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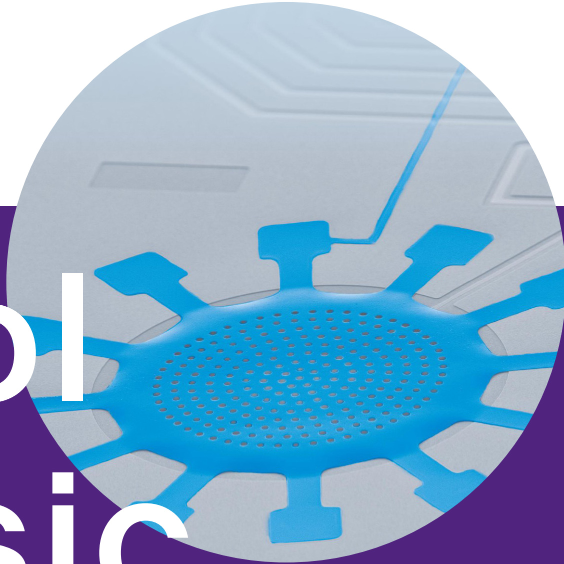
# School of Basic Sciences SB



ANNUAL REPORT 2023

IPHYS ISIC MATH

School of Basic Sciences SB

EPFL

# DEAN'S FOREWORD

Dear Friends, Supporters, and Colleagues,

It is with great pleasure that we present to you the Annual Report for the School of Basic Sciences at EPFL. As we reflect on the accomplishments and advancements of the past year, we are filled with gratitude for the dedication and collaborative spirit that defines our community.

The School of Basic Sciences at EPFL continues to be at the forefront of groundbreaking research, innovation, and education in the fundamental sciences. From exploring the mysteries of quantum systems to deciphering the complexities of biological systems, our faculty, researchers, and students are pushing the boundaries of knowledge. Moreover, our interdisciplinary approach fosters collaboration across traditional boundaries, leading to innovative solutions to some of society's most pressing challenges related to sustainability and health.

Our faculty members have made significant strides in a wide range of disciplines and not surprisingly receive many honors and awards, ranging from prestigious named lectureships, honorary doctorates, and national and international prizes, a selection of which are described in the Annual Report. I was especially proud to see Lesya Shchutska being honored by the Swiss Science Latsis Prize, joined by Philippe Brantut receiving the EPFL Latsis Prize, two of our young colleagues excelling in their fields of research.

2023 was also a year for outreach, ensuring a bright future by exciting bright young minds. We celebrated the EPFL open days, 30 years of fusion research, La fête des Maths and numerous other public events.

Despite the challenges imposed by ever increasing student numbers, compounded by budget cuts, our commitment to education is unwavering, and we take great pride in nurturing the next generation of scientific leaders. Through our rigorous academic programs, cutting-edge research opportunities, and hands-on learning experiences, we are equipping our students with the knowledge, skills, and mindset needed to make meaningful contributions to society.

As we look to the future, we remain excited about the possibilities that lie ahead. With continued collaboration, innovation, and dedication, we are confident that the School of Basic Sciences at EPFL will remain at the forefront of scientific discovery and education, helping to shape the world for the better. Beyond our Annual Report, you can discover more about the School of Basic Sciences by visiting our website at **www.epfl.ch/schools/sb**.

Thank you for your continued support and partnership.
Sincerely,

PAUL DYSON
Dean of the School of Basic Sciences, EPFL

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# PRIZES AND AWARDS

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# Lesya Shchutska wins the Swiss Science Prize Latsis 2023


© Daniel Rihs

**"I am delighted to receive the Latsis Prize. I'm also surprised, though – given that I haven't made a major discovery in particle physics." Lesya Shchutska, professor at EPFL, is clearly being modest about her achievements. But she is realistic, too: "Since the existence of the Higgs boson was discovered in 2012, there is no longer really any theory left to verify in particle physics", she explains.**

Indeed, scientists are not expecting great discoveries. The Standard Model was formulated some 50 years ago and brings together all the discoveries made in particle physics. It functions well with its 17 elementary particles explaining ordinary matter, of which the Higgs boson was the most recently discovered. However, this model also has a number of weaknesses which physicists are trying to explain. "More specifically, we are looking to fill the gaps in the Standard Model in places where it does not explain certain observations or phenomena, such as dark matter."

The 37-year-old researcher is working on this with her team, as well as with colleagues in numerous institutes throughout the world. It is for her brilliant work in the field of "new physics", and more specifically her research into particles that would expand the Standard Model, that she has been awarded the Swiss Science Prize Latsis 2023 by the Swiss National Science Foundation.

Lesya Shchutska has had a keen interest in physics for as long as she can remember; this was encouraged by her engineer father, who gave her books about science in an effort to satisfy her curiosity. At the age of 16, the young Ukrainian was a member of the national team at the International Physics Olympiad in Indonesia, where she won a bronze medal. This distinction earned her a place at the prestigious Moscow Institute of Physics and Technology, which has a notable reputation for physics. That was the start of her rapid career progression.

A few years later, we are interviewing Lesya Shchutska in her office on the sixth floor of EPFL, where she explains what lies at the heart of her current research. It all hinges on collisions between known particles which, under special conditions – e.g. at high energy – could produce new particles. And these particles decay into known particles which can be detected. It is for this purpose that the young scientist devises experiments, measures, calculates, analyses data, imagines, checks… and starts all over again.

Lesya Shchutska does in fact have access to a great deal of data to analyse, derived from experiments on particle collisions – particularly between protons. To this end, she works on various experiments at CERN in Geneva, seeking in particular to prove the existence of heavy neutrinos where the Standard Model only assumes the existence of low mass neutrinos. The theory that heavy neutrinos exist was formulated by Professor Mikhail Shaposhnikov of EPFL to reconcile the Standard Model with certain unexplained phenomena such as the nature of dark matter. "I have a soft spot for that theory," admits Lesya Shchutska. "Because if you prove the existence of heavy neutrinos, nothing else is required to explain the limitations of the Standard Model." However, these particles, if they exist, are very difficult to detect because they interact very weakly with known particles.

Although Professor Shchutska has not found them yet, she has not given up hope and is tirelessly exploring new avenues. She is one of the people behind the development of the neutrino detector at CERN as part of a recent experiment. In addition, she may soon be able to use even more powerful tools that will push the current boundaries of research. "We should be able to carry out five to ten times as many collisions in a few years' time," she enthuses.

At EPFL, Lesya Shchutska also collaborates with other scientists within CERN experiments aiming at measuring very precisely rare decays of known heavy particles; if the results deviate too much from what the Standard Model predicts, they could also reveal the existence of a new physics. Indeed, the scientific community had large aspirations, because since 2014, there were hints of measured deviations from the very precise theoretical predictions in a particular particle decay, interpreted as the possible presence of a new force that would couple together two kinds of particles. Recently, however, Professor Shchutska, together with her colleagues at EPFL and other universities, dashed these hopes when she found a way to demonstrate that the measured deviations were accounted for by processes from the Standard Model, which were tricking the detector.

What if she herself were never to make a crucial discovery? "That is of course a possibility. Whatever happens, the experiments we are conducting allow certain hypotheses to be eliminated, which is also a way of contributing to scientific progress. And our developments have other applications too, including in medicine and data analysis."

# Ambrogio Fasoli appointed director of EUROfusion

© EPFL N. Schopfer

**Professor Ambrogio Fasoli is currently serving as Director of the Swiss Plasma Center and Associate Vice President for Research at EPFL, and also holds the position of Chair of the General Assembly of the European Consortium for Fusion Energy, EUROfusion.**

He studied at the University of Milan and obtained his PhD at EPFL, then, after conducting experiments on the European JET tokamak, became a professor at MIT, where he worked from 1997 to 2001, before being appointed at EPFL. From 2014 through 2020 he has been the Editor-in-Chief of the Nuclear Fusion journal, of the International Atomic Energy Agency. He is a Fellow of the American Physical Society.

In his forthcoming role, Professor Fasoli will take charge of the EUROfusion Programme Management Unit (PMU) and will be responsible for the programme's strategic execution. His comprehensive understanding and vast experience in fusion energy research position him aptly to drive innovation, collaboration and integration in his new role.

The appointment of Professor Fasoli occurs during a critical period for fusion energy research. It is expected that his leadership will effectively address the current challenges of the European fusion energy research community and steer the programme towards new scientific advancements.

Professor Fasoli's tenure as the Programme Manager Elect of EUROfusion will officially commence on January 1, 2024.

The Swiss Plasma Center at EPFL extends its heartfelt congratulations to Professor Fasoli in his new role.

# Jean-Philippe Brantut wins 2023 EPFL Latsis Prize


© EPFL Alain Herzog

**Professor Jean-Philippe Brantut at EPFL's School of Basic Sciences has been honored with the prestigious 2023 EPFL Latsis Prize.**

The Latsis Prizes are a series of prestigious awards that recognize outstanding young researchers for their significant scientific and technological contributions in Switzerland. The Prix Latsis Universitaires, in particular, are awarded to scholars who have demonstrated exceptional promise in their respective fields, with a focus on the impact and originality of their research. These accolades underscore the foundation's dedication to encouraging promising talents in the early stages of their academic careers.

The 2023 EPFL Latsis Prize has been awarded to Professor Jean-Philippe Brantut at EPFL's School of Basic Sciences. The Prize honors Brantut's groundbreaking research in quantum gases and quantum optics. His work delves into the complex interactions of Fermi gases within optical cavities, exploring the intricate dance between light and matter.

Brantut's research has led to significant insights into light-matter interactions in interacting Fermi gases, such as the observation of pair-polaritons. His laboratory has been at the forefront of quantum simulation using atoms and photons, with the realisation of random spin models or density-wave order induced by light. This contributes to our understanding of quantum many-body systems and their potential applications to quantum simulation or even gravity.

The innovative techniques developed in Brantut's lab, such as the cavity-assisted preparation and detection of Fermi gases, have opened new avenues for examining the quantum world with unprecedented precision.

# Annalisa Buffa named 2023 Sonia Kovalevsky Lecturer


© Association for women in Mathematics

**The Association for Women in Mathematics and the Society for Industrial and Applied Mathematics have selected EPFL mathematician Annalisa Buffa to deliver the 2023 Sonia Kovalevsky lecture.**

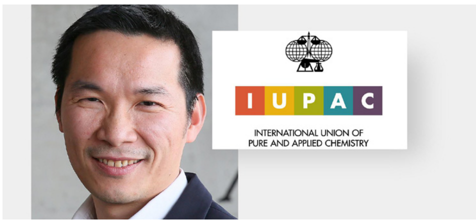
The Kovalevsky Lecture honors Sonia Kovalevsky (Sofya Kovalevskaya, 1850–1891), one of the most widely known Russian mathematicians of the late 19th century who is known for her important work in the theory of differential equations.

This year, the Association for Women in Mathematics (AWM) and the Society for Industrial and Applied Mathematics (SIAM) have selected EPFL mathematician Annalisa Buffa to deliver the 2023 Sonia Kovalevsky lecture.

In an announcement, the AWM cites Professor Annalisa Buffa as "among the most influential applied mathematicians of her generation; she has made pioneering contributions to modelling electromagnetism in non-smooth domains and the corresponding numerical methods." The announcement mentions that "she has contributed substantially to optimising the interplay of geometry and analysis in the simulation of solids and structures," and concludes that "these results are of seminal importance as they impact engineering applications and industrial mathematics, as well as offer deep contributions to the development and analysis of numerical methods in their own right."

"I love to work at the interface of mathematics and applications," says Buffa. "I am proud to be a woman working in hard sciences, and I am really honoured to be named the 2023 Sonia Kovalevsky Lecturer!"

# Xile Hu wins IUPAC-ZHEJIANG NHU International Award




© EPFL Alain Herzog

**Professor Xile Hu has been honoured with the IUPAC-Zhejiang NHU International Award 2023.**

Established in 2019, the IUPAC-Zhejiang NHU International Award honours advancements in Green Chemistry and their impact on human progress. Among the winners of the 2023 IUPAC-Zhejiang NHU International Award is Professor Xile Hu at EPFL's School of Basic Sciences, who received the "Experienced Chemist" Award. The IUPAC announcement cites Professor Hu:

"The group of Professor Xile Hu has made many outstanding scientific discoveries in the field of Green Chemistry, particularly in Green Catalysis and Green Energy. In the area of green catalysis, they have developed new catalytic methods and catalysts that are based on earth-abundant elements for organic synthesis. In the area of green energy, Prof. Hu and his team have developed a number of novel earth-abundant electrocatalysts for the hydrogen and oxygen evolution reactions (HER and OER), which are the two half-reactions for water splitting, the main route to green hydrogen. They have made significant contributions to highly active earth-abundant catalysts for the hydrogen oxidation reaction, the key anodic reaction in fuel cells. Their work is not only of fundamental value but has significant potential in industrial applications. For example, a start-up company, NovaMea SA, has been founded based on their work in green energy."

Professor Hu and the other winners of the were recognized at the 2023 IUPAC World Chemistry Congress in The Hague (18-25 August 2023).

# Award at CERN for two IPHYS technicians


© EPFL Frederic Blanc

**On the 7th of June 2023, Rodolphe Gonzalez, precision mechanic at the IPHYS mechanical workshop, and Norbert Adjadj, mechanic at the High Energy Physics Laboratory (LPHE), obtained high-level recognition from the LHCb Collaboration at CERN, consisting of more than 1100 scientists from 21 countries, and received the LHCb Technical Award 2023 for their "outstanding contribution to the construction and installation of SciFi detectors."**

The LHCb experiment at CERN aims at measuring fundamental properties of matter and interactions with high precision, in particular through the weak decays of heavy flavour hadrons. LPHE scientists have been members of the LHCb collaboration at CERN since its foundation. They have participated in the construction and operation of the detector, and in the analysis of the data. With the data collected between 2011 and 2018, over 600 scientific papers have been published.

Since 2019, the LHCb detector has undergone a major upgrade. One of the new detectors, used for tracking charged particles, is based on the technology of scintillating fibres read out with Silicon photomultipliers (SiPMs). The LPHE scientists played a major role in developing this technology and in the construction of the "SciFi Tracker" detector. During the construction, Norbert Adjadj and Rodolphe Gonzalez were involved in the manufacturing of 500 scintillating fibre arrays. With the precious help from the IPHYS workshops, their dedication to precision and efficiency allowed to reach the production quality under the tight time constraints imposed by the project timeline.

The installation of the SciFi Tracker in the LHCb cavern at CERN started in 2019. Rodolphe Gonzalez and Norbert Adjadj were first involved in the preparation of the mechanical infrastructure in which the detector elements would be installed. During the COVID-19 pandemic, while travel was restricted in most of Europe, they provided the main technical support ensuring the continuation of the detector installation. In March 2022, the final adjustments to the alignment of the detector was done with the help of the EPFL technicians, and the detector was ready for taking data for the restart of the LHC accelerator in Spring 2022.

The quality of the work of Rodolphe Gonzalez and Norbert Adjadj and their enthusiasm at all stages of the construction and installation of the detector was recognised by the LHCb collaboration, leading to this well-deserved LHCb Technical Award 2023.



# Prof. Mats Stensrud wins two awards for young statisticians

© EPFL

**Prof. Mats Stensrud, head of the Chair of Biostatistics (BIOSTAT) has been awarded both the Arthur-Linder prize by the Austria-Switzerland region of the International Biometric Society (IBS, ROeS) and the Lambert Prize by the Swiss Statistical Society (SSS).**

Professor Mats Stensrud, head of the Chair of Biostatistics at EPFL, has been awarded two prizes for young researchers.

The Arthur Linder prize is awarded every two years to a researcher below 35 years. This year's ceremony took place at the Central European Network conference in Basel, where Prof. Stensrud gave an invited talk. The prize was awarded in recognition of a rare combination of outstanding theoretical results and highly relevant practical applications present in Prof. Stensrud paper entitled "Conditional Separable Effects" first published online in the Journal of the American Statistical Association in 2022.

The Johann Heinrich Lambert Award is given every three years to recognize outstanding contributions in all areas of statistics by researchers below 35 years. Prof. Stensrud received this year's award for his contributions in causal inference and biostatistics.

# Lyndon Emsley wins 2023 Günther Laukien Prize


© EPFL, Alain Herzog

**Prof. Lyndon Emsley at EPFL is one of two winners of the 2023 Günther Laukien Prize, the most prestigious award in magnetic resonance research, for his cutting-edge research into nuclear magnetic resonance that has enabled new applications. Emsley shares the Prize with Dr Anne Lesage at ENS-Lyon.**

The Günther Laukien Prize was established in 1999 to honour the memory of Professor Günther Laukien and recognizes "cutting-edge experimental nuclear magnetic resonance research with a high probability of enabling beneficial new applications."

The 2023 Günther Laukien Prize recognizes their cutting-edge research into solid-state NMR spectroscopy, and especially the development of surface enhanced NMR spectroscopy.

Emsley is Professor of Physical Chemistry at EPFL. His research focuses on developing new NMR spectroscopy techniques to solve a range of problems across disciplines, and primarily aims at determining the atomic-level structure and dynamics of complex materials and molecular systems. Emsley has introduced new concepts in NMR spectroscopy to increase sensitivity and resolution, such as dynamic nuclear polarization (DNP) and methods to obtain high-resolution 1H spectra in solids. He has also developed new computational methods to model structure and to efficiently predict and extract NMR chemical shifts in solids.

# Teaching Awards

## BEST TEACHER AWARD OF THE MATHEMATICS SECTION

**José Luis Zuleta**

## BEST TEACHER AWARD OF THE PHYSICS SECTION

**Jean-Philippe Brantut**

## BEST TEACHER AWARD OF THE SECTION OF CHEMISTRY AND CHEMICAL ENGINEERING

**Horst Pick**

# Doctoral Schools Thesis Awards

## MATHEMATICS DOCTORAL THESIS AWARD

**Kartik Waghmare**
FOR HIS THESIS
*"Positive Definite Completions and Continuous Graphical Models"*
UNDER THE SUPERVISION OF
Prof. Victor Panaretos

## PHYSICS DOCTORAL THESIS AWARD

**Baptiste J. Frei**
FOR HIS THESIS
*"A Gyrokinetic Moment Model of the Plasma Boundary in Fusion Devices"*
UNDER THE SUPERVISION OF
Prof. Paolo Ricci

**Stefano Falletta**
FOR HIS THESIS
*"Self-Interaction and Polarons in Density Functional Theory"*
UNDER THE SUPERVISION OF
Prof. Alfredo Pasquarello

**Lorenzo Talamanca**
FOR HIS THESIS
*"Statistical Physics of Periodic Biological Processes"*
UNDER THE SUPERVISION OF
Prof. Paolo De Los Rios and Felix Naef

## CHEMISTRY AND CHEMICAL ENGINEERING DOCTORAL THESIS AWARD

**Lorenz P. Manker**
FOR HIS THESIS
*"Acetal-stabilized carbohydrates as novel platform molecules for renewable polymer production"*
UNDER THE SUPERVISION OF
Prof. Jérémy Luterbacher

**Rémi Andres**
FOR HIS THESIS
*"Catalytic enantioselective Pictet-Spengler reaction of carbonyl compounds: Development and application to the asymmetric total synthesis of indole alkaloids"*
UNDER THE SUPERVISION OF
Prof. Jieping Zhu

# External Thesis Awards

## A SWICCOMAS PRIZE 2023

**Alice Cortinovis**
FOR HIS THESIS
*"Fast deterministic and randomized algorithms for low-rank approximation, matrix functions, and trace estimation"*
UNDER THE SUPERVISION OF
Prof. Daniel Kressner

## SWISS NANOTECHNOLOGY PHD AWARD


**Amir Youssefi**
*"for excellent scientific first-author publications in the field of Nanotechnology and Nanoscience published by PhD students."*
UNDER THE SUPERVISION OF
Prof. Tobias Kippenberg

# Bachelor and Master Students Prizes and Awards

## MATHEMATICS

**Gaëtan Emmanuel Mancini**
Prix Douchet for best Master's average (5.94) of the Section of Mathematics and Prix EPFL for best average of all EPFL Master studies
**Julie Estelle Marie Bannwart**
Prix EPFL for best average (5.99) of all EPFL in Bachelor studies (all sections)
**Patrick-Cristian Dan**
Prix EPFL (ex aequo) for best average (5.98) in CP studies (all sections)
**Sandro Pfammatter**
Prix EPFL (ex aequo) for best average (5.98) in CP studies (all sections)

## PHYSICS

**Zeno Tecchiolli**
Prix EPFL for the 3$^{rd}$ best Master's average (5.90) and Gilbert Hausmann Prize for his Master's project under the supervision of Prof. Paolo Ricci
**Gaia Bolognini**
Gilbert Hausmann Prize for her master's project under the supervision of Prof. Jean-Philippe Brantut

## CHEMISTRY AND CHEMICAL ENGINEERING

**Damien Chen**
Firmenich Prize for best master project in Chemistry
**Noémie Hu**
Firmenich Prize for best master project in Chemical Engineering
**Damien Chen**
Prix Syngenta for best Master's average in Chemistry (5.77)
**Jiaming Tian**
Prix Syngenta for best Master's average in Chemical Engineering (5.73)

# FACULTY NEWS

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# Nominations

**Dr Radoslav Marchevski, previously Postdoctoral Researcher at Weizmann Institute of Science, Israel, has been appointed as Tenure-Track Assistant Professor of Physics as of January 1, 2023.**

Radoslav Marchevski's research lies in the field of particle physics, with special reference to kaon decay. He was closely involved with the NA62 experiment in the SPS accelerator at the nuclear research centre CERN. His appointment brings new expertise to EPFL, ideally complementing that of already present in the existing high energy physics laboratory. In addition, Radoslav Marchevski will collaborate on the LHCb experiment, to which EPFL has already made a notable contribution at CERN. He will strengthen EPFL's strategic interests at CERN and help to significantly raise the Federal Institute of Technology's visibility.

**Dr Manuel Guizar-Sicairos, formerly Senior Scientist at PSI, has been appointed as Associate Professor of Physics as of January 1, 2023.**

Manuel Guizar-Sicairos' research investigates digital imaging for the next generation of X-ray sources, particularly for nanotomography. His work on the connectome is especially significant because it delivered the first X-ray images of mammalian synapses, for which he was recognised by the scientific community. The future research of this internationally acclaimed specialist could have a major impact on the neurosciences. At PSI, Manuel Guizar-Sicairos will be Group Leader for the mathematics and physics of imaging.

**Dr Michael Herbst, earlier Postdoctoral Researcher at RWTH Aachen University, Germany, has been appointed as Tenure-Track Assistant Professor of Mathematics and of Materials Science and Engineering, in the Schools of Basic Sciences (SB) and Engineering (STI) as of March 1, 2023.**

Michael Herbst works on the theory and modelling of the electronic structure of materials, at the interdisciplinary boundary of mathematics, computational materials science, and computer science. He develops efficient and reliable algorithms for the high-throughput screening of calculations for materials, a field in which he has already obtained significant results. The aim of the joint professorship at the two Schools is to develop a future-oriented research programme for both disciplines. Michael Herbst will have an important role to act as a bridge between the Institutes of Mathematics and Materials.

**Dr Laura Grigori, formerly Director of Research at the National Institute for Research in Digital Science and Technology (INRIA), France, has been appointed as Full Professor of Applied and Computational Mathematics starting on May 1, 2023.**

Laura Grigori's interdisciplinary research lies at the interface between numerical linear algebra, high-performance computing and their various applications. She is a global leader in the field of numerical algebra. At PSI she will head the Laboratory for Simulation and Modelling (LSM), thus taking a managerial role as well as acting as an important bridge between the two institutions.

# Promotions

**Professor João Penedones, former Tenure-Track Assistant Professor, has been promoted as Associate Professor of Theoretical Physics in the School of Basic Sciences (SB) starting from the 1st of June 2023.**

João Penedones works in the field of quantum field theory and quantum gravity. He is an internationally acknowledged expert on the bootstrapping procedure. His excellent teaching is reflected not only in very good evaluations from students, but also in the decisive part he played in setting up an internationally recognised course on high energy physics that attracts scientists from throughout the world. João Penedones currently runs the Fields and Strings Laboratory while also taking a leading role in the new Bernoulli Centre.

**Professor Jean-Philippe Brantut, formerly Tenure-Track Assistant Professor at EPFL, is appointed Associate Professor of Physics as of 1st of August 2023.**

Jean-Philippe Brantut's research has a focus on cold atomic gases and quantum simulations using innovative experiments assemblies that he developed in his laboratory. This work has placed him at the forefront of research into the physics of ultracold atoms in optical cavities. He and his team discovered a novel material for interactions between light and matter. His research attracted an ERC Starting Grant in 2016 and an ERC Consolidator Grant in 2022. He is very successful at obtaining research funding and is a dedicated teacher.

**Professor Fabio Nobile, previously Associate Professor at EPFL, is appointed Full Professor of Mathematics starting from the 1st of August 2023.**

Fabio Nobile's research is concerned with numerical fluid dynamics, multilevel analyses using random coefficient models, and mathematical methods of uncertainty quantification. His achievements with the multilevel Monte Carlo method are regarded by the scientific community as a breakthrough and have opened up a whole new field of research. This internationally acclaimed researcher combines innovative and collaborative approaches at the interface with other disciplines in order to produce specific applications relevant in a number of different fields, particularly engineering. His appointment will boost EPFL's reputation.

**Professor Paolo Ricci, anteriorly Associate Professor, is promoted to Full Professor of Plasma Physics starting from the 1st of October 2023.**

Paolo Ricci's main area of research is the theory of plasma physics. He is regarded as one of the leading researchers in this field and has been awarded numerous prizes. Among other achievements, he developed a comprehensive theoretical model based on fluid dynamics to describe the behaviour of the plasma boundary layer. This model has been implemented in a cutting-edge code used by numerous research groups throughout the world. At EPFL he is head of the theory group at the Swiss Plasma Centre. He is also a dedicated teacher and an active member of the physics community.

# Promotions



### Andrea Cavalli, Frédéric Blanc and Jérôme Scherer promoted to Adjunct Professor

**Professor Andrea Cavalli, currently Full Professor at the University of Bologna, Italy, and Director of the Centre Européen de Calcul Atomique et Moléculaire (CECAM) at EPFL, has been nominated as Adjunct Professor at EPFL.**

Andrea Cavalli is a world leader in the development and application of computer-assisted methods used in different research areas, including drug discovery and precision medicine. He applies machine learning to datasets obtained from industry and hospitals.

**Dr Frédéric Blanc has been awarded the title of Adjunct Professor in the School of Basic Sciences.**

Frédéric Blanc is a particle physicist who has devoted much of his career to developing, improving and analysing data from the Large Hadron Collider beauty (LHCb), one of the four main LHC experiments at CERN and one in which he has played a leading role. He also applies his expertise to other projects in areas such as medical physics.

**Dr Jérôme Scherer has been awarded the title of Adjunct Professor in the School of Basic Sciences.**

Jérôme Scherer's research area is pure mathematics, particularly topology and algebra, with a focus on homotopy theory, homological algebra and semi-abelian categories. His work is published in leading journals and is frequently cited. This internationally recognised researcher makes a substantial contribution to EPFL.

# Departures

### Five Professors named Emeritus in 2023

- Prof. **John Maddocks**, who directed the Laboratory for Computation and Visualization in Mathematics and Mechanics at the Institute of Mathematics from 1997 to 2023.
- Prof. **Thomas Rizzo**, who directed the Laboratory of Molecular Physical Chemistry at the Institute of Chemistry and Chemical Engineering from 1994-2023.
- Prof. **Philippe Gillet**, Provost of the EPFL (2010-2016) and directing the Earth and Planet Sciences Laboratory at the Institute of Physics from 2010-2023.
- Adj. Prof. **Joachim Stubbe** who led his group at the Institute of Mathematics from 2014-2023.
- Adj. Prof. **Jacques-Edouard Moser**, who led the Group for Photochemical Dynamics at the Institute of Chemistry and Chemical Engineering from 2005-2023.

# HIGHLIGHTS

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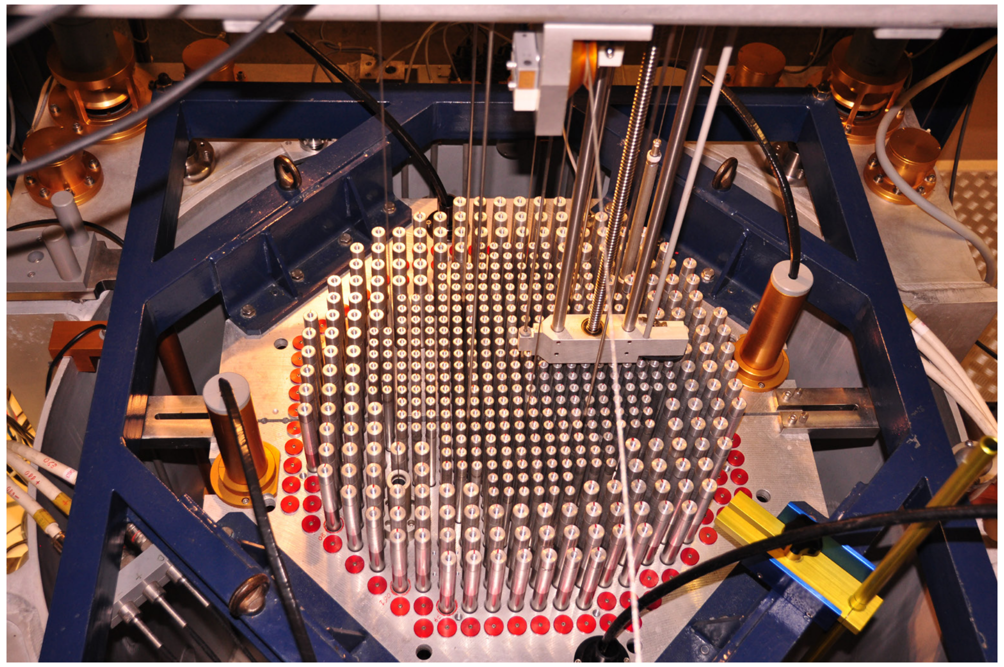
# Master program in Nuclear Engineering praised by IAEA



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**The M.Sc. in Nuclear Engineering offered jointly by the Ecole Polytechnique Fédérale de Lausanne (EPFL) and the Ecole Polytechnique Fédérale de Zurich (ETHZ) is an exemplary programme bringing together three organisations (the two EPFs and the Paul Scherrer Institute) with excellent teaching and superb facilities, to offer a world-class educational experience for students in the field of nuclear energy providing the Swiss and global nuclear energy industry with quality personnel.**

Established in 2008, the programme has a rigorous and highly competitive admissions procedures.

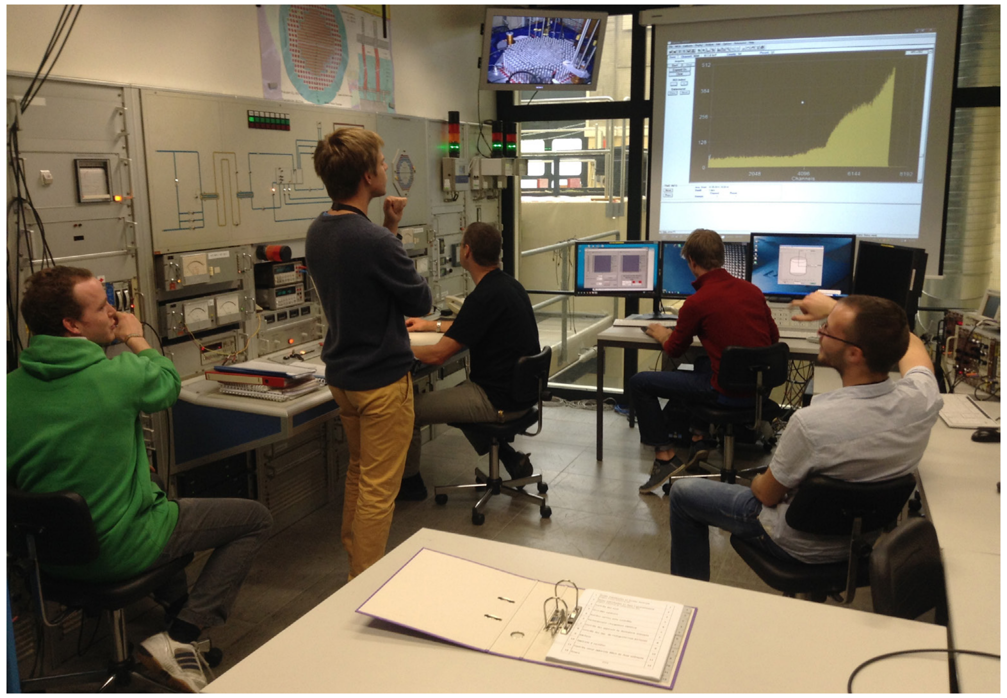
With a graduation rate of 98%, the vast majority of students remain in Switzerland, either to embark on a PhD at PSI, ETHZ or EPFL, or to start a job in industry with organisations such as nuclear power plants, NAGRA, the nuclear authority, utilities and nuclear engineering services consultancies.

A particularly significant milestone this year was a visit from the International Atomic Energy Agency (IAEA) as part of a level three KMAV (Knowledge Management and Assurance Visit). This type of visit is an initiative to strengthen international cooperation and promote the exchange and preservation of knowledge in the field of nuclear engineering. The IAEA, as a specialised agency of the United Nations, plays a crucial role in promoting the peaceful use of nuclear energy and in monitoring nuclear activities worldwide.

The visit was carried out by a team of international experts with direct experience in the field of nuclear energy. The purpose of a level three visit is to gather best practice from an established programme (such as that of the Swiss Federal Institutes of Technology) for the benefit of other international institutions that also offer nuclear energy education programmes with a view to continuous improvement and sustainability. During their four-day visit the IAEA experts were able to explore the programme's key experimental facilities, such as the CROCUS nuclear reactor on the EPFL site, meet the lecturers, professors and dean associated with the programme, talk to students and attend theoretical and practical courses. The visit concluded with a report summarising a number of good practices from which other universities could benefit, as well as suggestions to the host organisation.

In particular, it was noted that the three-institution model works very well and is based on long-standing cooperation between the two universities and PSI within Switzerland's leading research cluster, the ETH Domain. Students experience three different environments in addition to industrial placement, and benefit from the different expertise and cultural environments of the three organisations. The combination of EPFL's Institute of Physics and ETHZ's Department of Mechanical and Process Engineering brings a wide range of expertise to the programme, as well as a wider choice of specialisation than typically possible with a single institution.

Notably, the IAEA's visit as part of the KMAV further consolidated the links between the Nuclear Engineering programme and the International Atomic Energy Agency: EPFL is already a centre for collaboration in the field of modelling and experiments for innovative reactors, providing resources and a training framework for nations developing a civil nuclear energy programme since 2019. The presence of the IAEA on campus as part of a level three KMAV underlines the Basic Sciences School's commitment to excellence, scientific rigour and global relevance.



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# The SPC strengthens Tokamak shield to intensify fusion research



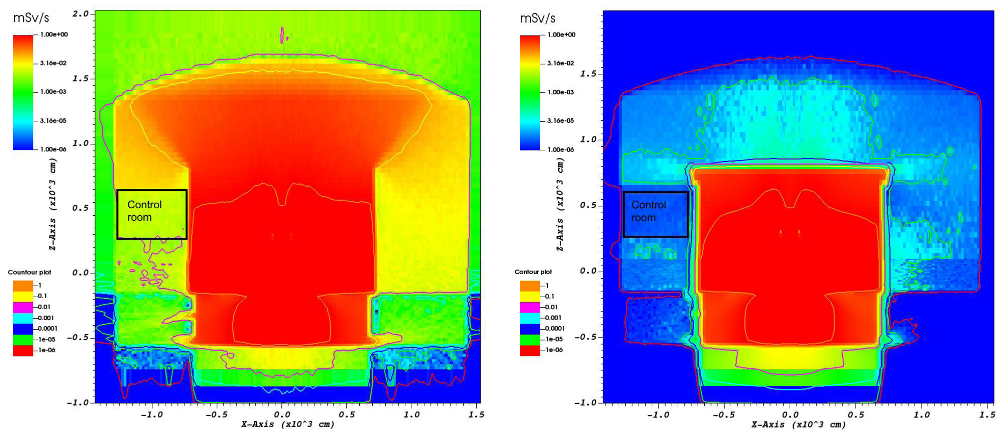
**It's a world first. After seven months of work, more than 220 tons of high-density polyethylene have transformed the shielding around the Tokamak à Configuration Variable (TCV). Never before has such a quantity of this material been used on such a large scale. The goal: to protect the public from ionizing radiation following the recent improvement of TCV's performance. This complex endeavor, a result of collaboration with the Operational Vice-Presidency of EPFL, was successfully completed in August 2023. It promises to propel fusion research to new heights.**

Since TCV start of operation in 1992, the reactor was surrounded by 50cm thick baryte concrete walls made of blocks to stop neutron and photons. Its very elongated vacuum chamber, highly flexible magnetic coils configuration and unique microwave heating system allowed TCV to provide significant breakthroughs in plasma research towards a fusion reactor. Recently, to further study fast ion physics, the TCV has been equipped with two 1MW Neutral Beam Heating (NBH) systems that directly heat the plasma ions. Heating the ions enhances the Deuterium-Deuterium fusion reaction rate and hence increases the neutron production inside the reactor. This modification required additional shielding around the torus hall to ensure the safety of areas open to the public against ionizing radiation, following the standards of the Federal Office of Public Health.

A collaboration with the Jozef Stefan Institute in Ljubljana allowed for the modeling of neutron and gamma ray transport, leading to a new design that includes increased thickness of existing walls, the addition of a roof, and the installation of doors. Usually, concrete is used for neutron shielding, but the TCV building foundations could not support the three additions if they were made of concrete. The solution? The use of high-density polyethylene. Although different materials were evaluated, it became clear that using polyethylene for additional shielding was the preferred solution due to its high hydrogen atom content and low density of about 1 kg/l. In fact, a 20 cm thick polyethylene plate has a similar moderating power to 50 cm of concrete but with 8.7 times less weight. Therefore, polyethylene was chosen as the main neutron moderator. In total, 220 tons of this material were installed in just 7 months of work. This is the first time such a quantity of polyethylene has been used on such a large scale!

The complexity of the work, launched in collaboration with the EPFL Operational Vice Presidency (VPO), required meticulous planning that began in 2020. The VPO took charge of project management while the SPC focused on the scientific aspect. This partnership proved essential for the success of the project. Technically, the shielding consists in recycled concrete blocs from the upper layers over the first 3m of the torus hall existing walls, 20cm thick PE slabs on all remaining 50cm thick concrete walls, 35cm thick PE dismountable roof, a concrete belt surrounding the roof and 35cm thick borated PE for doors. After the completion of the work in August 2023, a dose measurement campaign at ten reference points was conducted the following month. It demonstrated that this new shielding is a complete success. Experimental measurements align with model predictions within a factor of 2, and neutron attenuation exceeding 1000 was measured in the TCV control room.

Finally, in addition to the shielding, the opportunity was seized to modernize the building housing the TCV: the entire lighting system now operates with LEDs, three monoblocks and other ventilation systems have been replaced, fire safety has been reviewed, and emergency procedures adapted to ensure a faster response in critical situations. With this technological leap, the Swiss Plasma Center paves the way for safer and more promising fusion research, giving a new boost to the quest for a sustainable energy source for our future.




MCNP simulations of neutron doses for a source of $\frac{4e\cdot 13n}{s}$ on a vertical cut of the TCV building without and with neutron screening

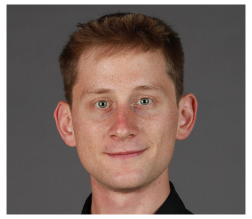
# The brilliant careers of two Euler course alumni

© EPFL Alain Herzog

**Fifteen years ago, a group of talented children in French-speaking Switzerland were chosen to participate in EPFL's first Euler course, an advanced course in mathematics. Two of them, Renaud Rivier and Shirley Ye, bear testimony to the program.**

EPFL's Euler course in mathematics, founded for young talents in French-speaking Switzerland by Kathryn Hess, currently EPFL associate Vice-President, is celebrating its 15th year anniversary and 120 alumni at la Fête des Maths this coming week-end. "Having benefited greatly from a program like the Euler course as a child, I was certain that it was worthwhile to create a similar program for highly talented children in Romandie. Fifteen years later, I am truly delighted with the development of the course and the remarkable achievements of Euler alumni," says Prof. Hess.

The Euler course is a mathematical program specially designed for high potential children, as a complement to the usual school curriculum. The six-year program is structured to allow young students to fast-track the usual curriculum in three years instead of six. The remaining three years are then dedicated to studying first year university courses in mathematics. "It is a very rewarding experience to teach such gifted and passionate students, to see them play with abstract concepts at a young age and progress at a challenging pace," says Jérôme Scherer, Euler Course coordinator.



Fifteen years ago, **Renaud Rivier** was part of the very first Euler class, he was also the youngest at 10 years old and had already skipped two years of school. Rivier recalls, "From the start, we had to take our own notes, we were taken seriously, and this was tremendous for developing my independence and confidence."

"The quality of teaching for the usual curriculum was efficient and of high quality. Then we received the handout for mathematics. There were no cartoons trying to sugarcoat the content, just mathematics. It was very concise, it was hard, but it was worth it," continues Rivier. As Rivier tells it, the Euler course comes with its share of challenges. "I failed my very first exam. It was quite a shock for a ten-year-old. I failed half of my exams during the first two years. But I always managed to pass the second-chance exams. It was stressful at first but I had the determination to stay in the program, an important lesson that things can get easier even if they are hard at the beginning."

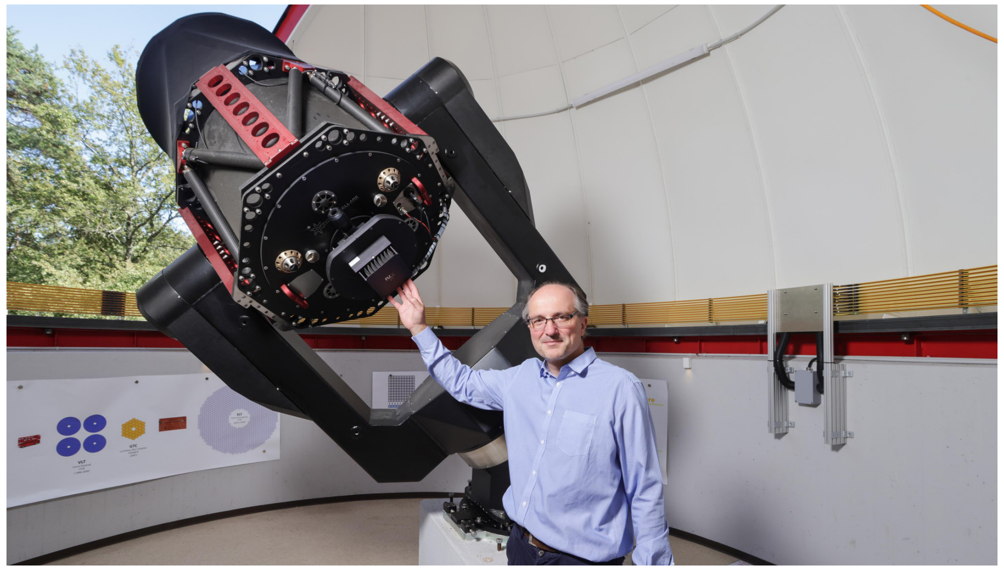
Upon completion of the Euler course, Rivier was admitted to EPFL's 2nd year mathematics program at 16, and recently completed a PhD in mathematics from the University of Geneva. Rivier says, "Entering university at such a young age was socially difficult for me. But the Euler course taught me rigorous thinking and how to study effectively." With a solid foundation in mathematics, Rivier, now 25 years old, is trying to find ways to apply mathematics to solve concrete problems. He is currently exploring his entrepreneurial skills, consulting opportunities, and challenging himself to connect with strangers as he rallies for political causes.

**Shirley Ye** also participated in the first Euler course. Originally from China, she had only lived in Switzerland for one year when she had entered the program, at 12 years old. By then, she could speak French, had already skipped 6th grade, and had won math and logic competitions. "Fifth grade mathematics was very easy," Ye recalls. She remembers being approached by her 7th grade teacher about the Euler course, after hearing about it on the radio. "My teacher saw that I was getting bored in 7th grade math, that it was probably better for me be challenged."

Yet she insists that her above average level in mathematics was not innate, "I am not that gifted in mathematics. The level in Switzerland was easy compared to what I learned in China. The course was a nice challenge and taught me many skills in self-development," continues Ye, now a doctor at 27 years old, pursuing her 4th year of internal medicine at Solothurn hospital. After completing the Euler course, Ye, who speaks 5 languages (French, English, German, Mandarin and Shanghainese) and gets by in Swiss German regarding medical topics, went on to study medicine at UNIL with a year exchange in Heidelberg. "My grandmother was a pediatrician. When I was young, she would take me along with her in consultations. I realized early on that I wanted to help people, across all generations and social aspects."

"Today, the mathematics that I use is in medicine is simple. But the Euler course taught me to think independently, how to perform research, how to acquire knowledge, and perseverance in solving problems," continues Ye. "I don't look for answers on the internet. Instead, I think about the theory in order to figure things out. I try to build answers on my own, pushing my limits."

# EPFL Space Center is celebrating its 20th anniversary



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**Since Jean-Paul Kneib arrived in 2012, he has played an integral role in many of EPFL's astronomy and space activities. He is currently the academic director of the highly interdisciplinary EPFL Space Center, which is celebrating its 20th anniversary this year. Years during which the Center saw space-related student projects win international awards and competitions and send their technology into space. It connects professors across campus from over 40 laboratories and maintains a network of space-related organisations from academia and industry across the country. Importantly they work with policymakers on issues of space sustainability.**

On any given day, it can be hard to know where Kneib will be. Sometimes he's at the observatory in Versoix, working on research for his Laboratory of Astrophysics (LASTRO). Other days, he might be on the EPFL campus, teaching or meeting with students at the EPFL Space Center. And often he is somewhere else in Switzerland or Europe or even further, such as in Australia or South Africa in his role of the Swiss Scientific Delegate to the Square Kilometre Array Observatory (SKAO) representing the Swiss Consortium (SKACH), which he helped bring into existence.

In 2012, he joined EPFL with an ERC Advanced Grant to shed new light and understanding on the "dark elements" of the universe. In 2016 he became full professor and took the leadership of the Laboratory of Astrophysics (LASTRO), and in 2017, he was offered the chance to lead and develop the EPFL Space Center (eSpace).

"At first, I didn't know exactly on which direction to focus, but students are really thrilled and motivated when it comes to space, so I could see a lot of potential for development in this very active domain", he says. Along with supporting and advising the student groups working on space, he also manages eSpace's many research projects on topics such as lunar exploration and space sustainability. He leads efforts for funding opportunities and helps connect space research across the EPFL campus. He also does scientific outreach, notably co-curating the 2022-23 Cosmos Archeology exhibition at EPFL Pavilions with Sarah Kenderdine of the Laboratory for Experimental Museology (EM+). The exhibition included the video "Archeology of Light" that used astronomical data Kneib collected over the last decade. "It was a new challenge for me," he explains. "If it's too easy, there's no point."

Decades of launches and the recent commercialisation of space has led to congested orbits, increasing the risk of satellite and space debris collisions. This will only get worse as more than 50,000 satellites are planned to be launched in the next decade, putting at risk the capacity of Earth orbit to safely accommodate new objects.

Kneib has been involved in these challenges for quite a while. "Sustainability in space is a major issue that should be a concern of everyone on Earth as our human society is critically dependent on measurements, information, and communication from space," he says. "As an astrophysicist, you know that there is only one habitable place in the solar system - the Earth. There's no planet B. And if you don't take your share of responsibility, nothing will change."

In 2018, Kneib supported the creation of the start-up ClearSpace from a project idea that began at EPFL in 2012. ClearSpace was selected by ESA to conduct a space debris removal mission in 2026, where it will rendezvous, capture and take down for reentry the upper part of a VESPA (Vega Secondary Payload Adapter) from Europe's Vega launcher.

Kneib is also responsible for leading the contribution from Switzerland to the Square Kilometre Array Observatory (SKAO), an international project building two giant radio telescope sites in Australia and South Africa that will give humanity new information on the origins of the universe and possibly even signs of intelligent life beyond our solar system. He became interested in this project back in 1998, when the first discussions about developing a giant radio telescope were taking place. As the SKA project matured from an idea to a project, Kneib renewed his interest and in 2016, he became the lead Swiss Scientist of the SKA and gathered a group of Swiss scientists to push for Switzerland's participation. In 2022, Switzerland officially joined the SKA under Prof. Kneib's leadership, and the technical and scientific activities are now organized through the SKACH consortium of nine Swiss institutions.

In 2023, the EPFL Space Center was restructured and now comprises two units: eSpace, which is responsible for aspects of education and research, and Space Innovation, which aims to develop innovative solutions and products in the space domain through its active network of Swiss industries, research and technology organisations, and academic partners. For Prof. Kneib, it's yet another challenge that he relishes taking on, and he's excited to continue making the EPFL Space Center an asset to the student community, the research community, and for industry across Switzerland.

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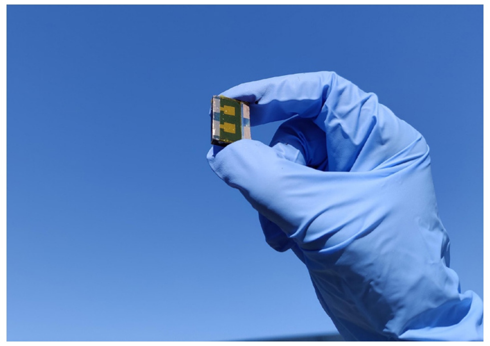
# New design solves stability and efficiency of perovskite solar cells



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**Perovskite solar cells (PSCs) stand at the forefront of solar energy innovation, and have drawn a lot of attention for their power-conversion efficiency and cost-effective manufacturing. But the way to commercialisation of PSCs still has a hurdle to overcome: achieving both high efficiency and long-term stability, especially in challenging environmental conditions. The solution lies in the interplay between the layers of PSCs, which has proven to be a double-edged sword. The layers can enhance the cells' performance but also cause them to degrade too quickly for regular use in everyday life.**

Now, a collaboration between the labs of Michael Grätzel at EPFL and Edward Sargent at Northwestern University, has made a significant leap in designing PSCs with record stability and power-conversion efficiency surpassing 25% addressing two of the most pressing challenges in the solar energy sector. The research is published in Nature.

The researchers focused on designing inverted PSCs, which have previously shown promise in terms of operational stability. They introduced a unique, "conformal self-assembled monolayer on textured substrates", which describes a special, single layer of molecules that spontaneously and uniformly coats the irregular surface of a textured substrate. The new design tackles the problem of "molecular agglomeration", which occurs when molecules clump together instead of spreading out evenly. When this happens on the textured surfaces of solar cells, it can seriously affect their performance.

To address this, the researchers introduced a special molecule called 3-mercaptopropionic acid (3-MPA) into the solar cells' self-assembled monolayer (SAM) formed by a molecular layer of phosphonic acids substituted by carbazole, which selectively extracts the positive charge carriers ("holes") that are produced under illumination in the perovskite films. However, this role is compromised by the aggregation of the PAC molecules. Adding 3-MPA enhances the contact between the perovskite material and the solar cell's textured substrate to improve performance and stability, allowing it to disassemble molecular carbazole clusters, and ensuring a more even distribution of the molecules in the self-assembled monolayer. With this addition, the molecules on the solar cell's surface spread out more uniformly, avoiding those problematic clumps and enhancing the PSC's overall stability and efficiency.

The new design enhanced light absorption while minimizing energy losses at the interface between layers, leading to a lab-measured power-conversion efficiency of an impressive 25.3%. In terms of stability, the inverted PSCs showed remarkable resilience. The device maintained 95% of its peak performance even after being subjected to rigorous conditions of 65°C and 50% relative humidity for over 1000 hours. This level of stability, combined with such high efficiency, is unprecedented in the realm of PSCs.

This breakthrough design is a significant step forward in putting PSCs into the market; addressing both their efficiency and stability issues, combined with their lower manufacturing costs compared to current solar cells, can lead to widespread adoption. The new method can also go beyond solar cells, benefiting other optoelectronic devices that require efficient light management, such as LEDs and photodetectors.

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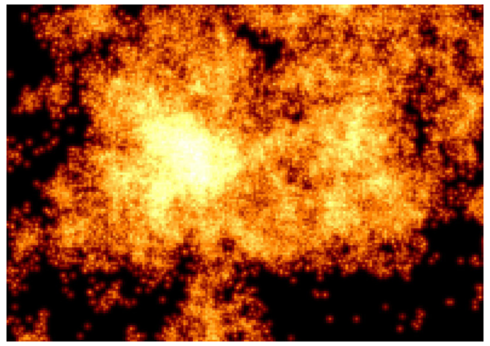
# Unravelling the mysteries of glassy liquids



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**Glass, despite its apparent transparency and rigidity, is a complex and intriguing material. When a liquid is cooled to form a glass, its dynamics slows down significantly, resulting in its unique properties.**

This process, known as "glass transition", has puzzled scientists for decades. But one of its intriguing aspects is the emergence of "dynamical heterogeneities," where the dynamics become increasingly correlated and intermittent as the liquid cools down and approaches the glass transition temperature.

In a new study, researchers propose a new theoretical framework to explain these dynamical heterogeneities in glass-forming liquids. The idea is that relaxation in these liquids occurs through local rearrangements, which influence each other via elastic interactions. By investigating the interplay between local rearrangements, elastic interactions, and thermal fluctuations, the researchers have formulated a comprehensive theory for the collective dynamics of these complex systems.

The study is a collaboration between Professor Matthieu Wyart at EPFL and his colleagues at Max Planck Institute in Dresden, the ENS, the Université Grenoble Alpes, and the Center for Systems Biology Dresden. It is now published in Physical Review X.

The team developed a "scaling theory" that explains the growth of the dynamical correlation length observed in glass-forming liquids. This correlation length is linked to "thermal avalanches", which are rare events induced by thermal fluctuations, which then trigger a subsequent burst of faster dynamics.

The study's theoretical framework also provides insights into the Stoke-Einstein breakdown, a phenomenon where the viscosity of the liquid becomes uncoupled from the diffusion of its particles.

To validate their theoretical predictions, the researchers conducted extensive numerical simulations in various conditions. These simulations supported the accuracy of their scaling theory and its ability to describe the observed dynamics in glass-forming liquids.

The study not only deepens our understanding of glass dynamics but also suggests a new handle to tackle the properties of some other complex systems where the dynamics is intermittent and jerky- features known to occur in a range of situations, from the brain's activity or the sliding between frictional objects.

"Our work connects the growth of the dynamical correlation length in liquids to avalanche-type relaxations, well studied, for example, in the context of disordered magnets, granular materials, and earthquakes," says Matthieu Wyart. "As such, this approach builds unexpected bridges between other fields. Our description of how avalanches are affected by exogeneous fluctuations, including thermal ones, may thus be of more general interest."

REFERENCES

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# Ultrathin films achieve record hydrogen separation


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**Metal-organic frameworks (MOFs) are a class of materials that contain nano-sized pores. These pores give MOFs record-breaking internal surface areas, which make them extremely versatile for a number of applications: separating petrochemicals and gases, mimicking DNA, producing hydrogen, and removing heavy metals, fluoride anions, and even gold from water are just a few examples.**

In the gas-separation domain, MOFs are particularly interesting for separating hydrogen from nitrogen, which is crucial for clean energy production, fuel cell efficiency, ammonia synthesis, and various industrial processes. Hydrogen-nitrogen separation also has a number of environmental benefits, making it integral to advancing sustainable technologies and industrial practices.

Now, a team of researchers led by Professor Kumar Varoon Agrawal at EPFL's School of Basic Sciences have developed MOF film with smallest possible thickness that can perform record levels of hydrogen-nitrogen separation. The researchers worked with a type of MOFs known as zeolitic imidazolate frameworks (ZIFs), which have garnered considerable attention for their potential in molecular separations, sensing, and other applications.

To make the films, the researchers used an innovative crystallisation method that capitalises on the precise alignment of ultra-dilute precursor mixtures with the underlying crystalline substrate. By carefully controlling precursor concentrations and interactions with the substrate, the team were able to suppress out-of-plane growth – a common problem in making thin films.

The approach paid off: Within a matter of minutes, and at room temperature, the scientists were able to fabricate macroscopically uniform two-dimensional (2D) ZIF films with unprecedented thickness: just one structural unit, measuring only two nanometers. The scientists also showed that the process is scalable preparing films with area of hundreds of square centimeters. The breakthrough overcomes conventional methods, which have limited ZIF film thickness to 50 nanometers, making their widespread use difficult.

The ZIF film has a unique configuration: a nanometer-thick film with a uniform array of hydrogen-sieving six-membered zinc-imidazolate coordination ring. Kumar Agrawal explains: "This allows for an exceptional combination of hydrogen flux and selectivity, holding immense potential for highly efficient gas-separation applications."

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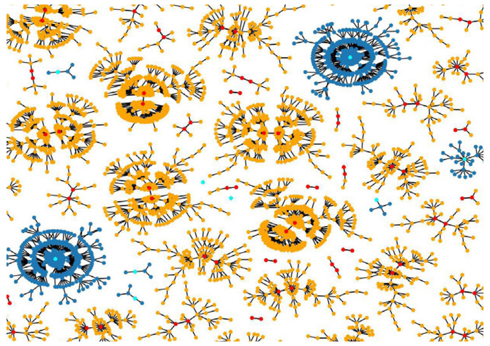
# Unravelling complex systems: The Backtracking Method



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**In physics, a "disordered system" refers to a physical system whose components – e.g. its atoms – are not organized in any discernible way. Like a drawer full of random socks, a disordered system lacks a well-defined, ordered pattern due to various factors like impurities, defects, or interactions between components. This randomness makes it difficult to predict the system's behavior accurately. And given that disordered systems are found in anything from materials science to climate or social networks and beyond, this limitation can be a serious, real-life problem.**

Now, a team of scientists led by Lenka Zdeborová at EPFL have developed a novel approach to understanding how things change and evolve in disordered systems, even when they are undergoing rapid changes, like a temperature change. The study was carried out by Freya Behrens at Zdeborová's lab, and Barbora Hudcová visiting EPFL from the Charles University in Prague.

The approach is called the Backtracking Dynamical Cavity Method (BDCM) and it works by looking first at the end state of the system rather than the beginning; instead of studying the system's trajectory forward from the start, it traces the steps backward from stable points. But why "cavity"? The term comes from the "Cavity Method" in statistical physics and refers to isolating a particular component of a complex system to make it easier to study – putting it in a conceptual "hole" or "cavity" while ignoring all the other components.

In a similar way, the BDCM isolates a specific component of the disordered system, but working instead backwards to understand its evolution throughout time. This innovative twist provides valuable insights about the system's dynamic properties, even when it is far from equilibrium, like how materials cool down or how opinions on a social network evolve, or even how our brains work.

"From our early results, we saw that it can be quite deceiving to only look at the number of attractors of the system," says Freya Behrens, referring to stable states that a system settles into overtime. "Just because there are many attractors of a given type, it does not mean your dynamics end up there. But we really did not expect that taking just a few steps back from the attractor into its basin would reveal so many details about the complete dynamics. It was quite surprising."

Applying the BDCM to a random arrangement of magnets, the scientists found out what happens to their energy of when they rapidly cool down or what type of patterns they form when they start with different arrangements. "What I like a lot about this work is that we obtained theoretical answers to basic yet open questions about the dynamics of the Ising model, among the most studied models in statistical physics," says Lenka Zdeborová. "The method we developed is very versatile, indicating that it will find many applications in studies of the dynamics of complex interacting systems, for which the Ising model is one of the simplest examples. Some application areas I can foresee include social dynamics, learning in neural networks or, for instance, gene regulation. I am looking forward to seeing the follow-up work!"

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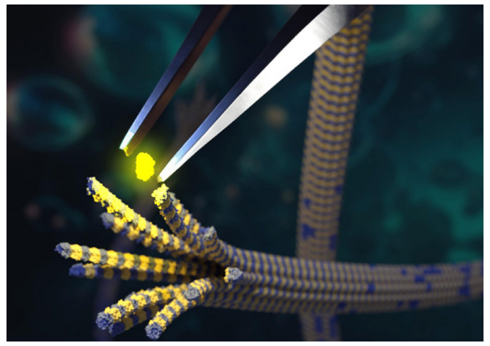
# Cracking the tubulin code





**Tubulin is a protein that plays a crucial role in the structure and function of cells. It is the main component of microtubules, which are long, hollow fibers that provide structural support, help the cell divide, give it its shape, and act as tracks for moving molecular cargo around inside the cell.**

There are two types of tubulin: alpha-tubulin and beta-tubulin. Together, they form dimeric (two-part) building blocks, spontaneously assembling into microtubules that undergo further continuous cycles of assembly and disassembly. To fine-tune microtubules, the dimers undergo various post-translational modifications (PTMs), which are chemical modifications that occur after they are synthesized, and can affect their structure, activity, and interactions with other molecules.

Two important PTMs take place on the unstructured tail of alpha-tubulin: Polyglutamylation, which adds chains of glutamate amino acids, and detyrosination, which removes the final tyrosine amino acid. These PTMs, among others, are found together in stable microtubules, e.g. in neurons. Combinations of PTMs form what scientists refer to as a "tubulin code", which is connected to specific functions of microtubules. Tubulin PTMs are critical for the proper functioning of microtubules.

Dysregulation of PTMs have been linked to various diseases, including cancer, neurodegeneration, and developmental disorders. Therefore, understanding the importance of tubulin PTMs is crucial for advancing our knowledge of these diseases and developing potential therapies. The problem is that the mechanisms that govern such PTM patterns are not well understood, mostly because we don't have the tools to dissect the function and regulation of tubulin PTMs.

Scientists at EPFL and the University of Geneva (UNIGE) have now developed a chemical method to engineer fully functional tubulin carrying precise combinations of post-translational modifications (PTMs). The study was led by Professors Beat Fierz (EPFL) and Assistant-Professor Charlotte Aumeier (UNIGE), in collaboration with the labs of Pierre Gönczy (EPFL) and Carsten Janke (Institute Curie), and provides insight into how specific PTMs regulate the function of tubulin in cells. The method uses chemo-enzymatic protein splicing to attach synthetic alpha-tubulin tails that were modified with varying degrees of polyglutamate to human tubulin molecules. Using these "designer tubulins" allowed the researchers for the first time to assemble homogenously modified microtubules.

The researchers also found that polyglutamylation of alpha-tubulin facilitated its detyrosination by enhancing the activity of the protein complex vasohibin/SVBP, the key enzyme responsible for this modification. The team confirmed their findings by changing the levels of polyglutamate in living cells and observing the effects on tyrosine removal. The study presents a novel approach to designing tubulins with specific PTMs and uncovers a new interplay between two key regulatory systems that control the function of tubulin: polyglutamylation and detyrosination. The new method of producing tubulins with defined PTMs can advance our understanding of their molecular function, and provide insights into how dysregulation of these PTMs leads to diseases.

Based on this work, the labs of Fierz and Aumeier, together with Jens Stein at the University of Fribourg and Michael Sixt at ISTA Vienna have received a Sinergia grant from the Swiss National Science Foundation to investigate how tubulin PTMs control the cytoskeleton in migrating immune cells.

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MATH

# Tossing coins to understand spheres



**For mathematicians, "Euler Class" is one of the most powerful tools for understanding complicated spaces by cutting them into simpler pieces. It is named after Swiss mathematician Leonard Euler who was the first to consider the idea.**

"Just like something as complex as DNA is ultimately made of simple atoms, it is how these simple pieces are assembled that contains the important information rather than the pieces themselves," says Professor Nicolas Monod, who leads the Ergodic and Geometric Group Theory research unit at EPFL. His group joined forces with colleagues at Purdue University to solve an old question about spheres. The answer has been published the leading mathematics journal Inventiones.

In 1958, Fields medalist John Milnor noticed a problem when trying to build spaces using only circles and two-dimensional surfaces: there was a limit on how complicated the Euler class can be in two dimensions. The observation snowballed into an entire field of research in higher dimensions, and mathematicians quickly realized that Milnor's "complexity bound" didn't apply for spaces in all dimensions.

Monod explains: "A question that had remained open for decades was, what about gluing spheres on 4-dimensional spaces? Is there also here a limit on how they fit together?" He continues: "Gluing spheres on 4-dimensional spaces is a particularly important construction because this is precisely how the very first "exotic spheres" have been constructed!"

Classical approaches of understanding spaces have proven unable to solve this 4-dimensional question. So the EPFL mathematicians turned to the Bernoulli process, named after Swiss mathematician Jacob Bernoulli, for inspiration. The Bernoulli process, which is a model of tossing coins, was combined with the study of spheres and the Euler class to finally solve the question.

"A very curious thing happened when we set out to solve this problem," says Monod. "If it remained unsolved for so long, it is perhaps because none of the classical methods used to understand spaces seemed to be able to crack this specific question about 4 dimensions. Instead, we turned to an unlikely source for inspiration: tossing coins!"

As a game with a 50-50 chance to guess the right side of a coin, this might seem very simple, but its simplicity is misleading. "The Bernoulli process already includes many of the advanced features of probability theory when we set out to repeat the toss more and more often," says Monod. "In fact, the Central Limit Theorem – which is a kind of Law of Large Numbers – even tells us that this simple model can emulate many of the most complicated random phenomena of nature if we are willing to toss enough coins for long enough."

Probability and random processes might seem not to have much to do with the analysis of higher dimensions in space, but mathematics is as much a creative art as a science. "Earlier this year, we published the discovery that Bernoulli's random coin games can help solve some difficult algebraic questions, very much non-random questions," says Monod. "This has now been combined with the study of spheres and the Euler Class to finally solve the old question about 4-dimensional spaces: no, there is no limit at all to the size of the Euler class for spheres in four dimensions."

"So the coins came to the rescue of algebra and geometry, and Bernoulli visits the Euler class: indeed, mathematicians do things differently," he concludes.

REFERENCES

DOI

IPHYS

# Schrödinger's cat makes better qubits

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**Quantum computing uses the principles of quantum mechanics to encode and elaborate data, meaning that it could one day solve computational problems that are intractable with current computers. While the latter work with bits, which represent either a 0 or a 1, quantum computers use quantum bits, or qubits – the fundamental units of quantum information.**

"With applications ranging from drug discovery to optimisation and simulations of complex biological systems and materials, quantum computing has the potential to reshape vast areas of science, industry, and society," says Professor Vincenzo Savona, director of the Center for Quantum Science and Engineering at EPFL.

Unlike classical bits, qubits can exist in a "superposition" of both 0 and 1 states at the same time. This allows quantum computers to explore multiple solutions simultaneously, which could make them significantly faster in certain computational tasks. However, quantum systems are delicate and susceptible to errors caused by interactions with their environment.

"Developing strategies to either protect qubits from this or to detect and correct errors once they have occurred is crucial for enabling the development of large-scale, fault-tolerant quantum computers," says Savona. Together with EPFL physicists Luca Gravina, and Fabrizio Minganti, they have made a significant breakthrough by proposing a "critical Schrödinger cat code" for advanced resilience to errors. The study introduces a novel encoding scheme that could revolutionize the reliability of quantum computers. [...]

"Schrödinger cat codes have been realized in the past using two distinct approaches," explains Savona. "One leverages anharmonic effects in the cavity, the other relying on carefully engineered cavity losses. In our work, we bridged the two by operating in an intermediate regime, combining the best of both worlds. Although previously believed to be unfruitful, this hybrid regime results in enhanced error suppression capabilities." The core idea is to operate close to the critical point of a phase transition, which is what the "critical" part of the critical cat code refers to.

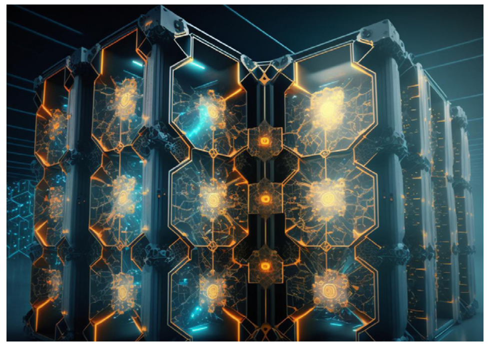
The critical cat code has an additional advantage: it exhibits exceptional resistance to errors that result from random frequency shifts, which often pose significant challenges to operations involving multiple qubits. This solves a major problem and paves the way to the realisation of devices with several mutually interacting qubits – the minimal requirement for building a quantum computer.

"We are taming the quantum cat," says Savona. "By operating in a hybrid regime, we have developed a system that surpasses its predecessors, which represents a significant leap forward for cat qubits and quantum computing as a whole. The study is a milestone on the road towards building better quantum computers, and showcases EPFL's dedication in advancing the field of quantum science and unlocking the true potential of quantum technologies.

REFERENCES

ISIC

# New AI model transforms research on metal-organic frameworks



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**How does an iPhone predict the next word you're going to type in your messages? The technology behind this, and also at the core of many AI applications, is called a transformer; a deep-learning algorithm that detects patterns in datasets.**

Now, researchers at EPFL and KAIST have created a transformer for Metal-Organic Frameworks (MOFs), a class of porous crystalline materials. By combining organic linkers with metal nodes, chemists can synthesize millions of different materials with potential applications in energy storage and gas separation.

The "MOFTransformer" is designed to be the ChatGPT for researchers that study MOFs. It's architecture is based on an AI called Google Brain that can process natural language and forms the core of popular language models such as GPT-3, the predecessor to ChatGPT. The central idea behind these models is that they are pre-trained on a large amount of text, so when we start typing on an iPhone, for example, models like this "know" and autocomplete the most likely next word.

"We wanted to explore this idea for MOFs, but instead of giving a word suggestion, we wanted to have it suggest a property," says Professor Berend Smit, who led the EPFL side of the project. "We pre-trained the MOFTransformer with a million hypothetical MOFs to learn their essential characteristics, which we represented as a sentence. The model was then trained to complete these sentences to give the MOF's correct characteristics."

The researchers then fine-tuned the MOFTransformer for tasks related to hydrogen storage, such as the storage capacity of hydrogen, its diffusion coefficient, and the band gap of the MOF (an "energy barrier" that determines how easily electrons can move through a material).

The approach showed that the MOFTransformer could get results using far fewer data compared to conventional machine-learning methods, which require much more data. "Because of the pre-training, the MOFTtransformer knows already many of the general properties of MOFs; and because of this knowledge, we need less data to train for another property," says Smit. Moreover, the same model could be used for all properties, while in conventional machine learning, a separate model must be developed for each application.

The MOFTransformer is a game-changer for the study of MOFs, providing faster results with less data and a more comprehensive understanding of the material. The researchers hope that the MOFTransformer will pave the way for the development of new MOFs with improved properties for hydrogen storage and other applications.

REFERENCES

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# Breaking the ice over a 40-year problem of supercooled water

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**Water is one of the most essential and widespread compounds on Earth. Covering over 70% of the planet's surface, it has shaped its composition and geology, it regulates its climate and weather patterns, and is at the foundation of all life as we know it.**

But water is also weird. It exhibits a number of anomalous properties, of which scientists have identified over seventy – so far. Several theories try to explain these anomalies, but verifying them experimentally is difficult. One of the reasons is that this would require studying water between 160 K and 232 K (-113 °C to -41 °C), a notorious temperature range known as "no man's land" where water crystallizes so fast that it has been impossible for scientists to study its properties.

But why would anyone want to cool water to such low temperatures? Because when water is cooled way below its freezing point it becomes "supercooled" with unique and fascinating properties; for example, under certain conditions it can remain in liquid form but can freeze instantly when disturbed or exposed to certain substances. Supercooled water is obtained by taking liquid water and cooling it below the freezing point while using tricks to prevent it from crystallizing or at least slowing this process down. However, even with these tricks, crystallisation in "no man's land" is still too fast.

"An experiment to systematically probe the structure of water across so-called 'no man's land' has remained elusive for decades," says Professor Ulrich Lorenz at EPFL's School of Basic Sciences. Now, scientists led by Lorenz have found a way to do just that. The team developed a way to rapidly prepare deeply supercooled water at a well-defined temperature and probe it with electron diffraction before it can crystallize.

"We have still not fully understood why water is an anomalous liquid, despite this topic being hotly debated for over forty years," says Lorenz. "The answer appears to lie in "no man's land". But because of fast crystallisation, any measurement over the full temperature range has not been possible. We do this for the first time. This brings us closer to solving this long-standing mystery."

The scientists performed the experiments with a specialized time-resolved electron microscope they custom built in their lab. They prepared the supercooled water at a well-defined temperature and probed it directly before crystallisation occurred. To do this, they cooled a layer of graphene to 101 K and deposited a thin film of amorphous ice. They then locally melted the film with a microsecond laser pulse to obtain water in "no man's land", and captured a diffraction pattern with an intense, high-brightness electron pulse.

The researchers found that as water is cooled from room temperature to cryogenic temperatures, its structure evolves smoothly. At temperatures just below 200 K (about -73 °C), the structure of water begins to look like that of amorphous ice – a form of ice where water molecules are in a disordered state – unlike the tidy crystalline ice we are usually familiar with.

"The fact that the structure evolves smoothly allows us to narrow down the range of possible explanations for the origin of water anomalies," says Lorenz. "Our findings and the method we have developed bring us closer to unriddling the mysteries of water. It is difficult to escape the fascination of this ubiquitous and seemingly simple liquid that still has not given up all of its secrets."

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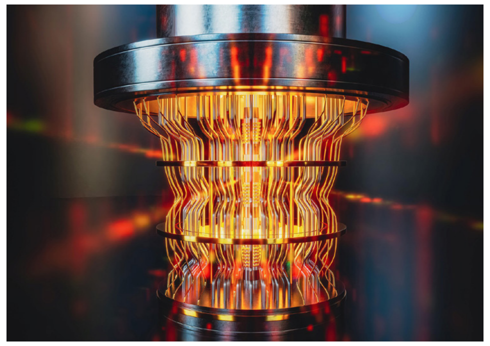
# An easier way to learn quantum processes



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**Imagine a world where computers can unravel the mysteries of quantum mechanics, enabling us to study the behavior of complex materials or simulate the intricate dynamics of molecules with unprecedented accuracy.**

Thanks to a pioneering study led by Professor Zoe Holmes and her team at EPFL, we are now closer to that becoming a reality. Working with researchers at Caltech, the Free University of Berlin, and the Los Alamos National Laboratory, they have found a new way to teach a quantum computer how to understand and predict the behavior of quantum systems, even with a few simple examples.

The researchers worked on "quantum neural networks" (QNNs), a type of machine-learning model designed to learn and process information using principles inspired by quantum mechanics in order to mimic the behavior of quantum systems.

Just like the neural networks used in artificial intelligence, QNNs are made of interconnected nodes, or "neurons," that perform calculations. The difference is that, in QNNs, the neurons operate on the principles of quantum mechanics, allowing them to handle and manipulate quantum information.

"Normally, when we teach a computer something, we need a lot of examples," says Holmes. "But in this study, we show that with just a few simple examples called "product states" the computer can learn how a quantum system behaves even when dealing with entangled states, which are more complicated and challenging to understand."

The "product states" that the scientists used refer to a concept in quantum mechanics that describes the specific type of state for a quantum system. For example, if a quantum system is composed of two electrons, then its product state is formed when each individual electron's state is considered independently and then combined.

Product states are often used as a starting point in quantum computations and measurements because they provide a simpler and more manageable framework for studying and understanding the behavior of quantum systems before moving on to more complex and entangled states where the particles are correlated and cannot be described independently.

The researchers demonstrated that by training QNNs using only a few of these simple examples, computers can effectively grasp the complex dynamics of entangled quantum systems.

Holmes explains: "This means that we might be able to learn about and understand quantum systems using smaller, simpler computers, like the near-term intermediary scale [NISQ] computers we're likely to have in the coming years, instead of needing large and complex ones, which may be decades away."

The work also opens up new possibilities for using quantum computers to solve important problems like studying complex new materials or simulating the behavior of molecules.

Finally, the method improves the performance of quantum computers by enabling the creation of shorter and more error-resistant programs. By learning how quantum systems behave, we can streamline the programming of quantum computers, leading to improved efficiency and reliability. "We can make quantum computers even better by making their programs shorter and less prone to errors," says Holmes.

REFERENCES

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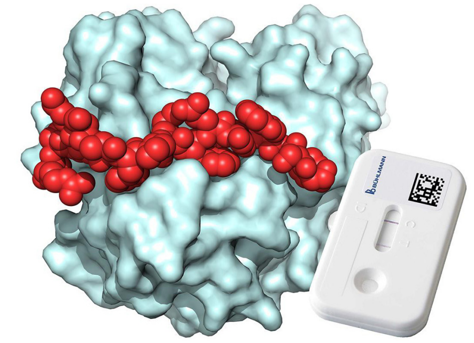
# Diagnosing inflammatory diseases with synthetic peptides





**Common inflammatory disorders such as ulcerative colitis and Crohn's disease can be diagnosed or monitored by measuring the protein calprotectin in stool samples, while serum levels of calprotectin could be used to monitor the inflammation status in rheumatoid arthritis. Calprotectin concentrations in patient samples are typically determined using antibodies that bind and detect the protein, e.g. in lateral flow assays like the now all-too-familiar home COVID-19 test kits.**

But there is a problem with antibody-based calprotectin assays: the results can vary depending on the type of antibody and assay used. This happens because antibodies may bind to different sites on the protein, or might not have a uniform composition. The antibodies can also become inactivated over time due to unfolding or precipitation.

One possible solution is to use peptides instead of antibodies to detect and measure disease markers like calprotectin. Peptides are sequences of up to 50 amino acids that can bind to proteins with high affinity and selectivity, but, unlike antibodies, they can be chemically produced with high purity and homogeneity. In addition, peptides are stable over time, are cheaper to produce than antibodies and with lower inter-batch variability, and they can be attached to a specific location on a surface, significantly simplifying diagnostic assay development because it allows for a more accurate and controlled way of detecting biomarkers.

With this idea, Christian Gerhold, CTO of the diagnostics company BÜHLMANN, worked with the group of Professor Christian Heinis at EPFL to develop human calprotectin ligands based on peptides. From a library of more than 500 billion different peptides, Cristina Diaz-Perlas, a postdoc in Heinis's group, isolated several binders of calprotectin, and showed that the peptides are suited for calprotectin quantification in simplified lateral flow assays. The best peptide had a dissociation constant of 26 nM – a measure of how tightly it binds calprotectin, making it a good candidate for diagnostic tests.

The peptide not only binds to a large surface region of calprotectin but also to a specific form of calprotectin that is the relevant species in patient samples. Under the guidance of Benjamin Ricken at BÜHLMANN, the peptide was finally tested in professionally assembled lateral flow cassettes and found that it was suited for accurate detection and quantification of calprotectin. In a proof-of-concept study, this setup was used to quantify the concentration of calprotectin in serum obtained from patient blood samples.

The peptide developed is the first synthetic affinity reagent that could be generated against the biomarker calprotectin. "The EPFL and BÜHLMANN teams are currently performing more tests with the calprotectin-specific peptide to translate the assay into a product that can bring the diagnostic power of this increasingly important biomarker to a new level to help patients suffering from inflammatory diseases," says Christian Heinis.

Christian Gerhold adds: "This collaboration greatly benefited from BÜHLMANN's knowhow to produce and handle the biomarker, and expertise of the EPFL team to generate and screen large combinatorial libraries of peptides by phage display."

REFERENCES

DOI

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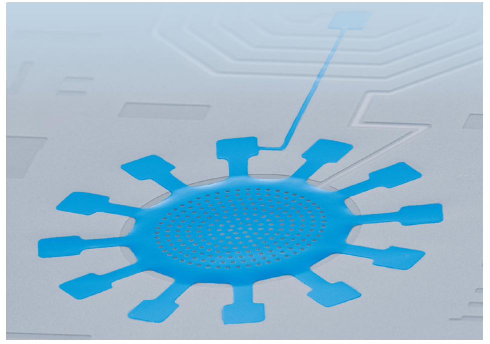
# A quantum leap in mechanical oscillator technology





**Over the past decade, scientists have made tremendous progress in generating quantum phenomena in mechanical systems. What seemed impossible only fifteen years ago has now become a reality, as researchers successfully create quantum states in macroscopic mechanical objects.**

By coupling these mechanical oscillators to light photons – known as "optomechanical systems" –, scientists have been able to cool them down to their lowest energy level close to the quantum limit, "squeeze them" to reduce their vibrations even further, and entangle them with each other. These advancements have opened up new opportunities in quantum sensing, compact storage in quantum computing, fundamental tests of quantum gravity, and even in the search for dark matter.

In order to efficiently operate optomechanical systems in the quantum regime, the mechanical oscillators must be properly isolated from their environment to minimize energy loss; while being well-coupled to other physical systems such as electromagnetic resonators to control them.

Striking this balance requires maximizing the oscillators' quantum state lifetime and oscillators frequency instabilities – what is known in the field as "decoherence". Compared to other technologies like superconducting qubits or ion traps, today's opto- and electro-mechanical systems still show higher decoherence rates.

Now, scientists at the laboratory of Tobias J. Kippenberg at EPFL have tackled the problem by developing a superconducting circuit optomechanical platform that shows ultra-low quantum decoherence while maintaining large optomechanical coupling that results in a high-fidelity quantum control. The work is recently published in Nature Physics.

"In simple words, we demonstrated the longest quantum state lifetime ever achieved in a mechanical oscillator, which can be used as a quantum storage component in quantum computing and communication systems," says Amir Youssefi, a PhD student who led the project. "This is a big achievement and impacts a wide range of audiences in quantum physics, electrical engineering, and mechanical engineering."

The key element of the breakthrough is a "vacuum-gap drumhead capacitor", a vibrating element made of a thin aluminum film suspended over a trench in a silicon substrate. The capacitor serves as the vibrating component of the oscillator and also forms a resonant microwave circuit.

Through a novel nanofabrication technique, the team significantly reduced mechanical losses in the drumhead resonator, achieving an unprecedented thermal decoherence rate of only 20 Hz, equivalent to a quantum state lifetime of 7.7 milliseconds – the longest ever achieved in a mechanical oscillator.

"Such ultra-low quantum decoherence not only increases the fidelity of quantum control and measurement of macroscopic mechanical systems, but will equally benefit interfacing with superconducting qubits and places the system in a parameter regime suitable for tests of quantum gravity," says Mahdi Chegnizadeh, another member of the research team "The considerably longer storage time compared to superconducting qubits makes the platform a perfect candidate for quantum-storage applications."

REFERENCES

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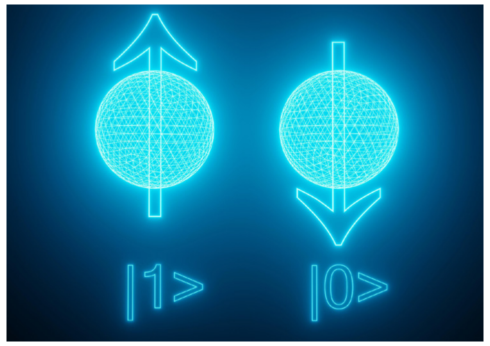
# Ultrafast control of spins in a microscope






**Researchers at EPFL have developed a new technique that can visualize and control the rotation of a handful of spins arranged in a vortex-like texture at the fastest speed ever achieved. The breakthrough can advance “spintronics”, a technology that includes new types of computer memory, logic gates, and high-precision sensors.**

Spin manipulation has attracted a lot of interest in recent years, giving rise to the field of spin electronics or “spintronics”. Apart from the fundamental study of spin, the more practical aim of spintronics is to exploit not just the charge of electrons – as in traditional electronics – but also their spin, adding and extra degree of freedom that can improve the efficiency of data storage and transfer.

However, this first requires that we can control small numbers of spins. “The visualisation and deterministic control of very few spins has not yet been achieved at the ultrafast timescales,” says Dr Phoebe Tengdin, a postdoc in Carbone’s lab, pointing out the very tight timeframes that this control needs to happen for spintronics to ever make the leap into applications.

Now, Tengdin along with PhD student Benoit Truc and fellow postdoc Dr Alexey Sapozhnik have developed a new technique that can visualize and control the rotation of a handful of spins arranged in a vortex-like texture, a kind of spin “nano-whirlpool” called a skyrmion.

To do this, the scientists used sequences of laser pulses at a femtosecond timeframe (10E-15 or a quadrillionth of a second). By arranging the laser pulses apart just right, they were able to control the rotation of spins in a selenium-copper mineral known in the field by its chemical composition, Cu2OSeO3. The mineral is quite popular in the field of spintronics, as it provides an ideal testbed for studying spins.

Controlling the spins with laser pulses, the researchers found that they could even switch their orientation at will by simply changing the delay time between successive driving pulses and adjusting the laser polarisation.

But the study didn’t stop there. By using a type of transmission electron microscope that can “see” nanoscale dimensions, the team were also able to actually image the spin changes. The breakthrough has enormous implications for the fundamental aspects of spintronics.

The work offers the field a new protocol for controlling magnetic textures at ultrafast timescales, and opens up exciting new opportunities for spin switches in next-generation information storage devices.

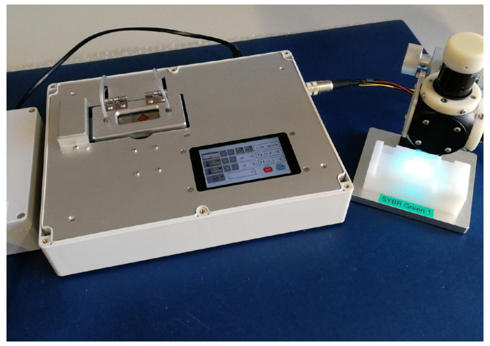
“Our experiments demonstrate that it is possible to manipulate and image a handful of spins at very high speed using a moderate intensity light beam,” says Tengdin. “Such an effect can be exploited in low-consumption ultrafast devices operating on spins. New types of memories or logic gates are possible candidates, as are high-precision sensors.”

REFERENCES

DOI

ISIC

# A microfluidic device for detecting SARS-CoV-2





**The past COVID-19 pandemic created an urgent need for ways to detect the SARS-CoV-2 virus quickly, accurately and on a massive scale in order to control its spread.**

Now, scientists from three Swiss institutions have developed a new microfluidic device that can detect SARS-CoV-2 with a high degree of accuracy. The device can distinguish SARS-CoV-2 from other respiratory viruses such as the Middle East Respiratory Syndrome CoronaVirus (MERS-CoV), making it a potential game-changer in the fight against coronaviruses. The project was led by Sandrine Gerber-Lemaire at EPFL, Igor Stefanini at SUPSI, and Francesco Bertoni at USI.

The device uses a DNA biosensor to detect RNA from SARS-CoV-2 in human saliva. When viral RNA binds to the DNA biosensor, it forms a DNA/RNA duplex. This is then detected by the sensor, which can pick up as little as 10 attomolar of the virus RNA. For perspective, one attomolar is equivalent to a drop of water in an Olympic-size swimming pool.

The device is based on microfluidics, a technology that controls the flow of very small amounts of liquids through tiny channels. With microfluidics, the new device controls the flow of saliva to allow the DNA biosensor to detect viral RNA. The DNA/RNA duplex is then detected with fluorescence measurements.

The virus detector can be deployed in non-medical environments, and can provide results in less than ten minutes, which makes it superb for point-of-care diagnostics in airports, schools, workplaces etc. And since it is highly selective for the SARS-CoV-2 virus, it does not produce false positives for other coronaviruses.

The device can play a significant role in population monitoring and mitigation efforts of the COVID-19 pandemic. It can also be adapted to detect other viruses with simple modifications to the sensor’s probe. “This device is highly versatile,” says Sandrine Gerber-Lemaire. “The biosensor unit can be easily adapted to the detection of other viruses by the selection and immobilisation of other DNA probe sequences.”

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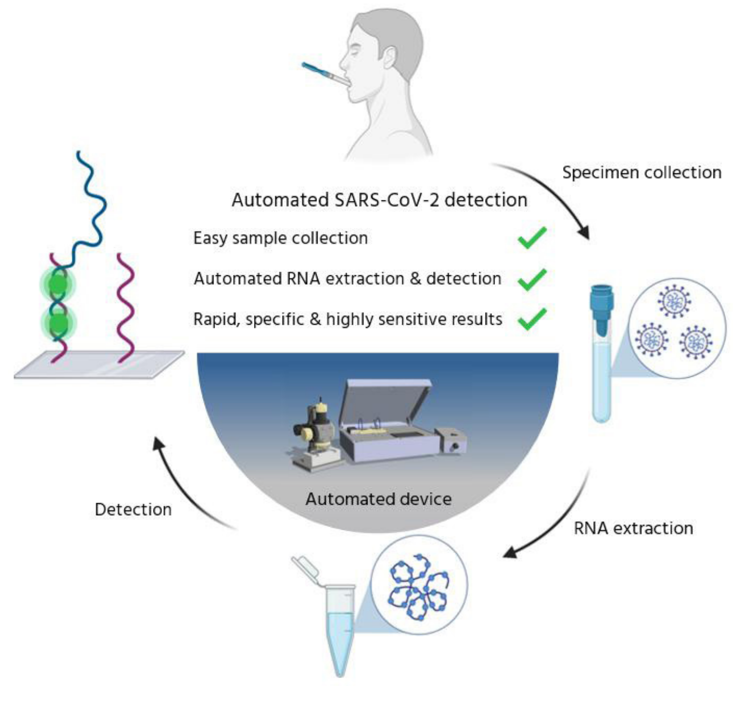

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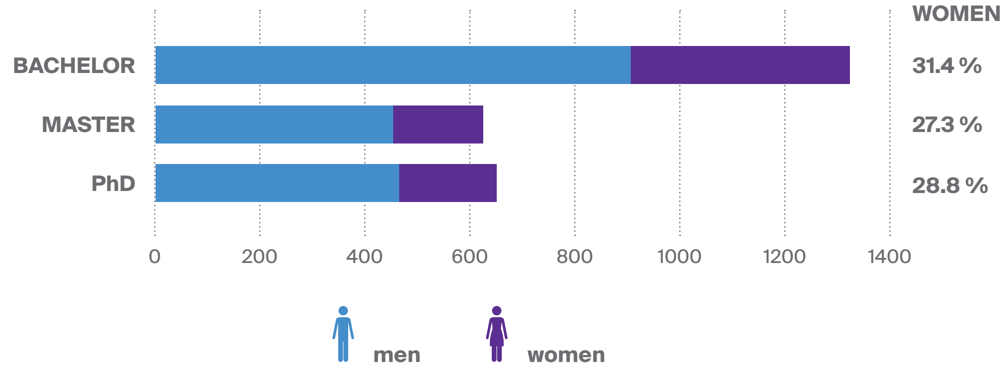
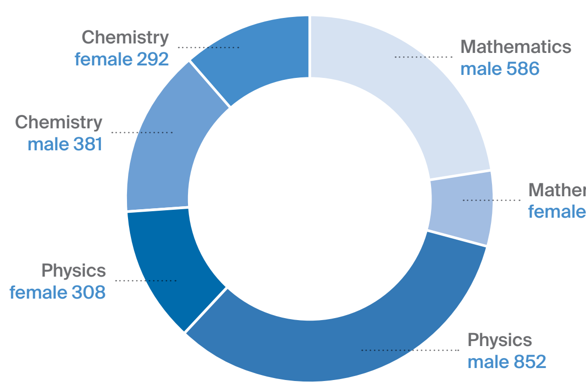
Sciences
SB

# PEOPLE

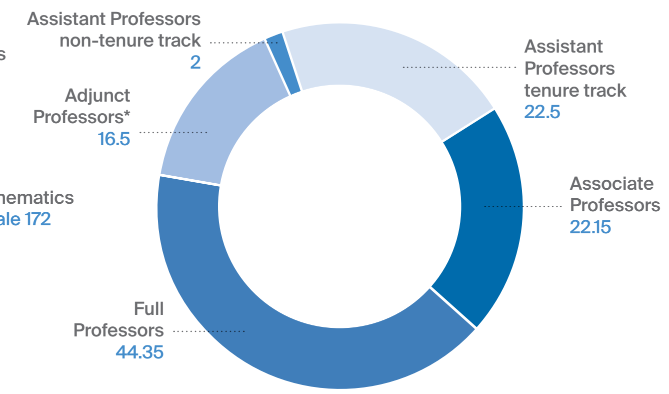
## SB Students




## SB Students (incl. PhD)

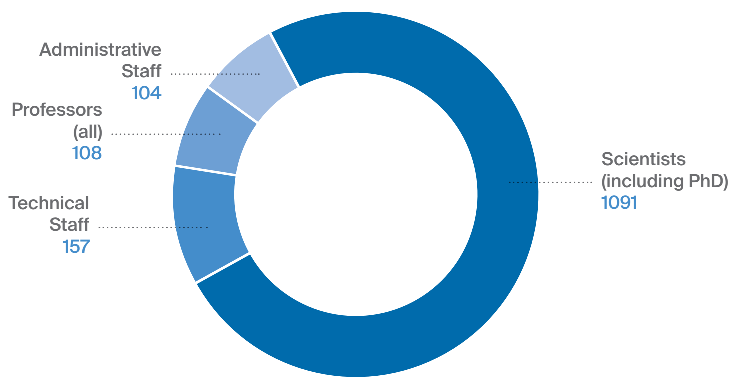



## SB Professors




* Including Assistant Professor non-tenure track

## SB Staff

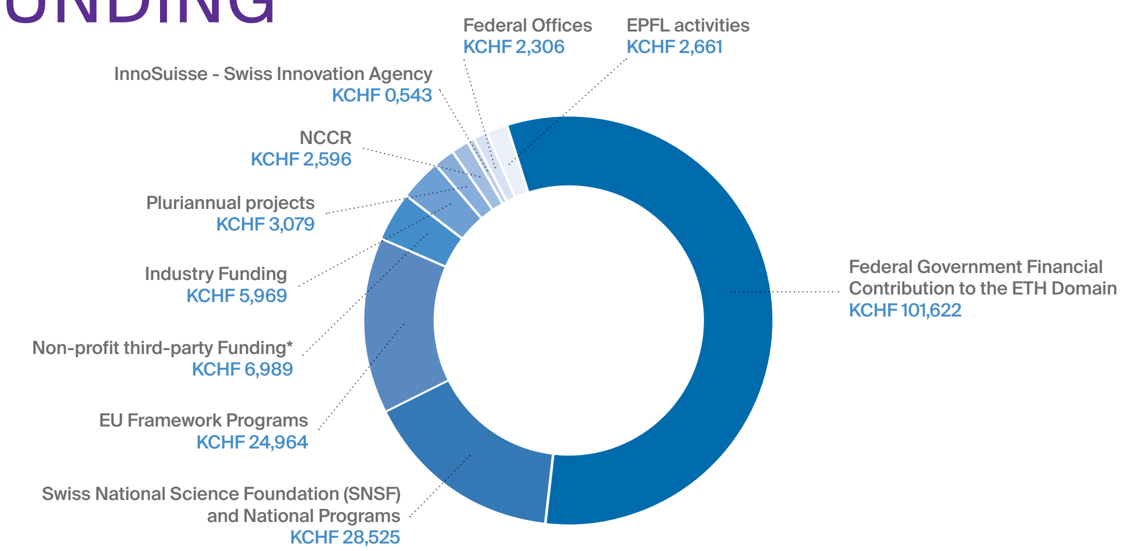





## SB Staff

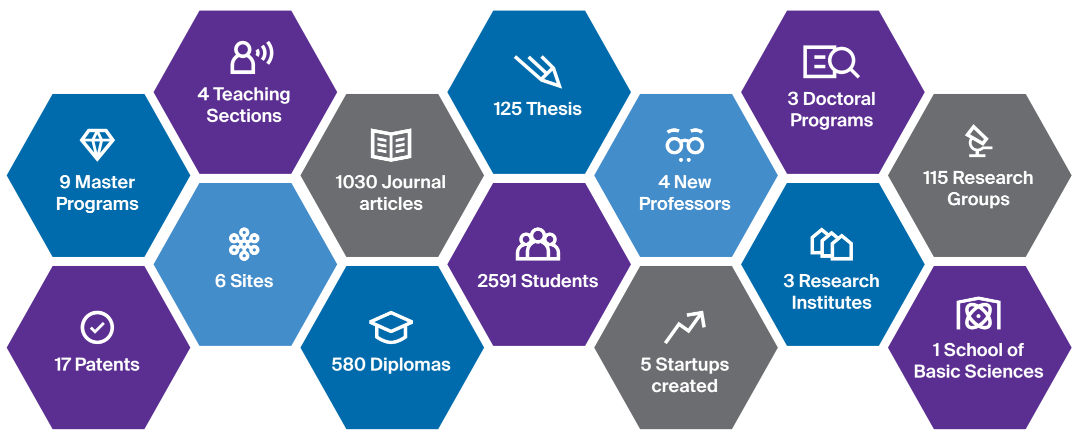
| STAFF | TOTAL | WOMEN % |
|---|---|---|
| PhD students | 649 | 29 |
| Scientific staff / Postdocs | 421 | 19 |
| Senior Scientists / MER | 21 | 5 |
| Technical / IT staff | 157 | 15 |
| Administrative staff | 104 | 68 |
| Apprentices | 38 | 34 |
| Full professors | 44 | 19 |
| Associate Professors | 22 | 21 |
| Tenure-Track Assistant Professors | 23 | 31 |
| Adjunct Professors / Titulaires | 17 | 24 |
| Assistant Professor non-tenure track | 2 | 0 |
| Emeriti Professors | 84 | 5 |

# FUNDING




* includes Foundations and Associations

# KEY FIGURES



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