”

“As pressure is increased, the magnetic transition of the iron is observed: the higher the pressure, the more the magnetic field detected by the NV centres decreases, until it disappears.”

Jean-François Roch

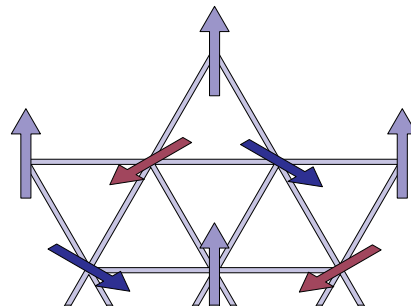
With supposedly quantum properties, metallic hydrogen is the Holy Grail for this type of research: the simplest element in the universe, it is supposed to become superconductive during metallic transition. This phenomena can be observed by applying such high pressure that the diamond anvils invariably break at 400 GPa, just before the hydrogen becomes metallic. Recently, Paul Loubeyre and his team at CEA-DAM reached pressures of 600 GPa with diamond anvils with machined torus tips. Using the SMIS beamline of the SOLEIL synchrotron, they observed metallic hydrogen formed at 425 GPa of pressure. This was unprecedented. Jean-François Roch and Paul Loubeyre are now turning their focus to metal hydrides, with properties similar to metallic hydrogen but metastable: these hydrogen-rich materials exhibit superconductive behaviour at near-ambient temperature under lower pressure. “Exploring and studying new compositions will require torus-shaped diamond

anvils with deeper NV centres,” acknowledges Jean-François Roch.

Dancing liquid spins

The spins of ferromagnetic materials become parallel when an external magnetic field is applied to them, but antiferromagnetic materials do not present the same pattern under the same conditions. Their spins only align under a critical temperature, but they do it antiparallel, in alternate directions. The overall magnetisation of the material remains zero.

Atypical materials with certain antiferromagnetic characteristics are the focus of research by Philippe Mendels and Fabrice Bert of the Laboratory of Solid Physics (LPS – UPSaclay, CNRS). They are known as quantum spin liquids, but are not exactly liquid. They are named after their particular magnetic state: they are in a state of dynamic disorder, even at very low temperatures close to absolute zero (0 K, -273.15°C) where the system should be ordered or frozen. This is due to the strange phenomenon called geometrical frustration. Due to the arrangement of atoms in a kagome lattice – a triangular network of Stars of David – electronic spins fail to achieve the required antiparallel alignment, and some of their interactions remain frustrated.



Subject of a purely theoretical description until recently, spin liquids now have a prize paragon: herbertsmithite ($ZnCu_3(OH)_6Cl_2$). This mineral, discovered in 1972, has original properties that were confirmed in 2012, by the LPS among others. “Synthesised, this mineral demonstrates the same properties as quantum spin liquids. We observed the absence of magnetic order and magnetisation at very low temperatures, to 20 mK, whereas spins are typically ordered at 200 K,” explains Philippe Mendels. The copper atoms (Cu) in this compound organise themselves in a kagome lattice.

In the heart of atoms

To penetrate atoms and explore their magnetic phenomena, researchers use nuclear magnetic resonance spectroscopy (NMR). The technique depends on the ability of certain atomic nuclei to interact with a magnetic

field. These are those with a nuclear spin – they present an odd number of protons or neutrons, or both – like the Oxygen-17 isotope (^{17}O). Initially, the nuclear spins are aligned with an external magnetic field and then stimulated with a pulsed radiofrequency. The emission of electromagnetic waves when equilibrium is returned constitutes the detected signal.

In the case of herbertsmithite, researchers have recently used this technique to determine the energy required by the system to transform from ground state to excited state. “We showed there is no rise in energy. A minute temperature just above absolute zero is sufficient to excite the system. The system then becomes slightly magnetic, which increases with temperature,” explains Philippe Mendels.

Using experience

The challenge for researchers is to develop this material, to understand it better, and to exploit its amazing properties, with a view to generating new physical concepts. “What are the effects of possible changes to the kagome lattice on the properties of the material?” wonders Philippe Mendels. “For example, by replacing certain atoms, we will be able to observe if the kagome lattice is preserved, and distinguish properties caused by copper atoms from those due to other atoms.” Fabrice Bert adds: “Herbertsmithite is a very good insulator. If we succeed in adding free moving charges, we may discover very original transport properties.”

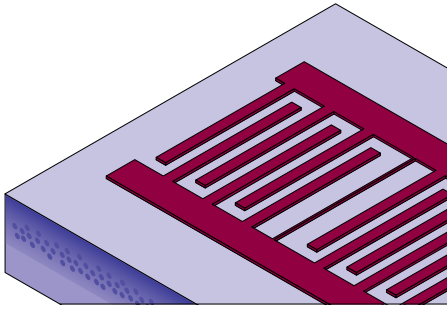
“The discovery of herbertsmithite was fundamental. It has allowed us to test theoretical predictions established in the 80s about spin liquids in experiments.”

Philippe Mendels

One thing is for sure: “The discovery of herbertsmithite was fundamental. It has allowed us to test theoretical predictions established in the 80s about spin liquids in experiments,” says Philippe Mendels. It is now a very fast-moving field. Other materials have joined this strange family, such as Sr-vesignieite or DQVOF, a vanadium oxyfluoride that does not exist in nature. “It is often the discovery of new materials that triggers our experiments,” agrees Philippe Mendels.



When spins cool



In the Condensed Matter Physics laboratory (SPEC – UPSaclay, CEA, CNRS) in the Quantronics group, other spins with strange behaviour in a crystal are attracting the attention of Patrice Bertet and his colleagues. Their recent work promises to boost the detection of signals by NMR or by electronic paramagnetic resonance (EPR), the equivalent of NMR for electronic spins. *“It is the polarisation (or alignment) of spins, initiated by the application of an external magnetic field, when performing a magnetic resonance experiment, that determines the strength of the signal transmitted during their relaxation after excitation. The signal coincides with the temperature of the crystal in which the spins are located: it is polarisation at thermal equilibrium,”* explains Patrice Bertet. *“To increase the signal, we try to increase either the intensity of the applied magnetic field, or the polarisation of spins beyond the authorised limited temperature, which is called hyperpolarisation.”* Following this last principle, researchers from SPEC developed an original radiative cooling method and succeeded in hyperpolarising electronic spins at a temperature lower than that of the sample.

“At low temperatures, an electronic spin spontaneously emits a photon every 10^{12} seconds – that’s every 32,000 years!”

Patrice Bertet

To do so, they reversed the balance between the mechanisms used by the spins to recover thermal equilibrium. *“When a system is excited in condensed matter physics – such as nuclear or electronic spins in an NMR or EPR experiment – balance can be achieved by exchanging a quantum of energy with the environment: either the emission of a photon (radiation) or a phonon (vibration),”* says Patrice Bertet. Spontaneous

emissions of photons are possible, but very rare: *“At low temperatures, an electronic spin spontaneously emits a photon every 10^{12} seconds – that’s every 32,000 years!”* The main relaxation mechanism used by spins is coupling with phonons, which thermalise at the temperature of the crystal structure. *“It is the temperature required to make atoms vibrate.”* To decrease even further, relaxation by spontaneous emission of photons must increase.

Using microwave containment

The researchers succeeded using a resonant microwave cavity. They first inserted bismuth atoms into a silicon crystal matrix, then coupled the electronic spins supplied by the system to a concentrated microwave electromagnetic field in the resonator. Using a coaxial cable, they connected the resonator initially at a temperature of 850 mK to a 20 mK cooled resistor. *“Using the microwave resonator, we increased interaction between spins and the electromagnetic field until microwave photon emission became the dominant mechanism of relaxation toward the equilibrium of spins. This is called the Purcell effect: spins thermally decouple from the crystal. Their temperature is entirely determined by the microwave field, not by the phonons.”* By measuring the RPE signal – 2.3 times higher – the researchers concluded that the microwave radiation cooled the spins to a temperature of 350 mK.


The method does not apply directly to nuclear spins, but it is possible to combine it with the dynamic nuclear polarization (DNP) technique, which uses electronic spins to hyperpolarise nuclear spins. To go beyond the physical limit imposed by the temperature of the cold source, researchers plan to use a mechanical or electrical oscillator. *“It will be possible to actively cool spins to a temperature much lower than the cryostat,”* says Patrice Bertet. The future of the search for new properties is assured.



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<p>Journal</p> <p>TECHNOLOGY NETWORKS <i>Exploring the Science That Matters to You</i></p>	<p>Journal</p> <p>The Economist</p>	<p>Journal</p> <p>ET Healthworld.com</p>
<p>Title</p> <p>EVIDENCE OF SARS-COV-2 TRANSMISSION ACROSS THE PLACENTA</p>	<p>Title</p> <p>HOW FRANCE CREATED A UNIVERSITY TO RIVAL MIT</p>	<p>Title</p> <p>HOW AI COMPUTATIONAL MODEL IS BEING USED TO FIGHT COVID-19</p>
<p>A study published in Nature Communications presented evidence of transplacental transmission of SARS-CoV-2 from an infected mother to her unborn child. The mother had been infected with SARS-CoV-2 during the third trimester of pregnancy, developing associated clinical signs, including coughing and pyrexia.</p> <p>www.technologynetworks.com/tn/news/evidence-of-sars-cov-2-transmission-across-the-placenta-337457</p>	 <p>A huge modernist university campus is emerging amid farmland on a plateau south of the French capital. The University of Paris-Saclay, officially launched this year, merges some 20 higher-education and research institutions. It has a teaching and research staff of 9,000, catering to 48,000 students – more than Harvard or Stanford.</p> <p>www.economist.com/europe/2020/08/29/how-france-created-a-university-to-rival-mit</p>	<p>Researchers are using the model to help clinicians in repurposing antivirals, disease diagnosis and detecting infection spread. In their efforts to fight the pandemic, academic institutions have been working overtime on various innovative strategies.</p> <p>www.health.economictimes.indiatimes.com/news/health-it/how-ai-computational-model-is-being-used-to-fight-covid-19/77144531</p>

<p>Journal</p> <p>FUTURITY</p>	<p>Journal</p> <p>LIST•SOLAR</p>	<p>Journal</p> <p>Technology News World</p>
<p>Title</p> <p>METHANE EMISSIONS HIT RECORD-BREAKING LEVELS</p>	<p>Title</p> <p>MACHINE-LEARNING FOR PV MODULE CLEANING</p>	<p>Title</p> <p>BEYOND THE MILKY WAY-DISCOVERED GALACTIC WALL</p>
 <p>Global emissions of methane have reached the highest levels on record, research shows. Growth of emissions from coal mining, oil and natural gas production, cattle and sheep ranching, and landfills are primarily driving the increases.</p> <p>www.futurity.org/methane-emissions-record-levels-2404792-2/</p>	<p>French researchers have actually established a machine-learning model to clean low-power PV projects and also standalone solar arrays in backwoods separated from the grid. Researchers from France's Sorbonne Université, the École Normale Supérieure de Rennes (ENS Rennes), and also the University of Paris-Saclay have actually recommended a new machine-learning modern technology created to facilitate the organizing of PV module cleansing operations.</p> <p>www.list.solar/news/machine-learning/</p>	 <p>Recently astronomers have discovered that Milky Way is a huge wall made up of thousands of galaxies, of clusters of trillions of stars and worlds, as well as the dust and gas arranged in the form of a curtain crossing at least 700 million light years of space.</p> <p>www.tech-news.websawa.com/beyond-the-milky-way-discovered-galactic-wall/</p>

CAMPUS LIFE

Campus and pandemic – P3 lab

Title

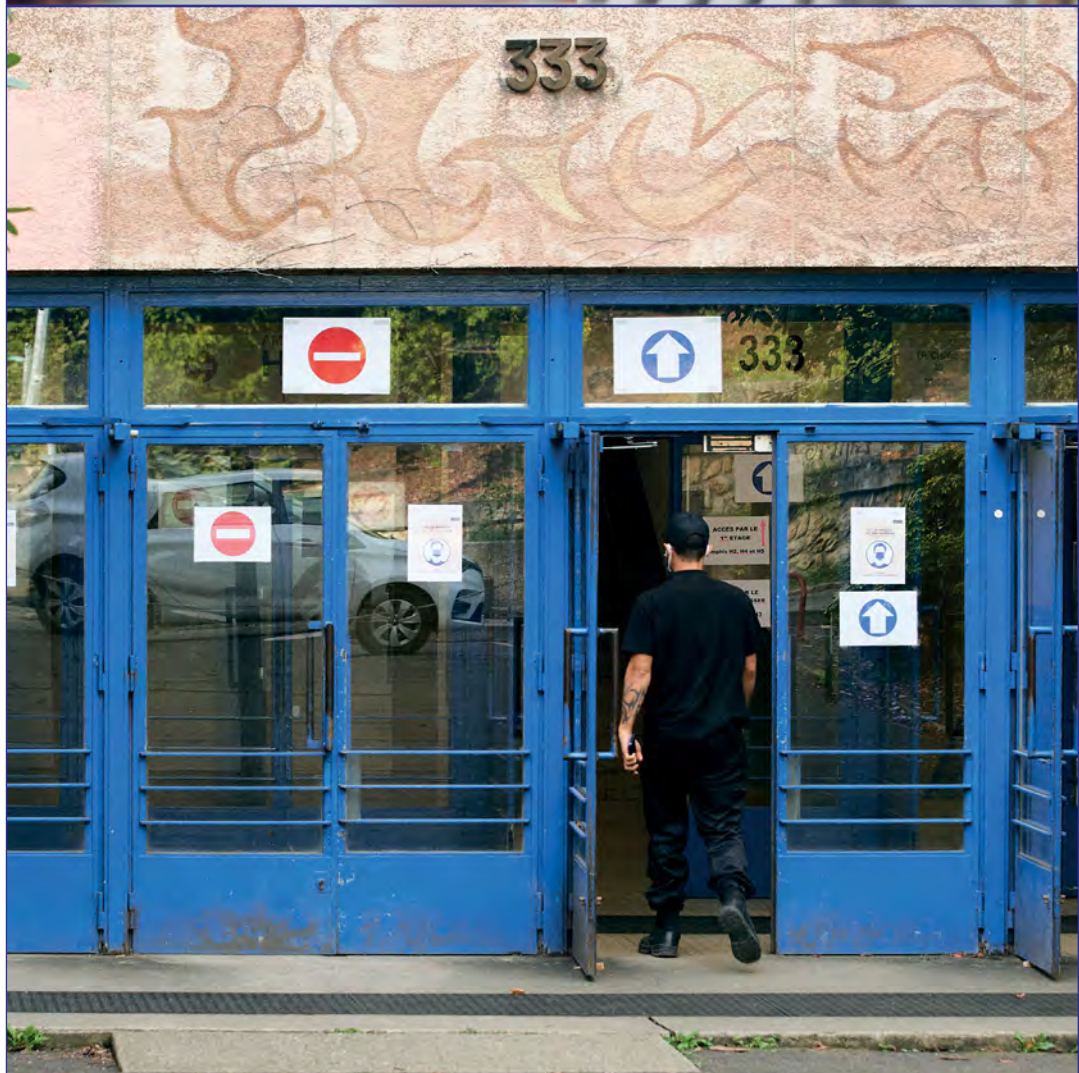
Campus life in the Covid era

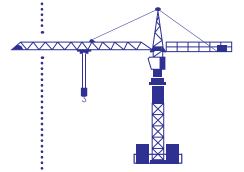
“The current health situation requires everyone’s constant attention, but we must continue to provide our range of quality services to students,” declares Hervé Rivières, head of student life at Université Paris-Saclay. With the application of government measures, certain disruptions to student life and the organisation are inevitable.

Since the start of the academic year, the University has set up a mask donation scheme with the help of Paris-Saclay University Foundation and a private company: one mask offered to all students and three additional masks to those receiving individual social assistance from the University or in difficulty. A major digitisation of the tools has been launched and access to them makes it easier to support vulnerable students with, in particular, the support of the AGORAE association. The mask is compulsory in the university canteen, cafeterias, common areas of student residences, libraries and sports facilities except when practising sports. Anti-bacterial hand gel must be available at all times, and premises must be cleaned and ventilated. Areas have been reorganised to ensure social distancing is possible and authorised capacities have been halved.

The network’s 33 libraries have been applying the same measures since reopening on 1st October. “Usually the place for meeting and exchange, there is currently very little group work,” says Julien Semperé, director responsible for libraries. New services are being created, such as the possibility to book a space in the library on the Affluences application, and library opening hours have been extended. As the campus is also applying hybrid learning practices, the number of computers and software has been increased so students can follow their courses online.

Started at the end of September, the sports courses offered by SIUAPS also show undeniable changes. Only the thirty or so sports available as teaching units remain and are also accessible as campus sports. “We have adapted activities to optimise protection for participants,” explains Patrick Maupu, director of the SUAPS programme. “Teachers apply health and education protocols to limit face-to-face or contact, reduce the length of games or avoid equipment sharing.” Subscribers are only eligible for one course per week this year. Bookings are required for the weight room, and access is limited to one hour per day. Some courses are already full, while others are off to a slower start.





Title

A maximum-security laboratory for studying pathogenic organisms in the Saclay area



© LPBA – UPSaclay

ENS Paris-Saclay recently moved to Gif-sur-Yvette, adding a P3 containment laboratory designed to study Class 3 pathogens to the Saclay arsenal. These microorganisms usually cause serious human disease, but in most cases, effective prophylaxis or treatment exist. The P3 laboratory is located in the ENS Paris-Saclay building in the Laboratory of Applied Biology and Pharmacology (LBPA–UPSaclay, ENS Paris-Saclay, CNRS).


“A P3 laboratory protects the environment and workers from possible contamination by the organisms studied,” explains Frédéric Subra, research engineer at the LBPA and responsible for the site. It accommodates eight people, distributed in two independent sections. As a result, different modes of virus transmission can be studied in the two areas: aerosol-borne such as SARS-CoV-2 in one, and blood-borne viruses such as HIV in the other.

The containment laboratory is managed by a committee of users who decide on applications for use. *“All Saclay users are welcome to work in the P3 lab, as long as we can regulate the projects,”* says Frédéric Subra. The LBPA is already working with other local entities, such as the Institute for Integrative Biology of the Cell (I2BC – UPSaclay, CEA, CNRS), and hopes for more, for example with the Châtenay-Malabry pharmacy faculty which will take up residence in the future biological, pharmacy and chemistry pole currently under construction, or with the Servier laboratory, also being set up on the site. The new P3 will undoubtedly generate new interactions and be useful to many of the university’s research projects.



© Christophe Peus – UPSaclay



<p>Due to the current Covid-19 pandemic and the ensuing uncertainty, the following events may be delayed or cancelled after this information is published.</p>			<p>Date: 16 Place: Saint-Aubin Host: Université Paris-Saclay</p>			<p>Date: 26 Place: Palaiseau Host: Institut d'Optique Graduate School</p>		
<p>WE WERE THERE</p>			<p>5TH EDITION OF THE SYSTEMS AND COMPLEX MATTER DAY (2020)</p> 			<p>Photonics Excellence Days</p> 		
<p>OCTOBER</p>			<p>PHOTONICS EXCELLENCE DAYS 2020</p>			<p>PHOTONICS EXCELLENCE DAYS 2020</p>		
<p>Date: 15 Place: Online Host: Université Paris-Saclay</p>			<p>Description</p> <p>The community specialised in complex matter and systems meets and exchanges about research themes that broadly cover disordered systems, complex fluids, complex dynamics, statistical approaches, multiscale materials and biological systems.</p> <p>www.universite-paris-saclay.fr/evenements/journee-systemes-matiere-complexes-5eme-edition</p>			<p>Description</p> <p>This event focuses on the latest photonic innovations covering themes such as quantum optics, laser systems and materials processing, instrumentation and diagnostics, sensors and imaging, and communication and networks. Industry players, SME/ETI, start-ups and photonics laboratories present their latest technological innovations in conferences and roundtables with exclusive demonstrations.</p> <p>www.systematic-paris-region.org/evenement/photronics-excellence-days-2020/</p>		
			<p>Date: 17 – 18 Lieu: Online Host: Université Paris-Saclay</p>			<p>DECEMBER</p>		
<p>#ERASMUSDAYS AT UNIVERSITÉ PARIS-SACLAY: ERASMUS+ FUNDING INFORMATION DAY</p> <p>Towards Erasmus 2020 – 2021: academic staff discovered the opportunities for European funding for education.</p> <p>www.universite-paris-saclay.fr/evenements/erasmusdays-de-luniversite-paris-saclay-journee-information-financements-erasmus</p>			<p>CARADOC 2020 – CAREERS AND DOCTORS CONVENTION</p> 			<p>Date: 19 Place: Évry Host: Université d'Évry</p>		
<p>DON'T MISS IT</p>			<p>Description</p> <p>Online workshops, roundtables, stands and networking for doctoral students and young researchers who want to improve their skills and develop their career project.</p> <p>www.caradoc-paris-saclay.fr</p>			<p>WOMEN AND MEN TALK ABOUT EQUALITY</p> 		
<p>NOVEMBER</p>			<p>Date: 18, 19, 20 Place: Gif-sur-Yvette Host: ENS Paris-Saclay</p>			<p>Description</p> <p>An event for exchange, dialogue and debate about gender equality with the prevention of violence against women as underlying theme.</p>		
<p>Dates: 12 – 14 Place: Château de Villiers -le-Mathieu Host: Labex LERMIT, Ariis, Aviesan, Inserm, Leem</p>			<p>"ARIANNA – A FANTASY ON A DESERTED ISLAND"</p> 			<p>THERAPEUTIC INNOVATION SCHOOL 2020</p> 		
<p>Title</p>			<p>Description</p> <p>The <i>Scène de Recherche</i> stages this show based on Monteverdi's lost opera. Ariane was sent into orbit, and can tell similar tales to Valentina Terechkova, the first woman to travel into space and the only woman to have experienced the space vacuum alone. Based on an ongoing space mission, the show demonstrates the associations between different fields of art and science.</p> <p>https://ens-paris-saclay.fr/agenda/arianna</p>			<p>Description</p> <p>After selection by an expert jury, 40 researchers from the private and public sectors and 40 PhD students will learn about the complexity of pharmaceutical R&D over 3 days of lectures, workshops and networking.</p> <p>www.evenium-site.com/site/jrs-eit-ecole-de-l-innovation-therapeutique-2020;jsessionid=tbXKoErlHiWYzJ5aH9iQgAR.glj3</p>		

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READING
HIGHLIGHTS



“La Quantique Autrement” – a new approach to quantum physics
Julien Bobroff, researcher at the Laboratory of Solid Physics (LPS - UPSaclay, CNRS) takes on this physics monument to reveal its wonders, with no equations or historical presentation.

256 pages. Éditions Flammarion.

The Conversation

The Bioethics Law – bioethics or biopolitics?

Emmanuel Hirsch, professor of medical ethics at Université Paris-Saclay’s Faculty of Medicine, and Valérie Depadt, lecturer in law at Sorbonne Université Paris Nord investigate the bioethics bill which was discreetly passed this summer in the French Assemblée Nationale.

www.theconversation.com/loi-relative-a-la-bioethique-quand-bioethique-rime-avec-biopolitique-143477

Comic book: Pourquoi mettre des fermes dans les villes? (Why put farms in cities?)
Urban microfarms are booming and researchers are taking an interest in this new development. Baptiste Grard, researcher at the Functional Ecology and Agroecosystem Ecotoxicology laboratory (ECOSYS - UPSaclay, INRAE, AgroParis-Tech), and Mathieu Ughetti, illustrator, have published a comics to explore this surprising form of agriculture.

www.theconversation.com/bd-pourquoi-mettre-des-fermes-dans-les-villes-142107

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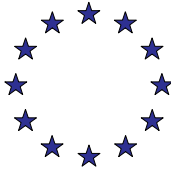

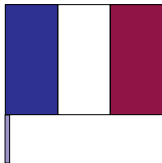

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