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ÉCOLE POLYTECHNIQUE
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2017

FRONT COVER
Simulated electric field profile of the resonant fundamental mode in a photonic crystal optical cavity

LETTER OF THE DIRECTOR

Dear Reader,

The Institute of Physics (IPHYS) is still comparatively young. We created it 2 years ago fusing 4 former Institutes that reflected the research areas of high-energy and astro-physics, solid state physics, biophysics and complex systems, as well as theoretical physics. A single institute enables to create new areas, share common facilities more efficiently, and defend the interests of physics at the School level in a more efficient way. Examples of newly created strategic areas are cold atoms, quantum science, and physics for energy. We further intend to develop a stronger theory effort.

This brochure summarizes the key figures, rankings, teaching, scientific achievements, and technology transfer of the year 2017. Let me just point out a few. We welcome Sahand Rahi (Harvard University) as new tenure-track professor in the field of biophysics, Frédéric Courbin (astrophysics) and Ivo Furno (plasma physics) were promoted to adjunct professor, and Christoph Galland obtained an SNF professorship. We congratulate Alessandro Vichi for his ERC Starting Grant and Fabrizio Carbone for his ERC Consolidator Grant, as well as Tobias Kippenberg for his lead of two large (14 M€) EU projects.

Teaching physics to all students of EPFL and some at UNIL is an important part of our mission. Teaching awards have been given to Nicolas Turin (Polysphère d'Or), Laurent Villard (Physics Teacher Award), and Olivier Schneider (Craie d'Or). Another key mission is technology transfer. Our colleagues have deposited several patent applications in recent years, and one of the patents by Tobias Kippenberg is used by the startup Ligentec created recently. A water purifier panel developed by Laszló Forró and his collaborators was rewarded internationally.

Davor Pavuna, Minh Quang Tran and Benoît Deveaud retired in 2017 and we express our sincere gratitude to them, especially to Benoît who directed IPHYS from January 2016 through March 2017. In April Olivier Schneider and myself took the lead of the institute and we would like to express our gratitude to Blandine Jérôme for her scientific support and to Claire-Lyse Rouiller for her administrative assistance. In wishing you a good read,

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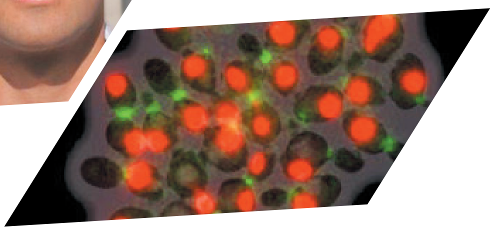


SAHAND RAHI EXPLORES SYSTEMS OF INTERACTING GENES AND CELLS

Sahand Jamal Rahi has been appointed Tenure Track Assistant Professor of Biophysics.

Sahand Rahi will start at EPFL in July 2018. He is presently a visiting scholar in the Department of Physics at Harvard University. From 2010 until 2017, he was a Fellow at The Rockfeller University after completing a PhD in Physics at MIT in 2010. Sahand Rahi's research has crossed the border between biology and physics a number of times before finally settling in at the interface between the two, in biophysics. In college, he worked on mathematical biology, for example, on how to create maps of proteins on the surfaces of simpler objects like spheres and tori. During his PhD, he studied the forces that keep much of the matter around us together, quantum fluctuation forces, which are also known as Casimir or van-der-Waals forces. He derived a formula for calculating these forces on objects of arbitrary geometries and showed that, like electrostatic forces, they cannot hold objects in space stably in general. Then, as a postdoc, Sahand Rahi returned to biology and, in particular, to systems biology, where he seeks to understand how interactions between genes explain various aspects of life. For example, he recently discovered that two major classes of genetic networks can be distinguished by stimulating the cell or the whole organisms with a periodic signal, an extremely difficult task by existing methods.

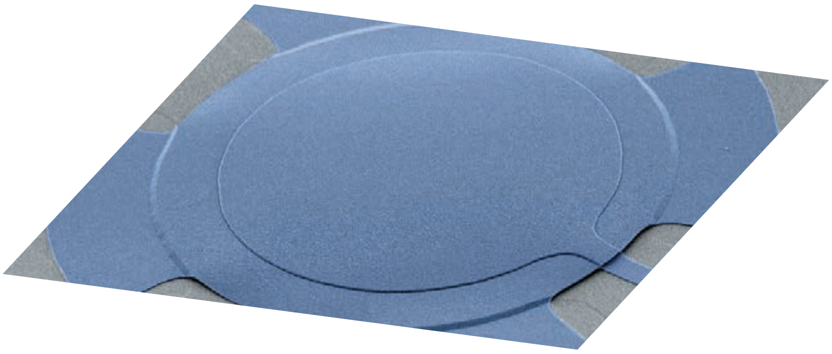
Why and how biological systems fail to do what they were optimized for

"The beauty of working on living systems as a physicist right now", explains Sahand Rahi, "is that there are many unanswered fundamental questions and the tools for pursuing them by genetic manipulation and microscopy are becoming easier and more powerful. I focus on networks of interacting genes and how their dynamics explains the properties of the organism. Can we understand these networks well enough to make predictions? Well enough to manipulate them toward predetermined outcomes?"

One question Sahand Rahi is particularly interested in at the moment is why and how biological systems fail to do the job they are thought to have been optimized for during the course of evolution. For example, there is a network of proteins that monitors damage in cells. However, faced with prolonged stress, it just shuts down after a certain period of time. The question is why and how. "IPHYS provides two important ingredients for our research", says Sahand Rahi: "great potential collaborators within IPHYS, as well as in the life sciences (SV), and, also, outstanding students to work and interact with. The density of such excellent people makes EPFL truly unique".

Sahand Rahi is also passionate about teaching: "I find myself learning the material more deeply each time I teach, and I enjoy the performance of teaching. One of my personal missions has always been to take greater advantage of the Internet for physics education, for example, creating online interactive lectures and leaving classroom time for discussions. At EPFL there are many initiatives and like-minded people that I can team up with in that effort such as other physics faculty who hold similar views as well as the Center for Digital Education".

A MECHANICAL QUANTUM RESERVOIR FOR MICROWAVES



EPFL researchers use a mechanical micrometre-size drum cooled close to the quantum ground state to amplify microwaves in a superconducting circuit.

In a recent experiment, a microwave resonator, a circuit that supports electric signals oscillating at a resonance frequency, is coupled to the vibrations of a metallic micro-drum. By actively cooling the mechanical motion close to the lowest energy allowed by quantum mechanics, the micro-drum can be turned into a quantum reservoir – an environment that can shape the states of the microwaves. The findings were published in *Nature Physics* [1].

László Dániel Tóth, Nathan Bernier, and Dr. Alexey Feofanov led the research effort in the Laboratory of Photonics and Quantum Measurements, with support from Andreas Nunnenkamp, a theorist at the University of Cambridge, UK.

Microwaves form the backbone of several everyday technologies, from microwave ovens and cellular phones to satellite communication, and have recently gained further importance in manipulating quantum information in superconducting circuits — one of the most promising candidates to realize future quantum computers.

The micro-drum, only 30 microns in diameter, 100 nanometers thick and fabricated in the Center of Micro-Nanotechnology at EPFL, constitutes the top plate of a capacitor in a superconducting microwave resonator. The drum's position modulates the resonator's resonance frequency and, conversely, a voltage exerts a force on the micro-drum. Through this interaction, energy can be exchanged between mechanical vibrations and the microwave oscillations.

In the experiment, the micro-drum is first cooled close to its lowest energy level by a suitably tuned microwave tone. Every microwave photon carries away the energy of the mechanical motion. This cooling process increases the dissipation and turns the micro-drum into a dissipative reservoir for the microwave resonator.

By tuning the interactions between the cavity and the cooled micro-drum, the cavity can be turned into a microwave amplifier. The most interesting aspect of this amplification process is the added noise, that is, how much unwanted fluctuations are added to the amplified signal. The amplifier realized here operates very close to the quantum limit, i.e. it is as "quiet" as it can in principle be. Interestingly, in a different regime, the micro-drum turns the microwave resonator into a maser.

Using the same architecture, in a separate experiment the researchers could also demonstrate a different device functionality: nonreciprocal microwave conversion and isolation. While commercial microwave isolators are common, they typically rely on magnetic ferrite materials, which can disturb the fragile qubits. The optomechanical isolator created at EPFL might form a new platform to build such nonreciprocal devices in the future without external magnetic fields. The work was published in *Nature Communications* [2].

Future activities on the emerging research possibilities created by these works will be supported by two recent EC Horizon 2020 projects: Hybrid Optomechanical Technologies (HOT) and Optomechanical Technologies (OMT), both coordinated at EPFL (see p. 15).

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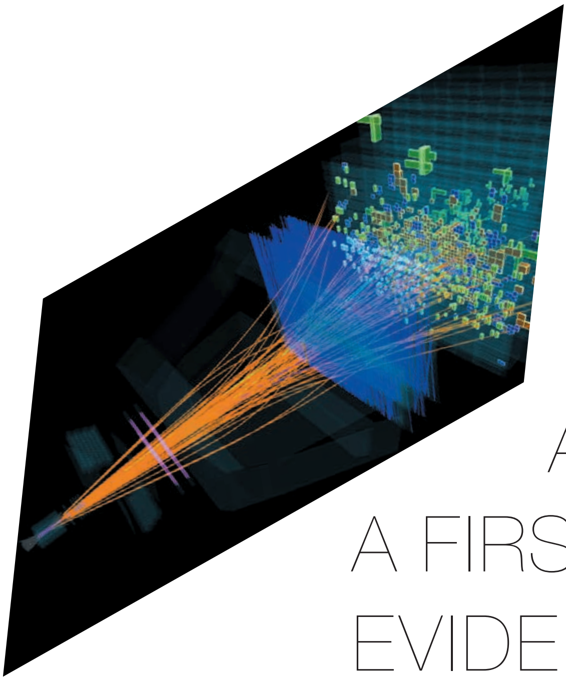

ASYMMETRY BETWEEN BARYONIC MATTER AND ANTIMATTER: A FIRST EXPERIMENTAL EVIDENCE

Measuring heavy baryons and antibaryons produced at CERN's Large Hadron Collider, the LHCb collaboration has obtained a tantalising evidence for differences associated with the non-invariance of fundamental interactions under the combined charge-parity transformation.

The violation of the symmetry between matter and antimatter, also known as CP violation, is a necessary ingredient to explain baryogenesis, a process that took place in the early Universe and led to today's imbalance between baryons (matter) and antibaryons (antimatter). CP violation was discovered in 1964 in a Nobel-Prize winning experiment by Cronin and Fitch with neutral kaons, composed of quarks from the first two families. In 1973, Kobayashi and Maskawa proposed a model where a single irreducible complex phase in the mixing of three families of quarks is responsible for CP violation. They were awarded the Nobel Prize in 2008 after their model was beautifully confirmed by experiments using decays of B mesons, containing the bottom quark from the third family.

Two intriguing facts can be noted. Firstly, CP violation predicted by the Standard Model of particle physics (which incorporates the Kobayashi-Maskawa model) is much too small to account for the observed matter-antimatter imbalance in the Universe. Secondly, all experimental observations of CP violation so far come from mesons (composed of a quark and an antiquark), rather than baryons or antibaryons (composed of three quarks or three antiquarks). Hence, a direct observation of CP asymmetries in baryons could reveal additional sources of CP violation and perhaps shed new light on the cosmological baryogenesis.

Using data collected with the LHCb detector during Run 1 of the Large Hadron Collider, physicists at EPFL and collaborating institutes have made the first observation of the rare decay of the heavy Λ_b^0 baryon (containing a bottom quark) to a proton and three charged pions, as well as of the corresponding decay of the anti-Λ_b^0. Close to 7000 such decays have been isolated. These four-body decays have a rich resonance structure, which may produce local enhancements of CP-violating effects. Asymmetries in scalar triple products of the final-state particle momenta have been measured to be as large as 20%

CP violation predicted by the Standard Model is much too small

in certain regions of the phase space. The significance of these asymmetries differing from zero is 3.3 standard deviations, leading to the first evidence for CP violation in baryon decays. The large data samples collected during the ongoing Run 2 and further subsequent runs will be analysed to decrease the statistical uncertainties of these initial measurements.

The LHCb collaboration currently involves 74 institutions from 16 countries and has already published over 400 physics papers. The EPFL group, led by Professors Bay, Nakada and Schneider, has made crucial contributions to the design, construction and operations of the LHCb detector. It is presently building a new scintillating fibre tracker in view of a major technology upgrade of the detector. Starting in 2021, the new detector will feature a full readout at 40 MHz and a greatly improved data-taking efficiency.

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Graduation Day

On a gorgeous day of October, a crowd of about 3,000 parents, friends, professors and special guests gathered at the Swiss Tech Convention Center to congratulate the 994 new Master's graduates. Among them, 61 received a degree in physics.

The Graduation Ceremony was honoured by the presence of Federal Councillor Johan Schneider-Ammann, among other special guests. EPFL President Martin Vetterli was the first to congratulate the graduates. He encouraged them to pursue their aspirations, and quoting Gandhi, to "be the change you wish to see in the world".

After the main ceremony, the physics graduates received their degree within their Section. We are very proud of our physics students and we warmly congratulate them for getting their degrees. Two of them received a special distinction: Yann Rausis was awarded the Sports Prize and Paul Martens was awarded the Hausmann Prize for his master thesis (see p. 18). We are also extending our congratulations to the 86 Bachelor students who completed their degree.

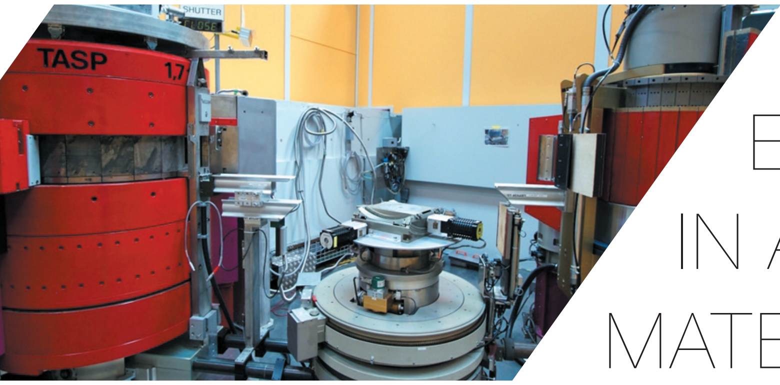
Graduation is always a nice moment to reflect back on the past years and look forward to developments taking place in the Physics Section. Seeing a whole class of students moving on to their new challenge definitely provides a nice sense of fulfilled duty to all the teachers who have taught and supervised them for the past five years. Looking at the in-coming stream, it is very encouraging to see the large number of students choosing these studies. For the second year in a row, the number of first-year students is over 220, while it was only 160 to 180 three years ago. So we expect the number of graduates to increase over the coming years.

With these increasing numbers of students, preserving the teaching quality is a top priority. This applies not only to the physics curriculum but also to the introductory physics courses taught to about 3850 students of various sections and even UNIL. The positive feedback of students through teaching awards (see p. 13) is a greatly appreciated recognition of the hard work teachers put in providing students the best education possible.

Frédéric Courbin unveils the mysteries of the Universe

Frédéric Courbin has been promoted Adjunct Professor in July 2017.

After graduating from Paris University (Orsay - Paris XI), Frédéric Courbin obtained his PhD from the University of Liège (Belgium), both on image de-convolution and gravitational lensing. He then left for 3 years to enjoy the clear skies of Chile, which hosts the most advanced optical observatories in the world. He returned to Europe on a Marie Curie Fellowship before joining EPFL Laboratory of Astrophysics in 2004. His interests span a broad range of topics, from the study of supermassive black holes and galaxies to cosmology. In particular he is internationally recognized for his work using the natural phenomenon of gravitational lensing to measure precisely the expansion rate of the Universe. Because top-notch analysis techniques are mandatory to exploit multi-wavelength and multi-temporal observations, Frédéric Courbin always works at the frontier between pure signal processing and astrophysics. He has developed many interdisciplinary projects, e.g. in connection with fields such as machine learning or biomedical imaging, in the context of the ESA Euclid mission (to be launched in 2021) for which he is recognized as one of the leading scientists in Switzerland.



NEW TYPE OF ENTANGLEMENT IN A 2D QUANTUM MATERIAL

Scientists from EPFL and PSI have shown experimentally, for the first time, a quantum phase transition in strontium copper borate, the only material to date that realizes a famous quantum many-body model.

Many physical phenomena can be modeled with relatively simple math. But, in the quantum world there are a vast number of intriguing phenomena that emerge from the interactions of multiple particles – "many-bodies" – which are notoriously difficult to model and simulate, even with powerful computers. Examples of quantum many-body states with no classical analogue include superconductivity, superfluids, Bose-Einstein condensation, quark-gluon plasmas etc. As a result, many "quantum many-body" models remain theoretical, with little experimental backing. Now, scientists from EPFL and the Paul Scherrer Institut (PSI) have realized experimentally a new quantum many-body state in a material representing a famous theoretical model called the "Shastry-Sutherland" model.

Quantum many-body physics remains a challenge

While there are several one-dimensional many-body models that can be solved exactly, there are but a handful in two-dimensions (and even fewer in three). Such models can be used as lighthouses, guiding and calibrating the development of new theoretical methods.

The Shastry-Sutherland model is one of the few 2D models that have an exact theoretical solution, which represents the quantum pairwise entanglement of magnetic moments in a square lattice structure. When conceived, the Shastry-Sutherland model seemed an abstract theoretical construct, but remarkably it was discovered that this model is realized experimentally in strontium copper borate.

Mohamed Zayed in the lab of Henrik Rønnow at EPFL and Christian Ruegg at PSI discovered that pressure could be used to tune the material away from the Shastry-Sutherland phase in such a manner that a so-called quantum phase transition to a completely new quantum many-body state was reached.

In the Shastry-Sutherland model, the atomic magnets – arising from the spins of the atom's electrons– are quantum-entangled in pairs of two. The researchers found that in the new quantum phase the atomic magnets appear quantum-entangled in sets of four –so-called plaquette singlets. "This is a new type of quantum phase transition, and while there have been a number of theoretical studies on it, it has never been investigated experimentally," says Rønnow. "Our system may allow further investigations of this state and the nature of the transition into the state."

"Quantum many-body physics remains a challenge where theory has only scratched the surface of how to deal with it," says Rønnow. "Better methods to tackle quantum many-body phenomena would have implications from materials science to quantum information technology."

This work was carried out in collaboration with the Paul Scherrer Institut, the Carnegie Mellon University in Qatar, the University of Geneva, University College London, the Centro Brasileiro de Pesquisas Fisicas, the University of Innsbruck, the University of Cambridge, Nanyang Technological University, Université Pierre et Marie Curie, the Russian Academy of Sciences, the Institut Laue-Langevin, and the Forschungszentrum Julich GmbH.

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Fabrizio Carbone awarded an ERC Consolidator Grant

European Research Council
Established by the European Commission

Prof. Fabrizio Carbone has been awarded a Consolidator Grant from the European Research Council.

The European Research Council's (ERC) Consolidator Grants are given annually to researchers of any nationality with 7-12 years of research experience after completion of their PhD, as well as "a scientific track record showing scientific talent and an excellent research proposal".

Professor Fabrizio Carbone directs the Laboratory For Ultrafast Microscopy and Electron Scattering at EPFL. His research focuses on the study of ultrafast phenomena in solids and nanostructures. Specifically, his lab studies novel superconductors, charge-density waves, spin-density wave solids, and phase transitions in low-dimensional materials.

The project "Imaging Spectroscopy and Control of Quantum states in advanced Materials" deals with the visualization and control of spins and charges in solids that display spatially ordered ground states. Some examples are topological magnets or cuprates, in which superconductivity can coexist with charge and spin density waves. The ability to observe and manipulate in real-time and real-space such states of matter offers fascinating perspectives for both fundamental science and applications. For instance, resolving the dynamical evolution of spin textures in topological magnets can reveal the microscopic details of the competition between topological protection and thermodynamic fluctuations, while developing methods to control such dynamics would provide a handle for manipulating spins in new data-storage or even sensing devices.

The typical length-scales associated with such a phenomenology are in the range of one to a few hundreds of nanometers, while the characteristic times can be as fast as attoseconds for high-energy electronic collective modes, or as slow as microseconds for some long-range magnetic ordering effects. In this project, we will use ultrafast transmission electron microscopy to cover such time and length scales. In such an instrument, electron pulses provide the spatial resolution down to the atomic level and sensitivity to local magnetic fields, while light pulses can be used to control the properties of the solid. Differently to what is usually done, we plan to achieve the local (nm/femtosecond) control of spins and charges in materials by exciting with light pulses plasmonic resonators directly nano-fabricated on quantum materials. With this method, we will generate nm-confined fs electric or magnetic field pulses with which we can manipulate individual skyrmions, a whirling distribution of spins, magnetic domains and even superconducting vortices.

Ivo Furno exploits plasmas under all conditions

Ivo Furno has been promoted Adjunct Professor in July 2017.

Ivo Furno joined the Center for Research in Plasma Physics (CRPP, now Swiss Plasma Center, SPC) in 2005. After a Master in Nuclear Engineering at the Politecnico di Torino, he obtained his PhD at the CRPP in 2001, and has been a senior researcher at Los Alamos National Laboratory. He first conducted research on magnetic instabilities in tokamak fusion reactors, and in space plasmas. In his thesis, he pioneered tomographic methods to reconstruct the plasma temperature profile from X-ray emissions in the CRPP tokamak, while at Los Alamos he conceived and built a facility to investigate magnetic reconnection, a key phenomenon in magnetized plasmas, both in fusion reactors and in space and astro-physical systems, such as in the earth magnetic tail and in accretion disks.

At the SPC he became responsible for the basic plasmas and applications group, conducting research on plasma interactions with turbulence on the TORPEX device. He contributed to major breakthroughs such as unveiling the origin and dynamical evolution of turbulence structures, and a large number of more applied projects, ranging from food packaging to micro-satellite propulsion. He also keeps collaborating with the SPC tokamak. These activities incarnate the new philosophy of the SPC, with a well-defined core business in fusion sciences, but with an eye for diversification in areas of large innovation potential for industry and society at large.

FNSNF

The SNSF awards a professorship to Christophe Galland

The Swiss National Science Foundation (SNSF) has awarded a professorship to Dr. Christophe Galland for his project "Quantum dynamics of phonons in nanostructures and molecules".

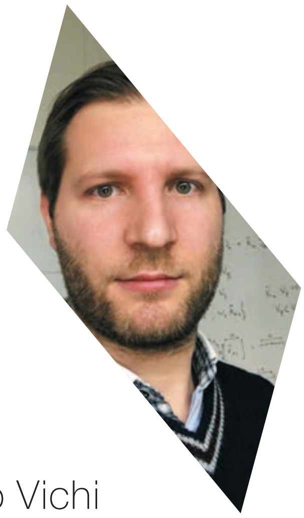
The highly selective SNSF professorships are meant for young researchers who intend to pursue an academic career and wish to establish their own team to carry out a research project. The funding period is four years and may be extended by no more than two years.

Christophe Galland and his team are developing new optical techniques to probe the dynamics of non-classical vibrational states inside nanoscale systems, such as molecules and engineered nanostructures.

For example, using a pair of ultrashort laser pulses and detectors sensitive to single photons, it is possible to excite a single quantum of vibration (a phonon) and watch its decay over a few picoseconds (10^{-12} s). The group is working to apply this technique to ever smaller objects, and to engineer nanocavities to enhance the photon-phonon interaction.

The research aims at improving our fundamental understanding of ultrafast vibrational quantum phenomena occurring at the molecular and nano-scale. Moreover, the techniques developed in the project could contribute to the advancement of quantum technologies, in particular in the field of quantum photonics, for the generation, manipulation and storage of non-classical states of light.

AWARDS



European Research Council
Established by the European Commission

Alexandro Vichi awarded an ERC Starting Grant

Prof. Alessandro Vichi, SNSF professor at the Institute of Physics, has been awarded a Starting Grant from the European Research Council in the area of Physical Sciences and Engineering.

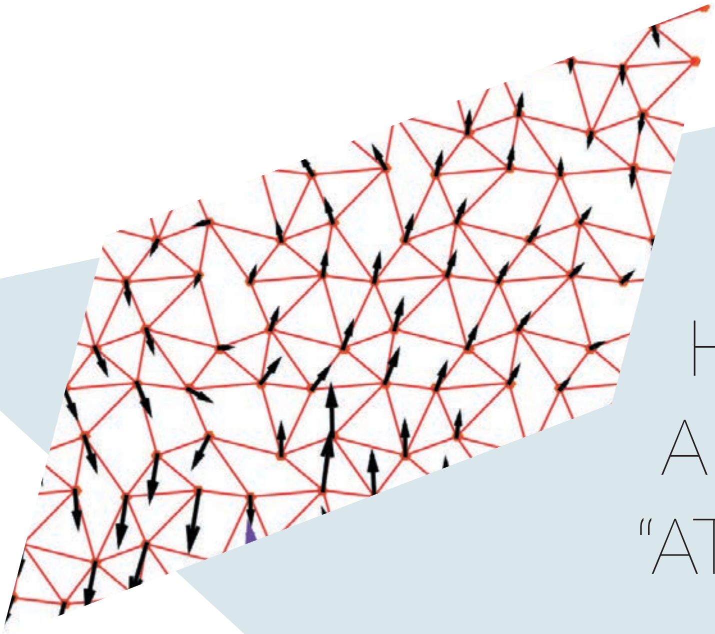
The ERC Starting Grants are given each year to researchers of any nationality and in any field of research with 2-7 years of experience since their PhD, with a promising scientific track record and an excellent research proposal. The application must be made from an EU or associated country, and each Starting Grant can be up to €1.5 million given over a period of five years.

Among the 2017 ERC Starting Grant winners, Alessandro Vichi got a grant for his project entitled 'Charting the space of Conformal Field Theories: a combined nuMerical and Analytical aPproach' (CFT-MAP). Conformal Field Theory (CFT) was originally conceived in four and three dimensions, with applications to particle physics and critical phenomena in mind. However, it is in two dimensions that the most spectacular results have been obtained. In higher dimensions, there used to be a general feeling that the constraining power of conformal symmetry by itself is insufficient to tell nontrivial things about the dynamics, hence the interest in various additional assumptions. This is not fully satisfactory, since there are likely many CFTs that do not fulfill any of them.

The main focus of the CFT-MAP project is to take a fresh look at the idea that the mathematical structure of CFTs is instead such a strong constraint that it can allow for a complete solution of the theory. This program, known as conformal bootstrap, has provided a new element in the quantum field theory toolbox to describe genuine non-perturbative cases. This project aims to explore new directions and push forward the frontiers of conformal field theories, with the ultimate objective of a detailed classification and understanding of scale invariant systems and their properties.

CFT-MAP will develop more efficient numerical techniques and complementary analytical tools making use of two main methods: by studying correlation functions of operators present in any quantum field theory, such as global symmetry conserved currents and the energy momentum tensor, and by inspecting the analytical structure of correlation functions. The project will scan the landscape of CFTs, identifying where and how they exist. By significantly improving over the methods at disposal, this proposal will be able to study theories that are currently out of reach.

Besides innovative methodologies, a fundamental outcome of CFT-MAP will be a world record determination of critical exponents in second phase transitions, together with additional information that allows an approximate reconstruction of the quantum field theory in the neighborhood of fixed points.



NEW COMPUTER MODEL SHOWS HOW PROTEINS ARE CONTROLLED "AT A DISTANCE"

EPFL scientists have created a new computer model that can help better design allosteric drugs, which control proteins "at a distance".

Enzymes are large proteins that are involved in virtually every biological process, facilitating a multitude of biochemical reactions in our cells. Because of this, one of the biggest efforts in drug design today aims to control enzymes without interfering with their so-called active sites –the part of the enzyme where the biochemical reaction takes place. This remote approach is called "allosteric regulation", and predicting allosteric pathways for enzymes and other proteins has gathered considerable interest. Scientists from EPFL, with colleagues in the US and Brazil, have now developed a new mathematical tool that allows more efficient allosteric predictions. The work is published in *PNAS*.

Allosteric regulation modulates numerous cell processes

Allosteric regulation is a fundamental molecular mechanism that modulates numerous cell processes. Most proteins contain parts in their structure away from their active site that can be targeted to influence their behavior remotely. When an allosteric modulator molecule binds to such a site, it changes the 3D structure of the protein, thereby affecting its function.

The main reason allosteric sites are of such interest to drug design is that they can be used to inhibit or improve the activity of a protein, e.g. the binding strength of an enzyme or a receptor. Despite the importance of allosteric processes, we still do not fully understand how a molecule binding on a distant and seemingly unimportant part of a large protein can change its function so dramatically.

The key lies in the overall architecture of the protein, which determines what kinds of 3D changes an allosteric effect will have.

The laboratory of Matthieu Wyart sought to address several questions regarding our current understanding of allosteric architectures. Specifically, these researchers looked at the structure of proteins as randomly packed spheres that can evolve to accomplish a given function. When one sphere moves a certain way, this model can help scientists track its structural impact on the whole protein.

Using this approach, the scientists addressed several questions that conventional models do not answer satisfactorily. Which types of 3D "architecture" are susceptible to allosteric effects? How many functional proteins with a similar architecture are there? How can these be modeled and evolved in a computer to offer predictions for drug design?

Using theory and computer power, the team developed a new model that can answer these questions. The model proposes a new hypothesis for allosteric architectures, introducing the concept that certain regions in the protein can act as levers. These levers amplify the response induced by binding a ligand and allow for action at a distance. The computational approach can also be used to study the relationship between co-evolution, mechanics, and function, while being open to many extensions in the future.

This work involves a collaboration of EPFL's Physics of Complex Systems Laboratory with the University of California Santa Barbara and the Universidade Federal do Rio Grande do Sul in Brazil. It was funded by the US National Science Foundation (NSF), the Swiss National Science Foundation (SNSF), and the Simons Foundation.

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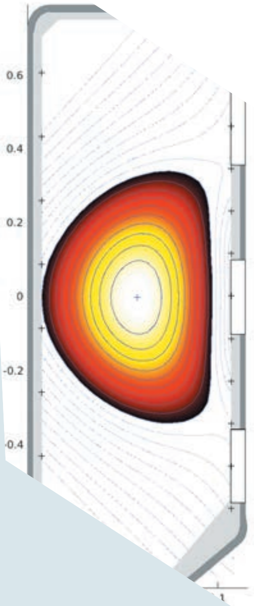

THE UNIQUELY VERSATILE TCV TOKAMAK BREAKS NEW GROUND FOR FUSION REACTORS

A key challenge for fusion is to increase the time over which magnetic fields trap plasmas that are hotter than the core of stars. Using the shape flexibility and control of the TCV tokamak, researchers at the Swiss Plasma Center demonstrate why a plasma triangular, inverted D-shape cross-section leads to significantly improving the confinement.

Negative triangularity (i.e. a plasma triangular cross-section with one edge pointing towards the center of the torus) leads to doubling the plasma confinement time. This discovery, obtained on TCV a few years ago, was immediately recognized to have a great potential impact for fusion reactors, but was also accompanied by a puzzle, namely how a shape that characterizes mostly the peripheral region of the plasma influences also its hot core, where the heat diffusivity is observed to be drastically reduced. Local numerical simulations in fact predict turbulence and transport reduction only at the edge, which would be less significant for fusion performance.

This conundrum was solved by recent observations of density and temperature fluctuations and turbulence, measured in TCV using phase-contrast and electron-cyclotron emission techniques [1]. Turbulence, which is the primary cause of particle and heat transport, is suppressed at negative triangularity well into the plasma core. Global effects are thus at play, a finding of interest in plasma physics beyond tokamak shaping, as confirmed by global 5D turbulence HPC simulations.

Experiments of this kind have been made possible by recent TCV upgrades on measurement systems such as the Thomson Scattering apparatus, whose spatial and spectral resolution for temperature and density profile measurements were greatly enhanced, and by the newly installed 1MW 15-30 keV Neutral Beam Injector, which directly heats the plasma ions. In addition, a paramount role was played by a novel digital feedback control system, which employs a new singular-value decomposition method to allow preferential weighting of individual moments or specific properties of the shape [2]. These developments on control methods are themselves at the forefront of tokamak research, in particular in view of the operation of ITER.

Runaway electrons are of great concern in a prospective nuclear-fusion reactor

A second example of investigations carried out on TCV in preparation of ITER, using the most recent developments in plasma heating, diagnostic and control tools, and in the frame of campaigns supported by the European consortium EUROfusion, is that on the generation of runaway electrons at the final stage of a plasma disruption. Runaway electrons are of concern in a prospective nuclear-fusion reactor as they carry mega-amp currents and reach ultra-relativistic energies, hence can escape from the confinement region and damage the vacuum vessel. Risk-mitigation techniques include limiting the runaway electron generation through massive gas injection and controlling the runaway beam once developed. In TCV, where a full conversion of the plasma current to runaway beam current has been observed in some scenarios, a new controller has been successfully employed to stabilize the position of the beam and effect a controlled current ramp-down [3].

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[3] G. Papp *et al.*, **Runaway electron generation and mitigation on the European medium sized tokamaks ASDEX Upgrade and TCV**, Proceedings of the 26th IAEA Fusion Energy Conference, EX / 9-4 (2016)

Nicolas Turin awarded the Polysphère d'Or 2017

During the Graduation Ceremony, the AGEPoly has presented the Polysphère d'Or to Nicolas Turin, teacher in the Physics Section.

Every year, during the Graduation Ceremony, the students honour the best teacher of each faculty with a polysphere. The teacher who obtains the highest mark in the vote receives the Polysphère d'Or.

This year, the Polysphère d'Or has been awarded to Nicolas Turin who is involved in different courses of the Physics Section. He fosters a special contact with the students, as he is close to them as soon as they arrive at EPFL. Indeed, Nicolas Turin assists the 1st year metrology course, which allows him to get to know them and also them to know him. In 2nd and 3rd years, they are also in contact during the practical work sessions. "I deeply enjoy exchanging with them and following their progress", rejoices Nicolas Turin.

In addition, Nicolas Turin teaches the course 'Introduction to construction technics' together with Florian Bernard (mechanical engineer at IPHYS) and Antonio Gentile (ET technician at SPH). Students learn in this course to design parts, to make them in the mechanical workshop, and to build electronic circuits. "Students are generally interested and motivated since the course is optional".

"After almost 10 years spent with the students, this award deeply touches me and I feel like continuing to invest myself for them", concludes Nicolas Turin.

AWARDS

Laurent Villard awarded the Teacher Prize of the Physics Section

The Physics Section honours every year one teacher who has particularly excelled in this important mission. The trophy of the Teaching Prize 2017 was presented to Prof. Laurent Villard during the Master's graduation ceremony.

Laurent Villard teaches the course 'Computational physics' to 2nd year bachelor students in physics, a course he created and taught for the first time in 2006. This highly hands-on course encourages the students to learn by testing solutions themselves. "It's a sort of laboratory in which the students, who have already studied programming, use numerical methods to solve physics equations," says Villard.

The course is challenging, but Laurent Villard knows how to pique the students' curiosity. "I love sharing my knowledge and I'm passionate about my work. In class, I use all the methods I can: blackboard, overhead projector, demonstrations through numerical simulations, in-class discussions – what's important is to keep the class moving, regardless of the method." And his approach works. "We demand a lot of work from the students, but they are very enthusiastic. Many of them even go beyond what we ask, such as by creating short videos or by coming up with new applications for the computational methods they saw in class or in their exercises." And that's what Villard finds particularly rewarding. "If my course makes them want to go further, then I'm the happiest teacher there is!"

AWARDS

Craie d'Or 2017 awarded to Olivier Schneider

The 3rd year Bachelor students in Physics have awarded the Craie d'Or of the best Bachelor Teacher to Olivier Schneider for his course in nuclear and particle physics.

Physics students have decided to reward the teaching of quality that they get by voting every year, at the end of their bachelor curriculum, for the three best teachers of their bachelor years. The teacher taking first place gets the Craie d'Or, a trophy created for this occasion by Pierre Wets, Antonio Gentile and Nicolas Turin of the Physics Auditoriums. The Craie d'Or recipient also becomes ineligible for 2 years.

On 2 June 2017, the 3rd year students designated their best teachers for the first time. Their delegates, Quentin Talon and Tara Tosic, revealed the winners at the end of the poster session of Physics Lab III, in front of a full auditorium. Paolo De Los Rios (Analytical Mechanics, 2nd year) took the 2nd place and Donna Testerman (Advanced Linear Algebra, 1st year) the 3rd place.

The Craie d'Or was awarded to Olivier Schneider for his 3rd year course (nuclear and particle physics). Moved by the appreciation of the students, he first thanked them for creating the award and making him the first awardee. He added that he was accepting this trophy with humbleness, as he is aware that many other colleagues also deserve it.

Invention places second in UAE sustainable water competition

A gravitational solar-thermal water purifier panel developed by Endre Horváth and coworkers from László Forró's lab has won second place in the category of "Innovative Research & Development – International Institutions" of the first cycle of the United Arab Emirates' Mohammed bin Rashid Al Maktoum Global Water Award.

The Award, valued at $1,000,000, aims at encouraging the development of sustainable and innovative solar-energy solutions to the problem of water scarcity across the world.

A patent-pending gravitational solar-thermal water purification panel developed by László Forró's lab came second in the Innovative Research and Development category. The device uses sunlight to filter and sterilize contaminated water. It is based on an innovative nanoporous photocatalytic aerogel composite membrane, which, upon solar irradiation, renders contaminated water safe by removing and inactivating disease-causing biological agents such as bacteria, viruses, protozoa and worms. The system does not require electricity or chemical agents, while lab tests predict that a 1 m^2 panel can filter 70 liters of drinking water in 5 hours (the average daily water intake of a small community).

"We are honored and delighted to be winners today and to receive this award," says Dr Endre Horváth, who leads the project. "This technology has the potential to provide a step forward for infrastructure improvements aimed at addressing health improvement under extreme poverty".

Physics beyond the classroom

Hands-on experience is an integral part of the physics curriculum. In this framework, students have the opportunity to prepare for the International Physicists' Tournament as part of their bachelor practical courses.

EPFL started taking part in the International Physicists' Tournament (IPT) in 2011, sending two teams to the Moscow Institute of Physics and Technology. Five years later, after two IPT editions successfully organized at EPFL, three participations in the final round and one victory in 2013, the Physics Section decided to include the tournament preparation to its bachelor courses, acknowledging the benefits of such a competition in the training of the students.

The preparation takes place during the third-year practical work (TPIII). Students who wish to participate can use the IPT problems as part of their practical work projects. They are granted a room and equipment to perform experiments to solve a number of complex and open-ended problems proposed by the IPT. They are coached by Emeritus Prof. Gérard Gremaud and former IPT competitors Vivien Bonvin and Evgenii Glushkov.

During the fall semester, participants prepared for the national selection, which took place at EPFL on December 9th 2017. During the competition, teams compared their solutions of the problems in so-called Physics Fights. The problems must not only be presented, but also challenged and reviewed by the other participants. After a very tight competition against the team from the University of Fribourg, the EPFL team won, and will represent Switzerland at the international competition in Russia.

The EPFL team also won the national selection in 2016 and participated in the international competition in March 2017 in Göteborg (Sweden). Quentin Bouttefeux, Quentin Dubey, Joel Fischer and Alexia Vernier, with Lucas Grosjean and Louis Munier from the Microtechnics Section, spent weeks working on the proposed problems. Needless to say that it required much more time than planned for practical work. As Alexia Vernier puts it: "The biggest issue was to manage the time spent on each experiment. I always wanted to go further! Unfortunately, we have to stop at one moment."

The team spent a week in Göteborg confronting teams from all over the world, finishing 13th out of 18 teams. "I really enjoyed seeing presentations of different, and sometimes really impressive, solutions to problems we worked on ourselves, and in particular debating those solutions with members of other teams" comments Joel Fischer.

Despite the huge time pressure such a competition preparation puts on their studies, the participants put forward what they have learned from the experience: practicing problem solving, presenting and debating, new experimental and computational methods, not to mention organization skills... Joel Fischer advises: "I'd recommend every bachelor student with enough time, motivation and commitment to take this opportunity and participate too."

Quantum Devices Award attributed to Nicolas Grandjean

Nicolas Grandjean received the Quantum Devices Award for “fundamental contributions to the physics and technology of III-nitride quantum structures” during the Compound Semiconductor Week 2017 organized in Berlin.

The award, attributed every year, honors pioneering contributions to the field of compound semiconductor devices and quantum nanostructure devices including physics and epitaxial growth. This prize was initiated by Fujitsu Quantum Devices Ltd. in 2000 and is now sponsored by the Japanese section of the International Symposium on Compound Semiconductors steering committee.

Nicolas Grandjean markedly contributed to the understanding of the physics of GaN nanostructures, which are at the heart of blue LEDs. He is also acknowledged for the first demonstration of a polariton laser operating at room-temperature. Such a GaN-based device should require ten times less energy to operate than a conventional solid-state laser. This breakthrough could enable very low power lasers for use in optical data-storage systems.

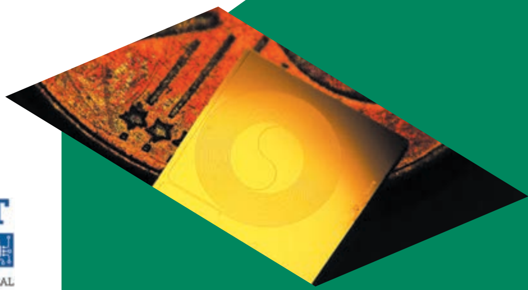
EPFL leads 14-million-€ EU projects in optomechanical technologies

The Laboratory of Photonics and Quantum Measurements, led by Prof. Tobias Kippenberg, coordinates two Horizon 2020 projects for a total of 14 million. The projects involve two parallel collaborations, Hybrid Optomechanical Technologies (HOT) and Optomechanical Technologies (OMT).

The projects stem from very competitive calls of Future and Emerging Technologies (FET) Proactive (€10M) and of Marie Curie European Training Network (€4M). Key players from academia and leading industries (IBM, Bosch, Thales, Hitachi, STMicroelectronics) have united to strengthen Europe’s leadership in quantum optomechanics.

The Hybrid Optomechanical Technologies (HOT) project is a consortium of 17 partners that lays the foundation for a new generation of devices connecting or containing several nano-scale platforms in a single “hybrid” system. HOT specifically focuses on nano-optomechanical devices that comprise electrical, microwave, optical, as well as micro- and nano-mechanical systems.

In parallel, a Marie Curie research and training network focused on exploring new applications of Optomechanical Technologies (OMT) brings together 14 EU partners, including IBM and Bosch. OMT offers 15 PhD students the opportunity to join leading research groups and participate in competitive experiments. Innovative workshops, secondments and access to state-of-the art technology facilities at partner institutions will prepare PhD students for top-quality academic research and provide a platform to interact with high-profile industry partners.

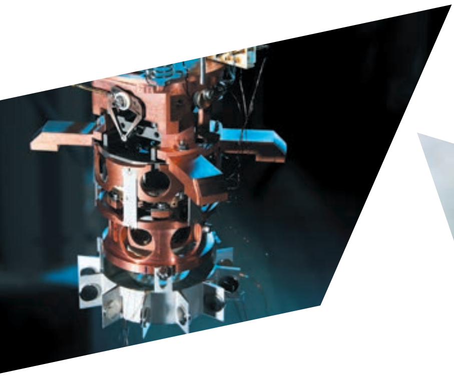


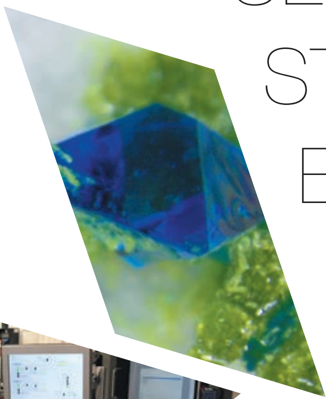
Low loss photonic integrated circuits

LIGENTEC, a start-up created in 2016, offers photonic integrated circuits (PICs) with unprecedented silicon nitride thickness up to 2500 nm maintaining very low propagation loss. With their innovative technology, they are able to bring an optical circuit designed by their customer to a PIC that can be four times smaller than standard thin film silicon nitride PICs.

The company was founded by Michail Geiselmann and Michail Zervas and uses a patent pending technology, the photonic Damascene process, originally developed in the Laboratory of Photonics and Quantum Measurements led by Prof. Tobias Kippenberg. Making PICs implies the very challenging fabrication of highly confined waveguides from silicon nitride. So far, fabrication typically involved etching the waveguide structures into a previously deposited thin film, often leading to highly stressed films and the formation of cracks, which are unacceptable for photonic circuits. The photonic Damascene process overcomes these challenges by prepatterning the substrate prior to the deposition of the silicon nitride and avoiding the build-up of stress.

Recently, LIGENTEC started collaborating with VLC Photonics to offer an open access generic platform for the prototyping and production of PICs for many different applications. Targeting mainly the most common communications wavelengths, the platform is also customizable for shorter visible wavelengths, suitable for biophotonic and sensing applications.





SERVICES INVEST IN STATE-OF-THE-ART EQUIPMENT

Research in Physics is supported by state-of-the-art services, some of which serving also external research activities. To stay at the cutting edge in terms of capabilities, these services are continuously investing in new equipment.

The mechanical workshops and the electronic workshops take care of the construction and maintenance of customized scientific equipment specifically adapted to the needs of research and teaching. They also contribute to developing these original and complex systems. The electronic workshops, headed by Raymond Frei in the BSP building, Primo Locatelli in the PH building and Blaise Marletaz at SPC, design and build a wide variety of customized electronic devices, from circuits and high-power generators to controllers and experiment interfaces. The mechanical workshop is composed of three separate units based respectively in the PH building (headed by Gilles Grandjean), in the BSP building (headed by Alain Pinard) and at SPC (headed by Regis Chanliau). They hold an important know-how in the fields of CNC milling and turning, spark-erosive wire cutting, TIG/plasma welding, Plexiglas laser cutting, and 3D printing, and produce highly complex assemblies of precision engineering. In order to respond to new performance requirements, investments have been made in recent years through the purchase of five CNC milling and turning machines, a laser cutting machine as well as a drill mounted on a motorized table. Five poly-mechanic apprentices are being trained simultaneously in these three workshops.

The crystal growth facility, headed by Arnaud Magrez, is a complex of chemistry labs, furnace rooms, sample preparation labs and a platform for material characterization inaugurated in 2014. The facility aims at synthesizing crystalline materials from nanostructures to macroscopic crystals. A key aspect of the facility's mission is Materials Discovery, be it in polycrystalline or single crystal form. Several techniques are available for the synthesis of such materials: from low temperature solvo-thermal treatment to high-temperature flux method. A large spectrum of materials is available including oxides, dichacolgenides, graphene and inorganic nanostructures to name just a few. In 2018, the first laser-heated floating-zone furnace in Switzerland will be installed in this facility allowing the growth of crystals at temperatures above 2000°C. More than 100 EPFL users characterize the structure, chemistry and physical properties of their samples with the equipment available at the facility (XRD, XRF, Raman, PPMS…).

The IPHYS clean room, headed by Nicolas Leiser, assists users in the fabrication of devices ranging from lasers to LEDs, including surface passivation for devices to be implanted in human body, or thin layer deposition to solidify silicon based micro-parts for the watch industry. It offers a number of materials for thin film deposition, either by plasma or evaporation. Materials can also be engraved by plasma or wet chemistry. Photolithography technology by UV exposure of light-sensitive layers allows the production of micro-optoelectronic elements down to 1 µm. The latest investments were made in 2017, with the acquisition of an etcher by chlorine plasma and a metal evaporator electron beam that allows for electrical contacts on optoelectronic devices.

The IT team provides, configures and maintains the computer resources throughout the research and teaching units. It was reorganized this year, together with the IT services of the School of Basic Sciences. All IT specialists working in Physics are now gathered within one IT service for Physics headed by Florence Hagen.

Swiss Young Physicists' Competition

Physicists never lose an occasion to communicate their enthusiasm for science. They are particularly eager to reach out to youngsters to awaken and stimulate their interest.

In this framework, the EPFL hosted this year the Swiss Young Physicist's Competition (SYPC) in March. It was the first time the competition was organized outside of the German-speaking part of Switzerland. 61 high-school students from all over Switzerland gathered at EPFL after spending several months working on problems proposed by the SYPC. During several rounds of physics fights, participants presented their solution of one of the problems while an opponent critically reviewed this solution. To lighten the program, the fight rounds were interspersed with social events, including a Physics Show presenting some of the most exciting sides of Physics.

The performance of participants was evaluated by a jury of teachers and physicists, among which, several from EPFL. Vivien Bonvin and Patrick Gono, both graduate students at the Institute of Physics obviously enjoyed taking part in it. "The general level was surprisingly high for high school students", says Vivien Bonvin, "and some participants simply bluffed me. Other participants also showed amazing maturity in oral defense". "All the teams were keenly interested in the science behind their projects" remarks Patrick Gono. "Even when we had to criticize some aspects of their presentation, they took the comments rather well". And he adds: "I look forward to taking part in the jury next time as well".

EPFL Doctorate Award for Jiandong Feng

Jiangdong Feng got the award for his thesis entitled 'Probing chemical structures and physical processes with nanopores', under the supervision of Prof. Aleksandra Radenovich (Laboratory of Nanoscale Biology).

The award was attributed "For his exceptional contributions to the applications and fundamental understanding in the field of nanofluidics and biophysics. In particular applications include: engineering innovations in nanopore-based DNA sequencing and osmotic power generation, while in basic science the fact that the ionic Coulomb blockade model may contribute to our understanding of voltage-gated ion channels."

In nature, the passage of ions and molecules through nanometer sized holes plays a crucial role in biology. Jiangdong Feng's work aims at understanding such processes and demonstrating their potential applications.

This thesis began with engineering atomically thin molybdenum disulfide nanopores for sensing the modulation of ionic current from the translocation of DNA molecules towards sequencing. Controlling single ion transport in the engineered subnanometer realm led to the discovery of ionic Coulomb blockade, a phenomenon similar to its counter-part in quantum dots. This thesis also demonstrated that nanopores can be used to probe chemical structures and physical processes. Two finalists for the award got a special distinction from the selection committee: Momchil Minkov and Vivishek Sudhir.

First edition of the Physics Day a great success

The first edition of the Physics Day took place at EPFL, in the Forum Rolex, on the 16th of October 2017. The event was the occasion to celebrate physics and gather physicists from all over Switzerland.

The event brought together more than 200 participants for five talks spanning all areas of physics from the infinitely small to the infinitely large, from fundamental to experimental physics: the future of the LHC (Patrizia Azzi), super resolution microscopy (Stefan W. Hell, Nobel laureate 2014), quantum telescopes (Aglae Kellerer), ultra energetic plasmas (Luís O. Silva) or the behavior of allosteric materials (Matthieu Wyart).

The Physics Day led to numerous exchanges during the final cocktail and the poster session, featuring 35 entries for this first edition. Three poster awards were sponsored by LOT Quantum Design - a leading European company in hightech scientific instrumentation. Throughout the day, the Irrotationnels (Association of students in physics) showcased experiments and social events.

The Physics Day is organized by the graduate students in physics, who recently created their association, POLYPHYS. They can be commended for putting together such a high-quality program. We are looking forward to the second edition next year.

The event was supported by EPFL, the European Physical Society (EPS) Young Minds, LOT Quantum Design, the Swiss Physical Society (SPS) and the Swiss Academy of Science (SCNAT).

Gilbert Hausmann Award attributed to Paul Martens

Paul Martens won the award for his master thesis entitled "Arc mitigation methods for space applications". He performed his master project at RUAG Space in Nyon and was supervised from the EPFL side by Prof. Ivo Furno.

The Gilbert Hausmann Award was founded in 2015 and rewards two graduates having completed an EPFL master project and one PhD student having completed an EPFL PhD thesis in the field of mechanical engineering, electricity or physics. The three prize-winning projects should stand out through their excellence, particularly in terms of originality and the prospects that they open. The prize, worth 5'000.- CHF for each master laureate, is supported by a donation by Mr Gilbert Hausmann. It was presented during Graduation Day 2017.

At RUAG Space and in collaboration with the Swiss Plasma Center at EPFL, Paul Martens developed an innovative solution to mitigate breakdown discharges in satellite slip rings, a crucial component for the power transmission from solar panels to the main satellite body. This is of outstanding scientific and technological relevance for the next generation of high-voltage satellites. His studies have led to a preliminary design of a new and more robust slip ring, contributing to the improvement of the current state of the art of aerospace technology in the framework of the European Union's Horizon 2020 research and innovation program.

Fabio Riva gets the Physics Doctoral Thesis Award

Fabio Riva got the award for his thesis entitled "Verification and validation procedures with applications to plasma-edge turbulence simulations" supervised by Prof. Paolo Ricci at the Swiss Plasma Center.

Disentangling the complex plasma dynamics at play in fusion experiments requires sophisticated numerical computer codes. How can we ensure that these codes are bug free? How can we rigorously compare simulation results with experimental measurements? Fabio Riva's thesis gives a crucial contribution to addressing these questions, with an impact well beyond the plasma physics domain.

Fabio Riva transferred from computational fluid dynamics to plasma physics the method of manufactured solutions for assessing the correct implementation of codes. This methodology is now routinely used in plasma physics. Furthermore, he developed a rigorous verification methodology for Particle-In-Cell simulations, also used in solid-state physics, hydrodynamics and computer graphics.

At the same time, Fabio Riva simulated the impact of the magnetic field shape on plasma turbulence at the edge of fusion devices, rigorously comparing for the first time with experiments carried out in the TCV tokamak. This significant advance will be useful for ITER operation and for future fusion reactor design.

The Doctoral School also recognized the following doctorates with special distinctions: Edoardo Baldini, Natalia Chepiga and Georgio Karananas.

Edoardo Baldini wins a Chorafas Prize 2017

Edoardo Baldini was awarded a Chorafas Prize 2017 for his PhD thesis entitled "Nonequilibrium Dynamics of Collective Excitations in Strongly Interacting and Correlated Quantum Systems", supervised by Prof. Majed Chergui and Prof. Fabrizio Carbone.

The Chorafas Prize is awarded each year to a selection of graduating doctoral students from the Foundation's partner universities "for outstanding work in selected fields in the engineering sciences, medicine and the natural sciences."

Edoardo Baldini, now a postdoc at MIT, was co-supervised by Prof. Majed Chergui (ISIC) and Prof. Fabrizio Carbone. He was awarded the Prize "for his contributions to the study of fundamental excitations in solids, delivering unprecedented microscopic details about non-equilibrium phenomena on the femtosecond to picosecond timescales, and opening the route to a coherent manipulation of quantum particles such as phonons, excitons and plasmons."

Baldini investigated the dynamics of collective excitations in strongly interacting and correlated systems by means of ultrafast broadband optical spectroscopy. Within this approach, a material is set out-of-equilibrium by an ultra-short laser pulse and the photo-induced changes in its optical properties are subsequently monitored with a delayed probe pulse. Studying the time evolution of collective excitations gives access to the hierarchy of low-energy phenomena occurring in the material during its path towards thermodynamic equilibrium.

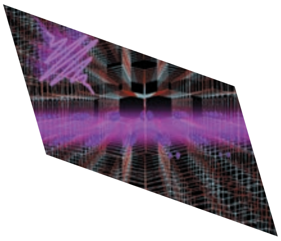
THREE PROFESSORS RETIRE

Professors Benoît Deveaud, Davor Pavuna and Minh Quang Tran retired after serving the scientific community within EPFL and beyond for decades. As we look back at their achievements, we express our gratitude for their commitment.

After graduating from the Ecole Polytechnique in Paris, **Benoît Deveaud** joined the French National Center for Telecommunications Research (CNET) in Lannion (France) and obtained his PhD from the University of Grenoble in 1984. In 1993, he was nominated full professor in Optoelectronics at EPFL and specialized in the study of the ultrafast dynamical properties of semiconductor nanostructures. His research achievements cover a wide range of subjects, including the luminescent properties of metal impurities in GaAs, vertical carrier transport in superlattices, exciton luminescence in semiconductor quantum wells, the physics of microcavity polaritons, and the demonstration of Bose-Einstein condensation of these polaritons. Besides being a passionate lecturer for both students and the general public, Benoît Deveaud has been a prominent manager within EPFL. He has served as Director of the Institute of Quantum Electronics and Photonics (1998-2008), Dean for Research (2008-2014), Chair of the Physics Strategic Committee (2014-2016), and he was the first Director of the Institute of Physics (2016-2017), which he very actively contributed to reunify.

Davor Pavuna graduated on magnetotransport in soft amorphous ferromagnets at the University of Zagreb in 1977. He received his PhD on the electronic properties of amorphous metals with Professor J.S. Dugdale at the University of Leeds in 1982. As post-doc at the CNRS in Grenoble he studied quasicrystals for three years. Shortly after joining EPFL in 1986 he started a successful research activity in high temperature superconductivity that educated a large number of Master and PhD students. In 1992, he co-authored a worldwide appreciated text-book entitled 'Introduction to Superconductivity and High-Tc Materials'. He has more than 150 scientific publications and is co-publisher of twenty-four books. In 2005, he was promoted to the rank of Adjunct Professor and taught elementary physics, basic and advanced quantum fluids. He co-organized more than 20 international conferences and summer schools in physics and served as active advisor to institutions and companies around the world.

Following an education in the French system in Vietnam, **Minh Quang Tran** graduated in Physics at EPFL, where he also obtained his PhD in 1977. He then spent two years at UCLA and came back to EPFL to lead the basic plasma physics group of the Center for Research in Plasma Physics (CRPP). He was named Adjunct Professor in 1992, and Full Professor in 1997. From 1999 through 2014 he was the Director of CRPP and of the EURATOM-Swiss Confederation Association. His research interests range from fundamental plasma physics to enabling technologies for fusion reactors, in particular in the field of microwave sources for plasma heating. Quang also devoted his efforts to coordinating large-scale research, both at EPFL and internationally. He directed the EPFL Institute for the Physics of Energy and Particles (IPEP), while at the European level he led the European Fusion Development Agreement. He has been the President of the Swiss Physical Society, and is still in charge of the Heating and Current Drive project of the European consortium EUROfusion. This exceptional commitment in research and management, but also in education at all levels, has greatly contributed to the prominent position that CRPP (now Swiss Plasma Center) and EPFL have on the international scene in plasma physics and fusion.



Shedding light on the absorption of light by titanium dioxide

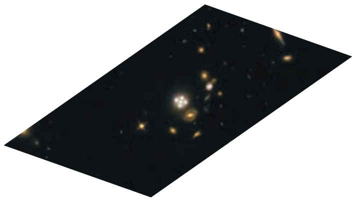
Titanium dioxide is one of the most promising materials for photovoltaics and photocatalysis nowadays. This material appears in different crystalline forms, but the most attractive for applications is called "anatase". Despite decades of studies on the conversion of the absorbed light into electrical charges in it, the very nature of its fundamental electronic and optical properties was still unknown. Scientists from ISIC and IPHYS, with national and international partners, have now shed light onto the problem by a combination of cutting-edge steady-state and ultrafast spectroscopic techniques, as well as theoretical calculations.

E. Baldini *et al*, **Strongly bound excitons in anatase TiO2 single crystals and nanoparticles.** *Nat Commun* **8**, 13 (2017). DOI: s41467-017-00016-6

Measuring time without a clock

Photoemission was explained by Albert Einstein in 1905, winning him the Nobel Prize. But only in the last few years, with advancements in laser technology, have scientists been able to approach the incredibly short timescales of photoemission. Such results are still poorly understood and require independent measurements. Researchers in the lab of Hugo Dil have now determined an attosecond delay in photoemission by measuring the spin of photoemitted electrons without the need of ultrashort laser pulses. The discovery has important implications for fundamental research and cutting-edge technology.

M. Fanciulli *et al*, **Spin polarization and attosecond time delay in photoemission from spin degenerate states of solids**, *Phys Rev Lett* **118**, 067402 (2017). DOI: 10.1103/PhysRevLett.118.067402



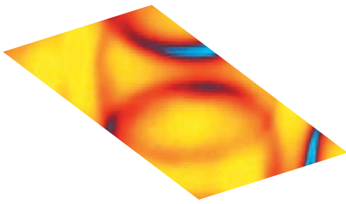
How fast is the universe expanding?

The rate of expansion of the universe (the Hubble constant H_0) is determined by the Standard Cosmological Model, which puts the current expansion rate at about 70.0 km/s/Mpc. A high-precision measurement of H_0 has profound implication both in cosmology and in physics. Now, the H0LiCOW collaboration, led by EPFL and the Max Planck Institute for Astrophysics, has used new tools to independently calculate H_0 with 3.8% precision. The new figure agrees with recent independent studies, which are however in tension with the predictions of the Standard Cosmological Model, potentially pointing towards new physics.

V. Bonvin *et al*. **H0LiCOW V. New COSMOGRAIL time delays of HE 0435−1223: H_0 to 3.8% precision from strong lensing in a flat ΛCDM model.** *Mon Notices Royal Astron Soc* **465**, 4914 (2017). DOI: 10.1093/mnras/stw3006

Ambrogio Fasoli appointed to Committee advising ITER on R&D program

The General Assembly of the EUROfusion Consortium appointed Prof. Ambrogio Fasoli as one of the three European members of the Coordinating Committee of the International Tokamak Physics Activity (ITPA). The ITPA provides a framework for internationally coordinated fusion research activities. The ITPA Coordinating Committee oversees the Topical Physics Groups in conducting their tasks and interfaces the ITPA with the ITER Organization.



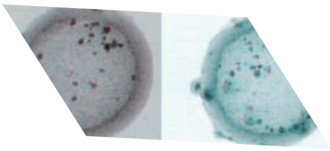
Electrons losing weight

The measured mass of electrons in solids is usually larger than the value predicted by theory. The reason is that theoretical calculations do not account properly for various interactions with other electrons or lattice vibrations that "dress" the electrons. IPHYS scientists have now carried out a study on a lithium-containing copper oxide and have found that, surprisingly, its electrons are 2.5 times lighter than predicted.

S. Moser *et al*, **Electronic phase separation and dramatic inverse band renormalisation in the mixed valence cuprate $LiCu_2O_2$**, *Phys Rev Lett* **118**, 176404 (2017). DOI: 10.1103/PhysRevLett.118.176404

Tobias Kippenberg elected OSA Fellow

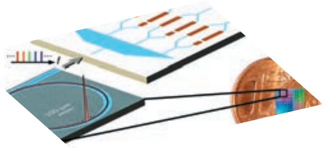
Tobias Kippenberg has been elected into the 2018 class of Fellows of The Optical Society (OSA) "for pioneering fundamental and applied research on microresonator frequency combs and cavity optomechanics".



New microscopy method offers one-shot 3D imaging of nanostructures

Physical and biological sciences increasingly require the ability to observe nano-sized objects. This can be accomplished with transmission electron microscopy (TEM), which is generally limited to 2D images. Using TEM to reconstruct 3D images instead usually requires tilting the sample through an arc to image hundreds of views of it and needs sophisticated image processing to reconstruct their 3D shape, creating a number of problems. Now, IPHYS and IC scientists have developed a scanning transmission electron microscopy (STEM) method that generates fast and reliable 3D images of curvilinear structures from a single sample orientation.

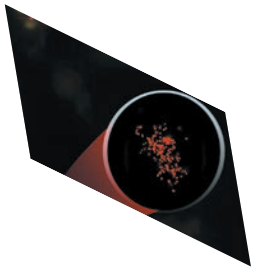
E. Oveisi *et al*, **Tilt-less 3-D electron imaging and reconstruction of complex curvilinear structures**, *Sci Rep* **7**, 10630 (2017). DOI: 10.1038/s41598-017-07537-6



Optical communication using solitons in microresonator

Solitons are special waveforms that propagate without changing their shape and are ubiquitous in nature. A collaboration of research groups led by Prof. T. Kippenberg from EPFL and Prof. C. Koos from Karlsruhe Institute of Technology has generated circulating optical solitons in on-chip silicon nitride optical microresonators. Generated from a single continuous-wave laser, these steadily circulating solitons lead to broadband optical frequency comb sources with a chip-scale footprint and having a multitude of optical channels. Two such superimposed frequency combs enabled massive parallel data transmission on 179 optical channels at a data rate of more than 50 Tbit/s – a record for frequency combs.

P. Marin-Palomo *et al*, **Microresonator-based solitons for massively parallel coherent optical communications**, *Nature* **546**, 274 (2017). DOI: 10.1038/nature22387



STORM reveals the secrets of telomeres

Cells defend themselves from destructive DNA damage with a network of mechanisms collectively named the “DNA damage response” or DDR. DNA itself is compacted into chromosomes whose tips are capped by specialized DNA-protein structures called telomeres. Using a custom-built super-resolution microscope for high-throughput imaging, scientists from SV and IPHYS have now been able to investigate what happens to the sizes and shapes of human telomeres when aberrant telomere DDR is induced.

A. Vancevska *et al,* **The telomeric DNA damage response occurs in the absence of chromatin decompaction.** *Genes Dev* **31**, 56 (2017). DOI: 10.1101/gad.294082.116

Jean-Paul Kneib appointed Director of eSpace

Prof. Jean-Paul Kneib, head of LASTRO (Laboratory of Astrophysics), was appointed Director of eSpace (EPFL Space Engineering Center). eSpace is an interdisciplinary unit responsible for the federation of space and drone activities at the School level. Specifically, eSpace is coordinating space education at EPFL, developing state of the art nano-satellites, and fostering space and drone research on campus.

SNSF awards two Ambizione grants

The Swiss National Science Foundation (SNSF) has awarded Ambizione grants to two young researchers to perform their own projects within the Institute of Physics: Elisabeth Agoritsas (hosted by Matthieu Wyart) and Michel De Cian (hosted by Olivier Schneider).

Fabian Natterer awarded SPS Prize related to Metrology

Fabian Natterer was awarded the SPS 2017 Prize related to Metrology “for his extraordinary postdoctoral work on the ultimate limits of the classical approach to high density magnetic storage media by a magnetically bistable holmium atom”.

PHYSICS IN FIGURES

WORLD RANKINGS

14th
QS WORLD UNIVERSITY RANKINGS

21th
nature INDEX

27th
NANYANG TECHNOLOGICAL UNIVERSITY

46th
ACADEMIC RANKING OF WORLD UNIVERSITIES

EUROPE RANKINGS

4th
QS WORLD UNIVERSITY RANKINGS

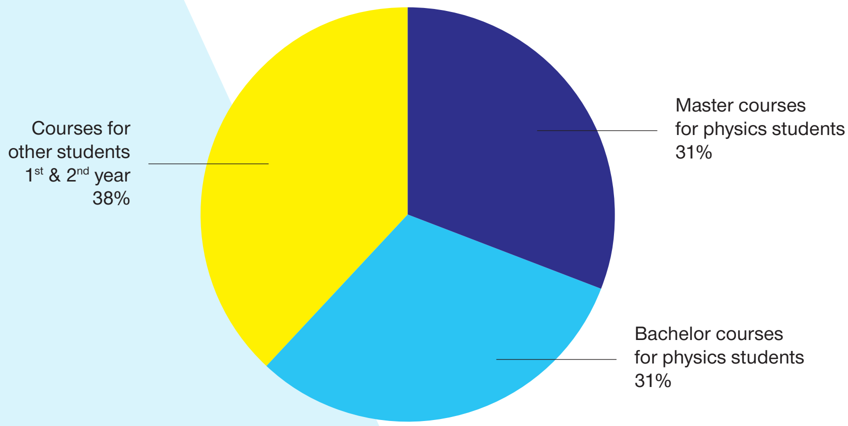
8th
NANYANG TECHNOLOGICAL UNIVERSITY

9th
nature INDEX

19th
ACADEMIC RANKING OF WORLD UNIVERSITIES

TEACHING

86	bachelor degrees delivered
61	master degrees delivered
41	PhD degrees delivered
631	physics students
3846	other students receiving physics courses
3500	experiments demonstrated



FACULTY AND STAFF

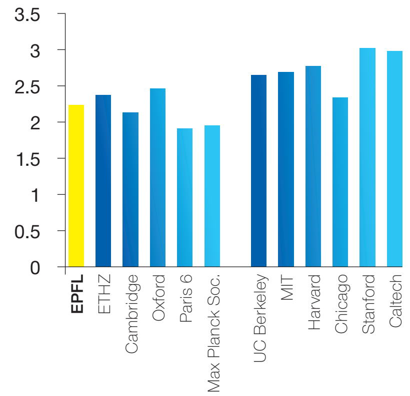
(in FTE, excl. SPC)

29.5	professors (chairs)
143	scientific staff and lecturers
149	graduate students
19	administrative staff
39	technical staff

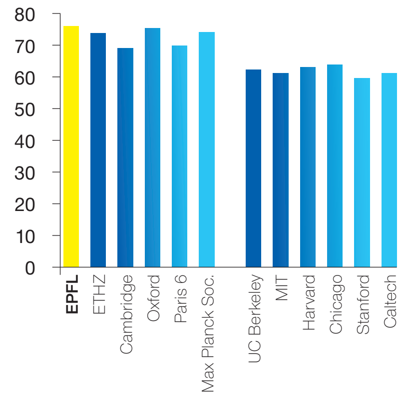
PUBLICATIONS 2011-2015

(InCites 05/01/2018)

Category normalized citation impact
Citations/paper normalized for subject, year, and document type

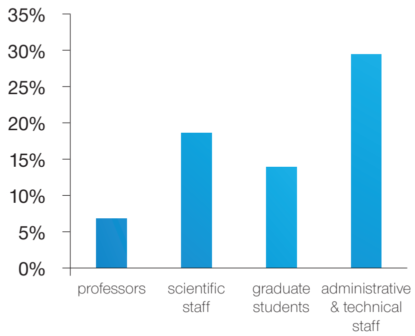


% International collaborations
% of publications that have international co-authors

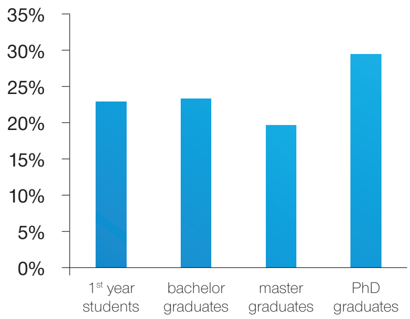


PROPORTION OF WOMEN

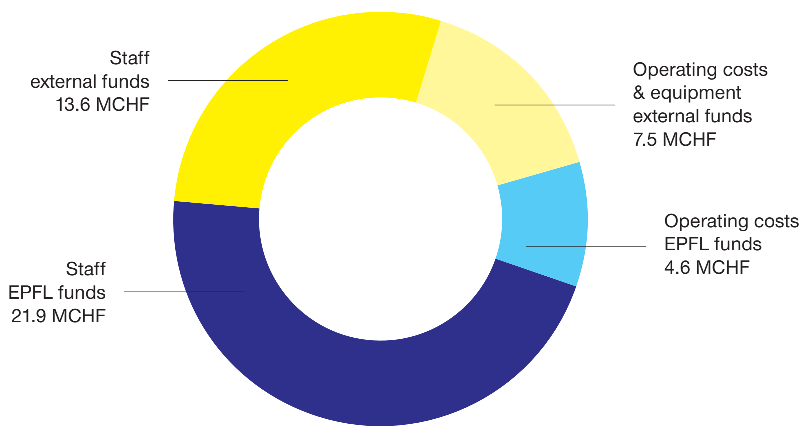
Faculty and staff



Physics students



FULL-YEAR EXPENDITURE (IPHYS)



TECH TRANSFER 2012-2017

20
patent applications

12
patents pending

3
patents granted

4
start-up companies created

EXTERNAL FUNDING

44%
external funding in total budget

6
ERC grants running

3
SNSF professorships

14
Ambizione grants running

Physics@EPFL

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Physics@EPFL 2017

TEXT
Mediacom, Institute of Physics, Swiss Plasma Center, Physics Section and Doctoral Program in Physics, EPFL

DESIGN
cullycully.studio

PHOTOGRAPHY

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Simulated electric field profile of the resonant fundamental mode in a photonic crystal optical cavity
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© Sahand Rahi, The Rockfeller University

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© László Dániel Tóth and Nathan Bernier, EPFL

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© LHCb collaboration, CERN

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Clean room
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Single crystal of $CuSeO_3.2H_2O$ surrounded by $CuSeO_3$ crystals
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Constant-energy contours in the band structure measured by ARPES
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Polygravia Arts Graphiques SA