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THE MAGAZINE OF THE EUROPEAN PHYSICAL SOCIETY

Perovskites: a class of materials with multiple functionalities and applications

EPS 50 years part II

Living on Mars: how to produce oxygen and fuel to get home

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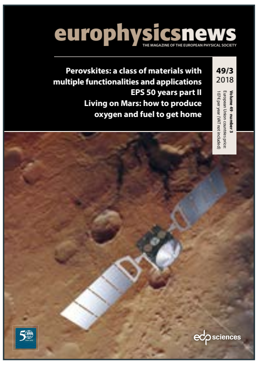

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See p. 15 Living on Mars: how to produce oxygen and fuel to get home.

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EPS 50 years Part II

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[EDITORIAL]

Recruiting Associate Members

The EPS is launching a vigorous initiative to increase the number and raise the profile of its Associate Members

In the European Physical Society, we know three categories of members: national Member Societies, Associate Members, and Individual Members. In the first category, the EPS today can be proud to federate not less than 42 national physical societies. This covers all of Europe, from Portugal to Russia and from Armenia to Iceland, with very few exceptions. However, this also means that there is very little potential for growth remaining in this category.

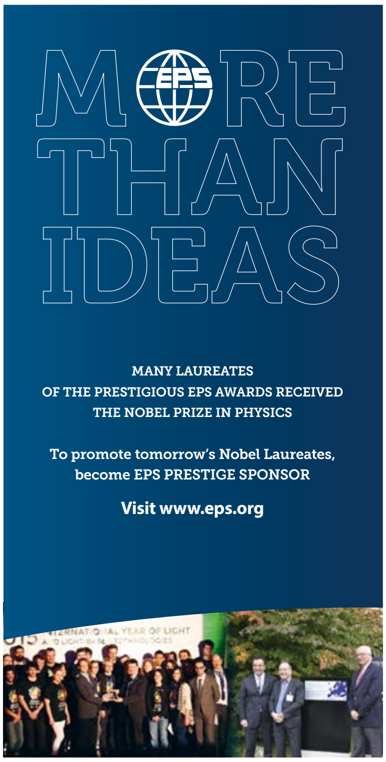
The situation is different for EPS Associate Members. According to our definition, Associate Members "represent cutting edge physics research in European research centres and industry". Indeed we have many of Europe's leading national and international research organizations on board. They form the bulk of our Associate Member base today. In contrast, there is only a small number of leading research universities and industries. While today we have almost as many Associate Members as we have Member Societies – the count presently stands at 40 – the potential for growth is, in principle, enormous.

From an EPS perspective, Associate Membership is an essential tool to connect our Society to research centres and research infrastructures at the institutional level, and to the industrial research community. The latter in particular is underrepresented not only in the EPS, but also in many of our Member Societies. The mutual benefits are numerous: each new Associate Member enhances the weight of the EPS in representing the European physics community at large, and reinforces the potential to achieve our goals. This is of particular importance with a view at building our presence in Brussels, and strengthening our credibility as partner of the European Commission and other European institutions. At the same time, it opens new opportunities to reach out to the individual physicist at his or her daily workplace, in a way that is complementary to membership in a national society.

Associate Members can draw significant benefit from their presence on the EPS platform – through publications, conferences, and other actions and events – to build networks and partnerships, enhance their visibility in the physics community and beyond, and to showcase strong vision and leadership in research, sustainability, and best practices.

To make EPS Associate Membership more visible and more attractive, the Executive Committee and the Secretariat, have teamed up under the strong leadership of Luc Bergé and have been working hard over the recent months to propose new schemes which introduce the principle of sponsorship in a more explicit way than this was the case in the past. Whereas Associate Membership in its present form will be continued, the new "EPS Prestige Sponsorship" will allow an Associate Member to support, in a visible and well-publicised manner, the prestigious prizes awarded by our Divisions and Groups. The new "EPS Sponsorship for Societal Challenges" is specifically aimed at supporting actions or distinctions in areas such as physics for development, physics education, diversity, and career development of young physicists – notably, of course, the Young Minds Project! We expect that these new schemes will be rolled out, and all details communicated, during the coming weeks and months.

Associate Membership is an essential tool to connect our Society to the European research community at the institutional level



◂ The EPS created a flyer to promote the Associate Members sponsorship. This document is available online at: www.eps.org/page/membership_am

I hope to have convinced you that our revamped Associate Member scheme is based on a broad and long-term vision, and on much greater ambitions than just creating new income for our society. To make it a success, it will need – as always – the strong support of all EPS stakeholders: Member Societies, Individual Members, the present Associate Members, Divisions and Groups. Whereas printed and electronic material is of course being developed to promote the new schemes, nothing can replace the spoken word and personal contacts.

And a last word – as soon as our new Associate Member policy is implemented, I hope that we can turn to addressing the next challenge: raise the number of Individual Members! ■

■ **Rüdiger Voss,**
EPS President

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Challenge "Experimental Physics for Africa"

Odette Fokapu Bouquet[1,2,6], Daniel Hennequin[1], Dave Lollman[2], François Piuzzi [1,2], Annick Suzor-Weiner [1,2,4,7], Paul Woafo [1,3,7,8]

- [1] Association pour la Promotion Scientifique de l'Afrique (APSA)
- [2] Physique sans Frontières committee of the Société Française de Physique (SFP)
- [3] Cameroon Physical Society
- [4] Université Paris-Sud
- [5] Université de Yaoundé I
- [6] Université Technologique de Compiègne
- [7] Agence des Universités Francophones
- [8] Sci-Tech-Services

In 2017, the Association for the Scientific Promotion of Africa (APSA), in collaboration with Professor Paul Woafo (Yaoundé I University – Cameroon) and the Cameroon Physical Society, organized a competition to reward the development of innovative sustainable cost devices that can be locally produced and used for physics education and research.

There is about one engineer for 10 000 inhabitants, versus 20 to 50 in industrialized countries. However, experimental sciences play a main role in economic development and societal challenges, such as environment, health, climate change, energy, *etc.*

Obstacles to the development of experimental sciences in Africa

One of the main obstacles to the development of experimental sciences is the lack of scientific instruments in high schools and universities. The reason is that scientific instruments are too expensive for low-resources countries. Moreover, their production is essentially located in developed countries, leading to maintenance and consumables issues. But that could change with the new tools and methods from the 3rd digital revolution: collaborative networks (Arduino, Raspberry Pi) and working spaces (Fab Labs), open access to scientific literature, open science hardware strategies and innovative technologies since these advances make the design, prototyping, fabrication and programming of sustainable cost instruments much easier and cheaper.

◂ **FIG.1:** Presentation of the awards ceremony (Yaoundé, 8th December 2017). Fisrt row, left to right: Hyacinthe TCHAKOUNTE (special jury prize), Kevin KENTSA ZANA (first prize), Béranger NYNGA NINI (second prize), Ulrich SIMO DOMGUIA and Raoul THEPI SIEWE (third prize).

Sustainable cost scientific instrumentation

These observations led us to organize this modest but determined action to find local solutions to tentatively improve the teaching of experimental sciences in secondary level and bachelor level, stimulate the development of locally sustainable cost-effective instrumentation and develop the research in applied sciences in Africa. The challenge was divided into three main stages: (i) selection of the best ten candidates by an international panel, (ii) training on the Arduino platform with making of a final project evaluated by a local panel, (iii) selection of the best three projects.

The challenge ended on 8 December 2017, with the awards presentation (figure1). The first prize (1500€) was given to Kevin KENTSA ZANA for a didactic test bench, the second prize (1000€) to Béranger NYNGA NINI for his Physicist Lab and the third prize (700 €) to Ulrich SIMO DOMGUIA and Raoul THEPI SIEWE for their special signal generator. A special jury prize was given to Hyacinthe TCHAKOUNTE for his Solar tracker (figure 2). The amount of the prizes is high enough to enable the laureates to develop and distribute some prototypes of their instruments and eventually create a small enterprise.

For this first edition of the challenge, 17 projects were submitted, with only two led by women. Due to the difficulties in bringing participants from other countries, it was restricted to Cameroon. In the future this challenge should be organized every two years: we will work to open the next edition to other countries and encourage girls' participation. We hope to find the funding through a strong lobbying on African firms. ■

We want to thank our sponsors:

International: European Physical Society (EPS), UNESCO
France: Fondation Daniel Iagonitzer, Institut Henri Poincaré (IHP), Société Française de Physique (SFP),
Cameroun: Académie des Sciences du Cameroun, Société Camerounaise de Physique, Société Express Union.

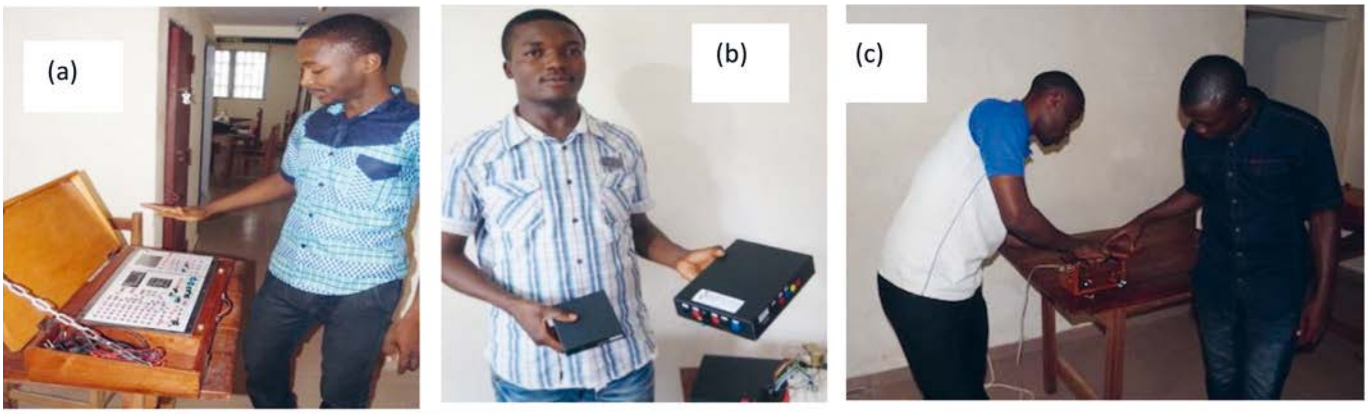


Figure 2

(a) « Banc didactique »: Didactic bench for analog electronic experiments.
(b) « Physicist lab »: Devices for acquiring and transmitting signals using the Arduino card.
(c) "Special signal generator": Device to study the behaviour of complex dynamic systems.
(d) « Solar tracker": system to optimize the performance of solar panels

Highlights from European journals

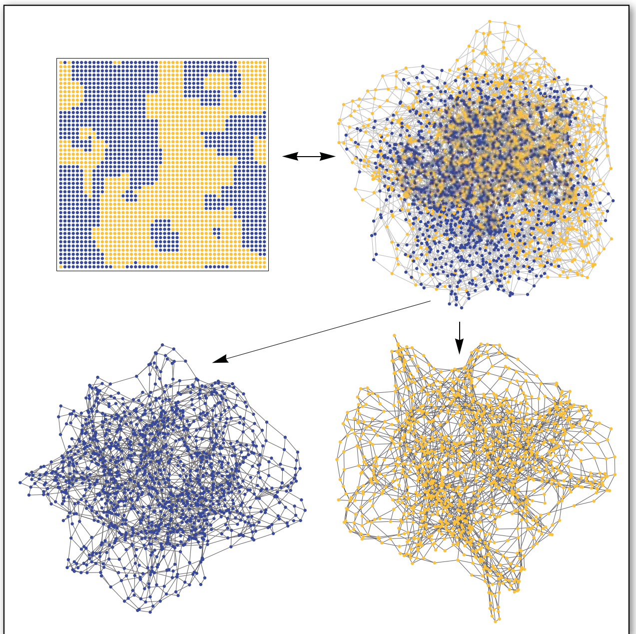
COMPLEX SYSTEMS

Disordered configurations of the Glauber model **on two-dimensional networks**

The Glauber model provides a paradigm for modeling ordering processes in complex systems. The question that we answer is: How is the efficiency of the ordering process in the Glauber model affected if we rewire the links of the two-dimensional host lattice? Our research reveals that the fraction of disordered configurations exhibits a nonlinear dependence on the rewiring probability. In the small-world regime, the Glauber dynamics remains trapped in a metastable configuration that is disordered. In fact, we have observed a stationary state that consists of two intertwined domains of similar size, as shown in the figure. For higher rewiring probabilities, we observe isolated droplets of spins, which emerge due to poorly connected nodes in the network. We have also studied what happens to the ordering process on two-layer networks, in particular comparing outcomes on a multiplex network and on the corresponding network with random inter-layer connections. We have shown that, in this case, the properties of the stationary state are strongly affected by the type of inter-layer connections. ■

■ **I. Bačić**, **I. Franović** and **M. Perc**,
'Disordered configurations of the Glauber model in two-dimensional networks', *EPL* **120**, 68001 (2017)

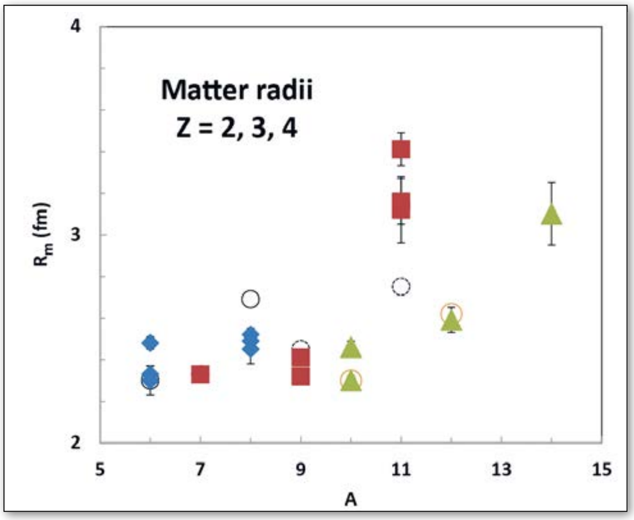
▼ A disordered configuration with two domains comprises a multiclustered state on the lattice.



NUCLEAR PHYSICS

Unresolved puzzles in exotic nuclei

A new review highlights the historical developments in our understanding of the nuclear structure of unstable and unbound forms of helium, lithium and beryllium



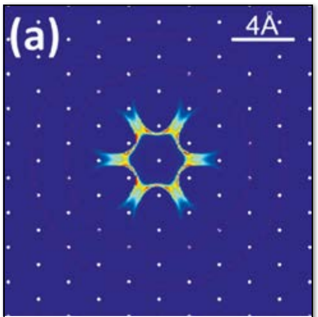
▲ Closed points are matter radii extracted from experiments for isotopes of Helium (diamonds), Lithium (squares), and Beryllium (triangles).

Research into the origin of elements is still of great interest. Many unstable atomic nuclei live long enough to be able to serve as targets for further nuclear reactions—especially in hot environments like the interior of stars. And some of the research with exotic nuclei is, for instance, related to nuclear astrophysics. In this review published recently, the author discusses the structure of unstable and unbound forms of Helium, Lithium, and Beryllium nuclei that have unusually large neutron to proton ratios—dubbed 'exotic' light nuclei. The author offers an account of historical milestones in measurements and the interpretation of results pertaining to these nuclei. The author also delineates some of the unresolved puzzles concerning the connection between microscopic structure and the values of quantities that are observable experimentally-- particularly the interplay between energies, widths or strengths and microscopic structure. For example, physicists have yet to resolve what is the occupancy of an orbital, called $2s_{1/2}$, in the ground state of beryllium-12? Or what is the nature of the unbound ground state of helium-10? ■

■ **H.T. Fortune**,
'Structure of exotic light nuclei: Z = 2, 3, 4', *Eur. Phys. J. A* **54**, 51 (2018)

CONDENSED MATTER

High-energy ions' movement affected by silicon crystal periodicity



▲ Simulated spatial and angular distributions for high-energy protons along a silicon axis.

Thinnest-ever silicon crystal enhances ion channelling performance in particle accelerators.

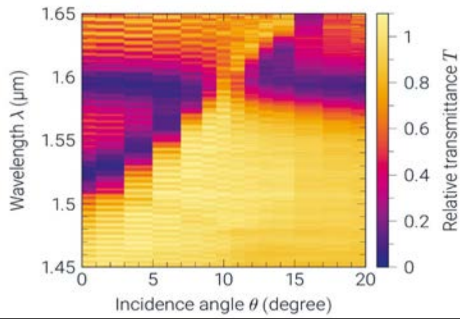
The thinner the silicon crystal, the better. Indeed, thinner crystals provide better ways to manipulate the trajectories of very high-energy ions in particle accelerators. Further applications include materials analysis, semiconductor doping and beam transport in large particle accelerators. All of these rely on our understanding of how positively-charged high-energy particles move through crystals. This process, called ion channelling, is the focus of a new paper published recently. In this paper, the authors study how the crystal periodicity affects the motion of ions whose energy belongs to a 1 to 2 MeV range, as they are transmitted through very thin crystals on the order of a few hundred nanometres, and how it impacts their angular distribution. What is so interesting about this work is that it relies on an advanced process of fabricating much thinner crystals than was previously possible, reaching 55 nanometres. This, in turn, makes it possible to observe much more sensitive and fine angular structures in the distribution of transmitted ions. ■

▮ **M. Motapothula** and **M. B. H. Breese**
'A study of small impact parameter ion channeling effects in thin crystals', *Eur. Phys. J. B* **91**, 49 (2018)

APPLIED PHYSICS

Shedding new light on angle-selective Huygens' metasurfaces

Huygens' metasurfaces form a class of ultra-thin optical devices which allow scientists to reshape the wavefront of an incident beam of light. Representatives of this class include highly efficient flat lenses, beam shapers, and holographic phase masks. More specifically, such metasurfaces are composed of a carefully designed, two-dimensional arrangement of high-refractive-index dielectric nanoparticles, which show virtually no absorption losses and exhibit electric and magnetic dipole resonances known from Mie scattering. When these resonances are designed to overlap spectrally, the nanoparticles scatter almost all light in the forward-direction only, and thereby emulate the behaviour of the forward-propagating elementary wavelets known from Huygens' principle.



◂ Transmission spectra of a metasurface in dependence on the incidence angle of a TM-polarized plane wave.

The authors have investigated this effect in dependence on the incidence angle and polarization of incident plane waves for a metasurface composed of silicon nanocylinders. They showed that the resonance overlap can be designed to appear at an arbitrary incidence angle. Furthermore, since the metasurface blocks all light incident at angles other than the design angle, angle-selective functionalities may be implemented as well. These findings open interesting opportunities for the design of advanced wavefront-shaping devices and computer-generated holograms. ■

▮ **D. Arslan**, **K. E. Chong**, **A. E. Miroshnichenko**, **D.-Y. Choi**, **D. N. Neshev**, **T. Pertsch**, **Y. S. Kivshar** and **I. Staude**,
'Angle-Selective All-Dielectric Huygens' Metasurfaces',
J. Phys. D: Appl. Phys. **50**, 434002 (2017)

HISTORY

Six decades **of cosmology**

The personal memories of Jayant Narlikar point to the need for restoring cosmology as the flagship of astronomy.

"Cosmologists are often wrong but never in doubt," Russian physicist Lev Landau once said. In the early days, astronomers began by observing and modelling stars in different stages of evolution and comparing their findings with theoretical predictions. Stellar modelling uses well-tested physics, with concepts such as hydrostatic equilibrium, law of gravitation, thermodynamics, nuclear reactions *etc.* Yet in contrast, cosmology is based on a large number of untested physical assumptions, like nonbaryonic dark matter and dark energy whose physics has no proven link with the rest of physics. In a paper published

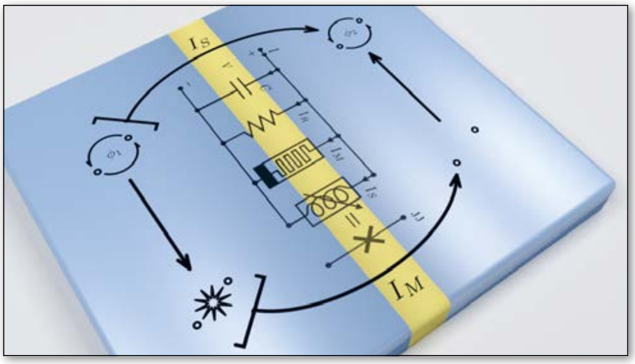
▾ Cosmos

recently, the author shares his personal reminiscences of the evolution of the subject of cosmology over six decades. He tells of the increase in our confidence in the standard model of cosmology to the extent that it has become a dogma. The German physicist Max Born said many years ago: "Modern cosmology has strayed from the sound empirical road to a wilderness where statements can be made without fear of observational check...". The author feels that those comments apply very well to the present state of cosmology. ■

J. V.Narlikar,
'The evolution of modern cosmology as seen through a personal walk across six decades', *Eur. Phys. J. H* **43**, 43 (2018)

APPLIED PHYSICS

Non-stationary noise with memory **in Josephson Junctions**



▲ The current flowing across a Josephson Junction may be thought of as including a memristive component I_M due to the microscopic process of pairs breaking, tunneling and recombining across the junction. As this process is dissipative, it also affects the intrinsic noise of the junction.

In addition to the non-dissipative supercurrent, Josephson junctions also possess a dissipative memristive current component, meaning that the instantaneous resistance of the junction depends on the history of the current. Devices that display this exotic behaviour are currently under intense study due to possible applications ranging from fast, high-density, nonvolatile computer memories to neuromorphic computing. In a previous work, the authors suggested a novel device to isolate this current component and thus realize a superconducting memristor. In this work the manifestation of the memristive behaviour in the current noise is considered. The presence of memory renders this noise non-stationary. The authors theoretically characterize both the thermal noise and the 'dynamic'-noise arising across a biased junction, using a mixed time-frequency description. A way to detect this effect of the memristive behaviour on the current noise is also proposed, which should be feasible with current experimental tools. ■

F. Sheldon, **S. Peotta** and **M. Di Ventra**,
'Phase-dependent noise in Josephson junctions', *Eur. Phys. J. Appl. Phys.* **81**, 10601 (2018)

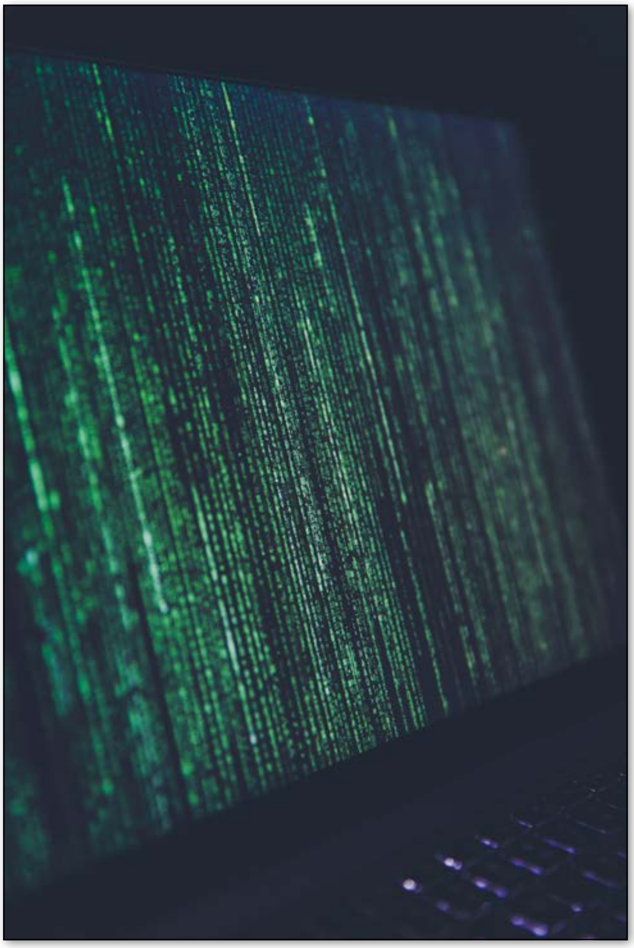
QUANTUM PHYSICS

Approximate quantum cloning: the new way of eavesdropping in quantum cryptography

New approximate cloning method avoids the previous limitations of quantum cloning to enhance quantum computing and quantum cryptography leaks

Cloning of quantum states is used for eavesdropping in quantum cryptography. It also has applications in quantum computation based on quantum information distribution. Uncertainty at the quantum scale makes exact cloning of quantum states impossible. Yet, they may be copied in an approximate way—with a certain level of probability—using a method called probabilistic quantum cloning, or PQC. In a new study published recently, the authors demonstrate that partial PQC of a given quantum state secretly chosen from a certain set of states, which can be expressed as the superposition of the other states, is possible. This cloning operation is very important with regard to classical computing. It allows scientists to make many copies of the output of computations—which take the form of unitary operations. These can, in turn, be used as input and fed into various further processes.

▼ New approximate cloning method facilitates quantum computing.
© Markus Spiske via Unsplash

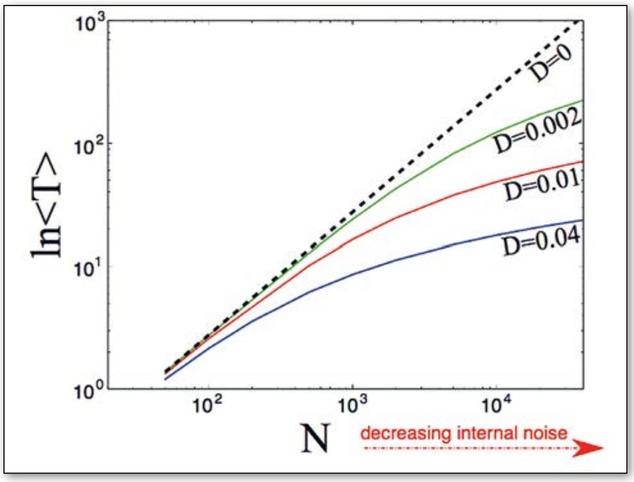


In quantum computing, for example, previous studies have shown that PQC can help to enhance performance compared to alternative methods. This means that when unitary operations generate some linearly-dependent states, partial PQC can be helpful. ■

▮ **P. Rui**, **W. Zhang**, **Y. Liao** and **Z. Zhang**,
'Probabilistic quantum cloning of a subset of linearly dependent states', *Eur. Phys. J. D* **72**, 26 (2018)

COMPLEX SYSTEMS

Rare events in "noisy" networks



▲ The average extinction time, <T>, for a regular network versus the number of nodes, N, and several amplitudes of external noise, D.

Bringing diseases to extinction and mitigating the effects of human-caused environmental changes which accelerate the rate of species extinction are issues of worldwide importance. Both phenomena are typically rare events, relying on the interplay between network topology, nonlinear dynamics, and random fluctuations from the environment and interactions. However, the prediction of such rare events in general stochastic networks was an unsolved problem, despite extensive work in network dynamics. Here we solve the problem of predicting rare events as large fluctuations from metastable states with a general theory that combines mean-field approximations, large-deviation techniques and network topology. A benefit of our approach is its flexibility in describing the effects of multiple sources of different continuous and discrete noise. Using our theory, we demonstrate that networks with both internal interaction noise and external parameter noise exhibit a crossover where the familiar exponential scaling of rare-event times with the number of nodes in the network is lost, and parametric noise dominates. ■

▮ **J. Hindes** and **I. B. Schwartz**,
'Rare events in networks with internal and external noise', *EPL* **120**, 56004 (2017)

APPLIED PHYSICS

A happy marriage between **critical phenomena and spintronics**

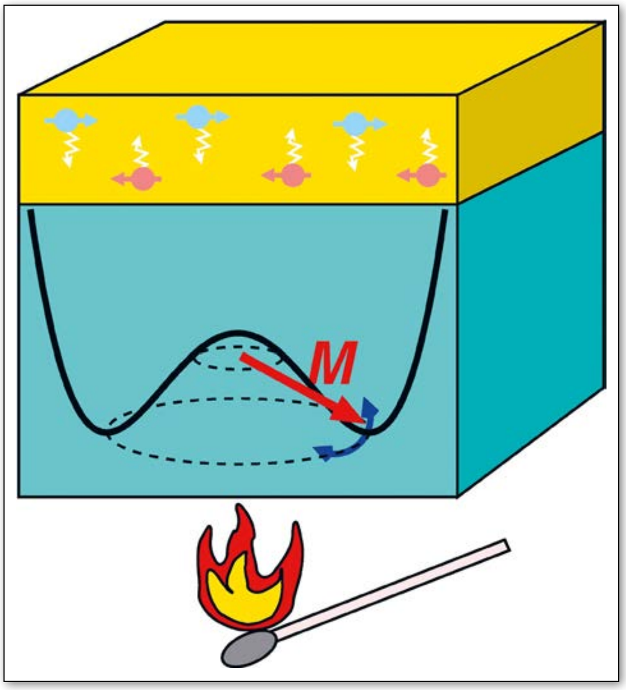
Spintronics is a technology that aims to use spin in information processing for practical application, whereas critical phenomena belong to an academic subject that deals with phase transition. These two seemingly different subfields meet at the interface between a magnetic insulator and a paramagnetic metal.

The thermal spin injection from an insulating magnet into the adjacent heavy metal is referred to as spin Seebeck effect. Since its discovery in 2008, this phenomenon has attracted much attention as a simple and versatile means for generating spin current that is needed to drive the functionality of spintronic devices. The spin Seebeck effect has been investigated extensively over the last few years, but only a little is known about its behaviour near the magnetic phase transition.

Using a stochastic model established through the study of dynamic critical phenomena, the authors have investigated the behaviour of the spin Seebeck effect near the Curie temperature *Tc* of a simple ferromagnet which is composed of a single sublattice such as EuO. They have clarified theoretically that the spin Seebeck signal scales with the magnetization, *i.e.*, $\sim(T\text{-}Tc)^{1/2}$. Because no corresponding experiments have been reported so far, the theoretical prediction awaits experimental proof. ■

▮ **H. Adachi**, **Y. Yamamoto** and **M. Ichioka**,
'Spin Seebeck effect in a simple ferromagnet near T_c: a 'Ginzburg–Landau approach', *J. Phys. D: Appl. Phys.* **51**, 144001 (2018)

▼ Schematic drawing of the spin Seebeck effect near the magnetic phase transition.



PEROVSKITES:

A CLASS OF MATERIALS WITH MULTIPLE FUNCTIONALITIES AND APPLICATIONS

Christophe Rossel – DOI: https://doi.org/10.1051/epn/2018301

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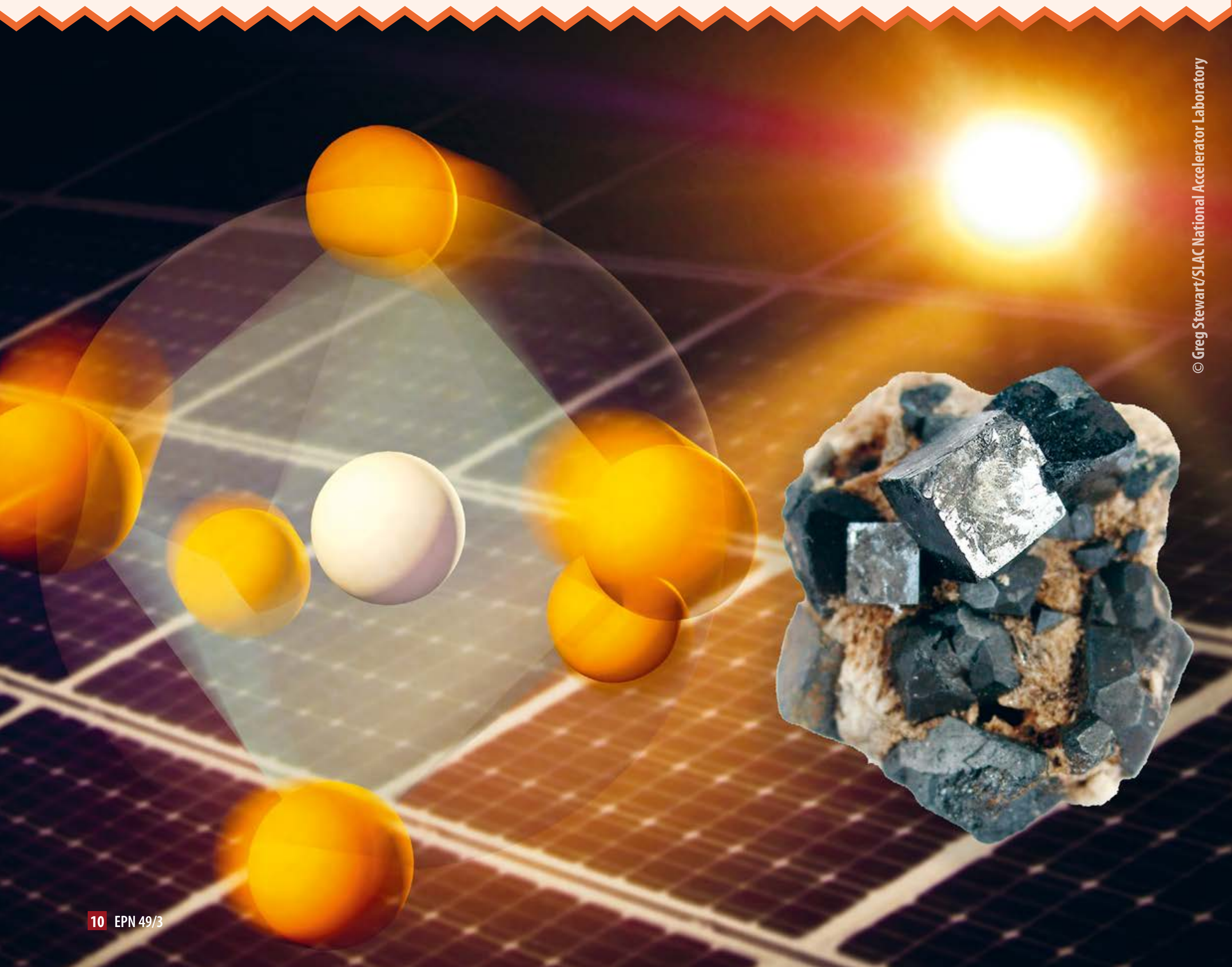
First discovered in 1839 by Gustav Rose and named after the Russian mineralogist L. A. Perovksi, the perovskites have been extensively studied. These materials have a wide range of properties and many potential applications. The discovery of high temperature superconductivity in layered copper oxides in the mid-eighties and of efficient photovoltaic properties in hybrid organic-inorganic perovskite solar cells less than 10 years ago, have boosted the research efforts on these materials as well as the number of yearly publications.



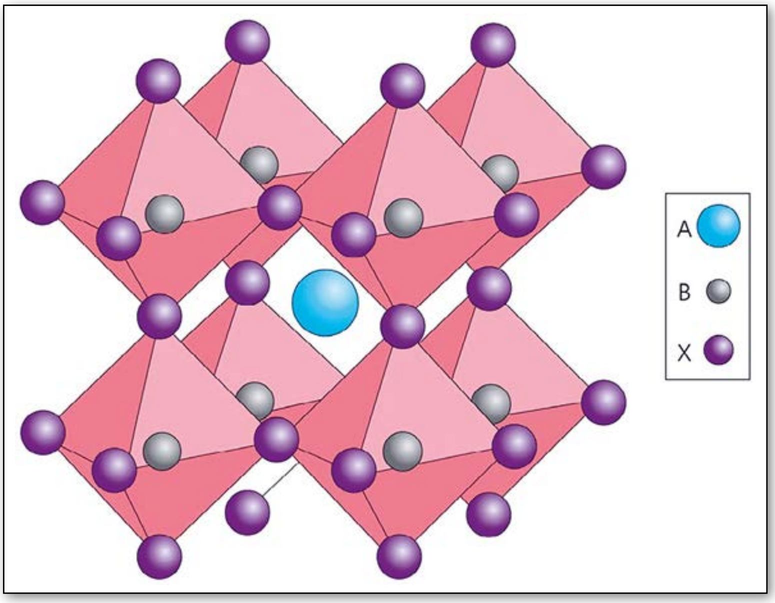
Structure

Perovskites have a cubic structure with the general formula ABX_3 (Fig. 1). In this ideal structure, the A-site ion is usually an alkaline earth or rare earth element. The B site ions can be 3d, 4d, and 5d transition metal elements and form an octahedral BX_6 with the X ion. Even if the best known perovskites contain oxygen (X = O) such as in the high temperature superconductors, a few others form with X = B, C, F, or Ni. The recent demonstration of high power conversion up to 22% in photovoltaic films of the hybrid halide perovskites $CH_3NH_3PbX_3$ with X = I, Br, or Cl made these materials more extraordinary.

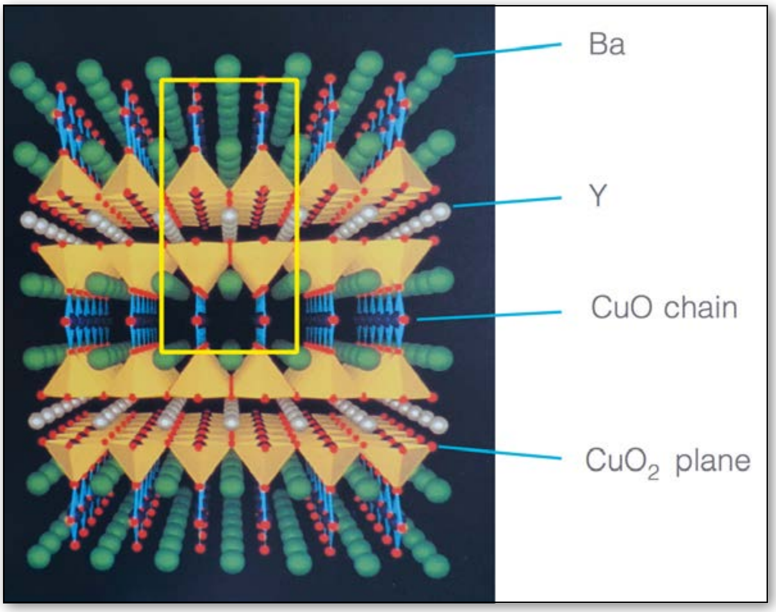
The requirements on the relative ion size is rather stringent for the stability of the cubic structure because slight buckling and distortion can produce several lower-symmetry distorted versions [1]. The symmetry breaking under the effect of pressure, temperature change, or doping can lead to tetragonal, orthorhombic or rhombohedral structures. When thin sheets of intrusive materials are inserted in this network, various layered structures can be obtained, as exemplified with the discovery of the high temperature superconductors by J.G. Bednorz and K. A. Müller in 1986 [2].

Scientific Developments and Ongoing Research

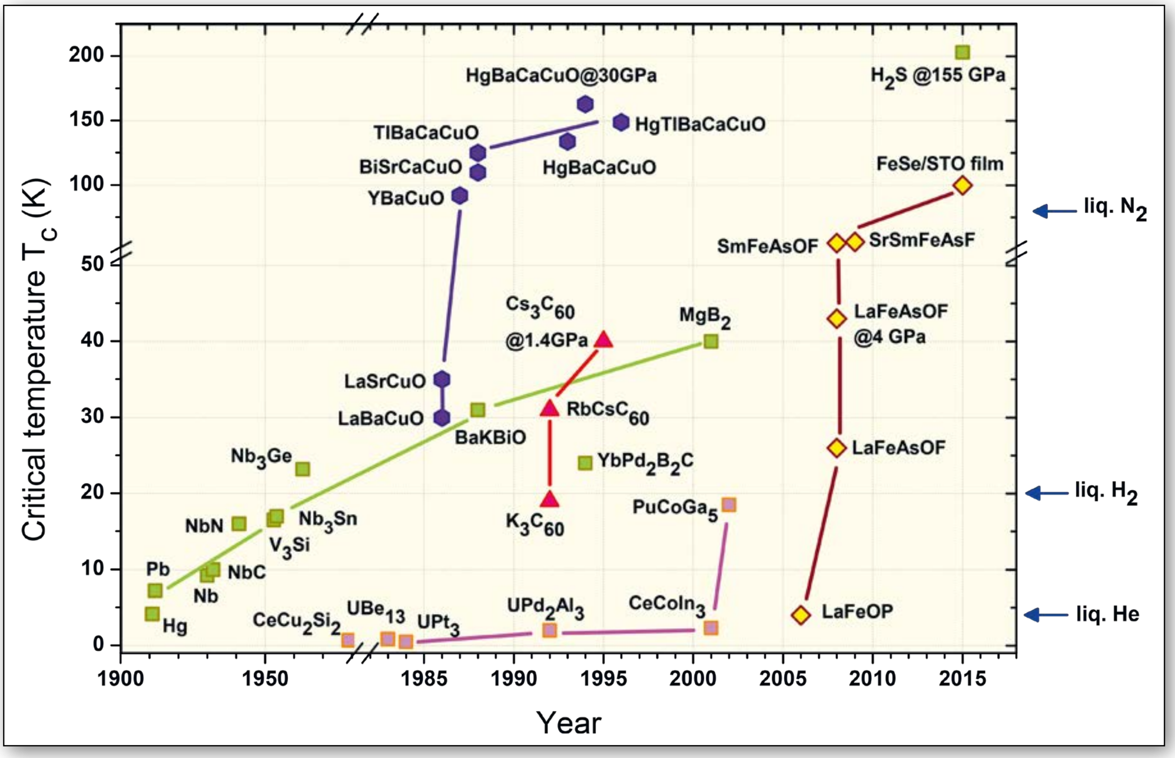
Earlier studies of the perovskites, in particular of its most famous representative member $SrTiO_3$ were performed by K.A. Müller (KAM) [3] using electron paramagnetic resonance (EPR), applied in particular to investigate the binding and local structure of defects and the different valence states of transition metals such as V, Cr, Mn, Fe, Co, *etc.* A fruitful application of EPR was also the study of the Jahn-Teller (J-T) distortion of ions in a lattice and more generally structural phase transformations, cubic to tetragonal/orthorhombic symmetry or order-disorder transitions. The experimental evidence of Fermi glasses and itinerant polarons in ionic solids with variable range hopping mechanisms [3] and the enhanced superconducting transition temperature Tc in granular Al immersed in amorphous Al_2O_3 [4] convinced KAM that superconductivity at higher T can be found in oxides. The knowledge of vibronic interactions via the J-T effect lead in 1986 to the discovery of superconductivity at 35 K in the layered perovskite Ba-La-Cu-O with mixed copper valence (Cu^{3+} and Cu^{2+}). The discovery by Bednorz and Müller [2] was soon confirmed by many groups, notably P. Chu in Houston and S. Tanaka in Tokyo [5], leading to a huge tsunami of activity in this field. New layered copper oxide superconductors such as $YBa_2Cu_3O_{7-x}$ (Fig. 2) and the Bi-, Tl- and Hg-based cuprates were rapidly identified and Tc raised up to ~134 K (Hg-1223) [6] (Fig. 2). Very quickly theoretical models suggested that high-temperature superconductivity (HTS) might involve d-wave pairing, an idea confirmed by a variety of experiments such as the direct observation of an anisotropic superconducting gap (with four lobes of alternating signs and nodes in between where the gap is zero) by Angle Resolved Photoemission Spectroscopy (ARPES) or from tunneling experiments. Indirect demonstration came from the temperature dependence of the penetration depth, specific heat and thermal conductivity. But other experiments showing a possible mixing of s- and d-wave pairing and more exotic pairing symmetries were also presented. After thirty years of intensive research, the exact origin of HTS is still not clear and the possible mechanisms are subject of considerable debates. Similarities and differences in the properties of hole- and electron-doped cuprates are visualized in the generic phase diagram [6] showing the evolution from an antiferromagnetic phase at zero doping to the superconducting phase at optimal doping, with the presence of a pseudogap phase. Other families of materials referred as high-Tc materials were later discovered, in particular the iron-based superconductors or ferropnictides (Tc_{max} ~ 56 K) [7], the magnesium



▲ **FIG. 1:** Cubic perovskite structure of ABX_3 type



▼ **FIG. 2:** Structure of the layered $YBa_2Cu_3O_{6+d}$ superconductor (T_c = 92 K) with the outline of the unit cell.



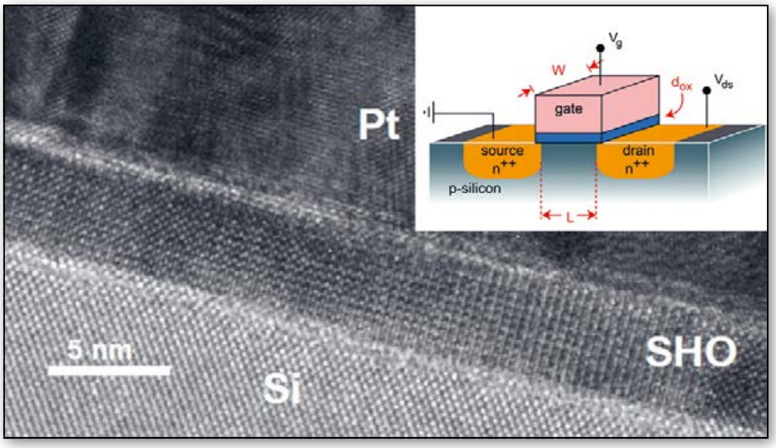
▸ FIG. 3: Evolution of T_c with time for different superconductors since the discovery of superconductivity in 1911.

diboride MgB_2 (Tc ~ 39 K) [8] and the fullerides such as Cs_3C_{60} (Tc ~ 40 K, under pressure) [9]. The latest sensation was the report of superconductivity at 203 K in H_2S under very high pressure [10], the highest reported Tc today (Fig. 3). The commercial applications of HTS cuprates have not reached the initial expectations so far, partly because of the brittle nature of these ceramics but also due the unusual properties of the magnetic vortex lattice (depinning, melting) [11]. Some of the potential applications include anyway induction heaters, transformers, fault current limiters, power lines and storage, motors and generators, magnets for fusion reactors and magnetic levitation devices.

The perovskites gained a lot of attention with other discoveries such as the colossal magnetoresistance (CMR) in the rare earth manganates $Ln_{1-x}A_xMnO_3$ (Ln = rare earth, A = divalent cation) because of its technological implications [12]. CMR occurs when the manganates become ferromagnetic and transform from an insulating state to a metallic state close to the Curie temperature. It must be distinguished from the giant magnetoresistance discovered by A. Fert and P. Grünenberg (Nobel Prize laureates 2007) in ferromagnetic heterostructures such as Co/Cu/Co, called spin valves and commonly used as magnetic read heads in hard disk drives.

The phenomenal improvements of deposition techniques have allowed to produce very high quality thin films, superlattices and nanodevices based on the perovskites. Following the pioneering work of McKee *et al.* [13] it has been possible to grow by molecular beam epitaxy (MBE) epitaxial $SrTiO_3$, or similar perovskite structures, on silicon wafers. One possible application was to use these materials as high-permittivity (high-k) gate oxides in the new generations of high performance Metal Oxide Semiconductor Field Effect Transistors (MOSFET) [14] (Fig. 4). The large linear electro-optical coefficient of the ferroelectric $BaTiO_3$ has been used to modulate light [15], paving the way in Si photonics towards efficient integrated devices, such as modulators, tuning elements, and bistable switches. Among the piezoelectric materials known today, PZT *i.e.*, $Pb(Zr_xTi_{1-x})O_3$ is certainly the most prominent one, used as ultrasound transducer, ceramic capacitor or STM/AFM actuators [16]. A more general type of materials that attracted a great attention are the multiferroics [17], which exhibit the primary ferromagnetic, ferroelectric and ferroelastic order parameters coexisting in the same phase. The field of multiferroics has become important not only to understand the basic interaction between magnetic and electric coupling, but also for their potential application in devices such as actuators, switches, magnetic field sensors or new types of electronic memories. In spite of the large

▾ FIG. 4: High resolution TEM view of a thin $SrHfO_3$ layer grown on Si by Molecular Beam Epitaxy (MBE) and used as high-k gate oxide insulator in a MOSFET structure (inset) [14]



number of magnetic and ferroelectric materials, there are relatively few multiferroic materials, because of the stringent conditions for co-existence of the different types of order, as shown in Fig. 5.

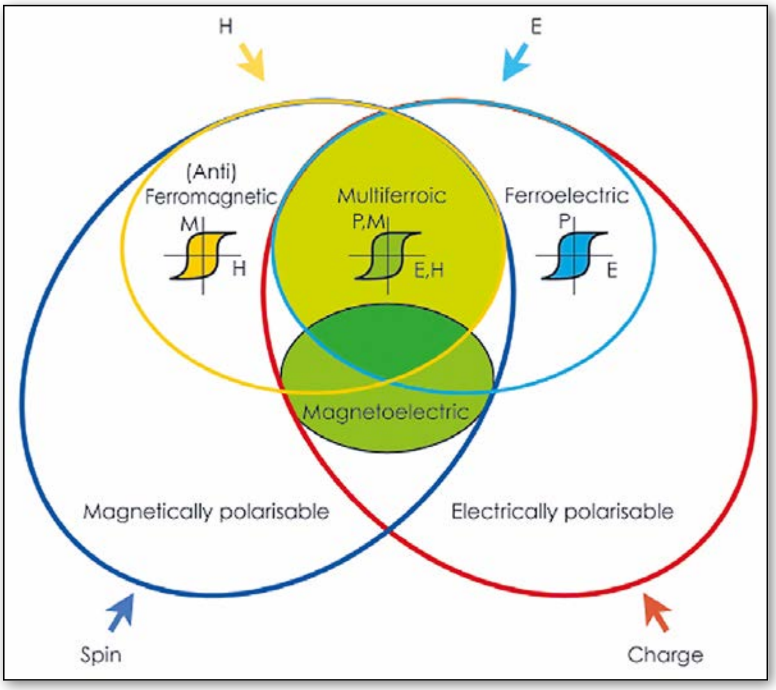
Typical materials showing such properties are perovskite transition metal compounds including, for example, $TbMnO_3$, $HoMn_2O_5$, $LuFe_2O_4$, or $BiFeO_3$, *etc.* There is an active ongoing research to understand the main classes of multiferroics.

Finally among other properties found in perovskites, it is worth to mention the early demonstration of reproducible resistance switching and non-volatile memory in epitaxial Cr-doped (Ba,Sr)TiO_3 or $SrZrO_3$ metal-insulator-metal (MIM) devices [18]. In addition to long retention times it was also shown that multilevel switching could be achieved, allowing the storage of more than one bit per memory cell (Fig. 6). Alternative types of memristors have been very broadly investigated [19] and are today aimed in applications like neuromorphic computing where attempt is made to replicate the functions of neurons and synapses [20], a concept developed in the late 1980's by Carver Mead [21]

An incredible revival of interest for the perovskites happened a few years ago in the field of solar cells thanks to advances in power-conversion efficiency up to 22% in the organic-inorganic hybrid perovskite methylammonium halide $CH_3NH_3PbI_3$ ($MAPbI_3$) as the primary semiconductor of interest [22]. Such a value rivals the performance of industry standard silicon photovoltaic cells (PC).

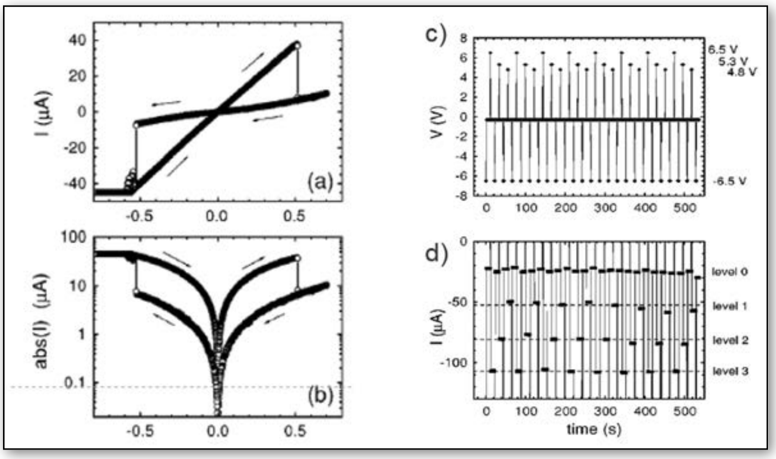
In fact since the first announcement, the number of yearly publications that include the word perovskite in their title or abstract exponentially increased from typically 2600 articles/year in 2012 up to ~6500 in 2017, according to Web of Science. An example of such a cell based on $MAPbI_3$ is shown in Fig. 7. The three major components for such a high efficient PC are a good light absorber (perovskite), a semiconductor to accept electrons from photo excited perovskite and a hole transporter p-type semiconductor. Recently thiocyanate (CuSCN) has been found to be an attractive and cheaper hole transporter as compared to the usual materials. The global efficiency is tuned essentially by an optimization of the morphology (grain size, porosity) and thickness of the device layers. Two issues have still to be solved for commercial applications: first, fabricate large areas of high quality and stable perovskites while retaining the high power-conversion efficiency above 20% and secondly, find efficient nontoxic lead-free alternatives. Another recent advance that could foster applications in medical imaging is the use of such organic-inorganic perovskites layers for X-rays detectors, as they can be 10 times more sensitive that the usual amorphous selenium photoconductors [23].

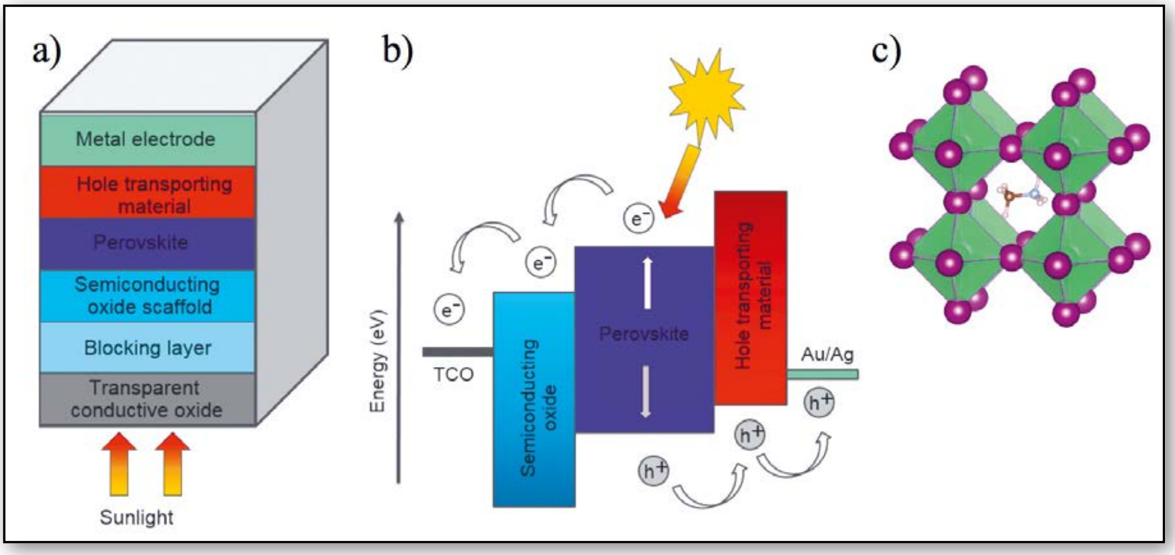
This exceptional class of materials exhibits also promising potential for light emitting diodes (LED) and lasers [24]. The direct bandgap and nearly defect free crystalline films favors efficient charge collection and long range charge transport. In spite of their moisture sensitivity these structures achieved in two years the brightness and efficiency that organic LED reached in two decades. Typically materials with photoluminescence quantum yields close to 100% have been achieved whereas LEDs with external quantum efficiency of 8 % and current efficiency up to 43 cd/A have been demonstrated. The effective light-emission of the hybride perovskites is due to the low defect densities, low non-radiative electron-hole recombination and their high photoluminescence. By tuning the halide composition, thin film devices with bright green and red light emission can be obtained. High quantum yields, narrow emission, high exciton binding energy and color tunability, can be achieved also in nanostructured



▲ **FIG. 5:** Schematic phase diagram representing the different spin and charge ordering phases and their coexistence in a multiferroic state.

▼ **FIG. 6:** Switching current-voltage (I-V) curves in a $Pt/SrZrO_3/SrRuO_3/SrTiO_3$ MIM heterostructure demonstrating the non-volatile memory effect in perovskites **a)** linear scale, **b)** log scale and the potential of multilevel storage **c)** applied voltage pulses, **d)** corresponding current levels [18]





▸ **FIG. 7: a) & b)** Schematic view of a perovskite-based photovoltaic cell heterostructure based on $CH_3NH_3PbI_3$ (Methylammonium lead iodide) with the different layers for collecting the photo excited electrons and holes **c)** Corresponding ABX_3 perovskite structure with $A = CH_3NH_3$, $B = Pb$ or Sn, $X = I$, Br or Cl.

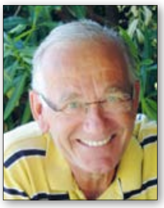
organic-inorganic or all-inorganic perovskites such as nanoparticles, nanoplates and nanowires. The nanostructuring of such materials by a judicious control of their synthesis conditions enables to generate nanoscale properties such as quantum confinement effects. At lower dimension higher intrinsic structural stability is also achieved as compared to 3D perovskites.

In addition to the mentioned LED developments, amplified spontaneous emission and lasing properties are also in the focus of researchers. Thus the success in photovoltaics has triggered a strong interest in developing perovskite optoelectronics for future commercial applications lasers and light-emitting devices.

Conclusions

Many research and review articles have been written on the role of the composition, crystalline structure, symmetry, and dimensionality of the perovskites on their physical and chemical properties. More will follow. In this short overview some important developments and applications of these materials have been outlined. The list is far from being exhaustive, but I hope that the reader will appreciate the extraordinary structural flexibility of this family of materials and the impressive progress that have been made in particular in the last 30 years, since the discovery of high-T superconductivity. ■

About the Author



Dr. Christophe Rossel is a Condensed Matter physicist with education and academic professional experience in Switzerland and in USA. In 1987 he joined the IBM Research-Zurich Laboratory pursuing a scientific career focused on the physics of superconductors and later on nanoscience and the integration of advanced functional materials for semiconductor technology. As member of various panels and president of the Swiss (2008-2012) and European Physical Societies (2015-2017) he has engaged in science policy issues, representing the community of physicists and advocating the contribution of physics and open science to the economic, social and cultural advancement in Europe.

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LIVING ON MARS:
HOW TO PRODUCE OXYGEN AND FUEL TO GET HOME

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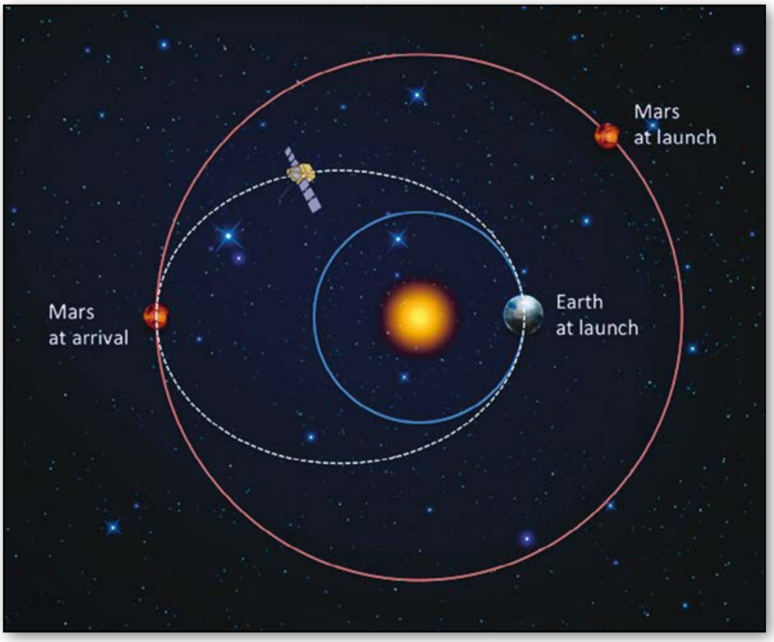
Sending a manned mission to Mars is one of the next major steps in space exploration. Creating a breathable environment, however, is a substantial challenge. A sustainable oxygen supply on the red planet can be achieved by converting carbon dioxide directly from the Martian atmosphere. A new solution to do so is on the way: plasma technology.

Space exploration is on the verge of an exciting new era, with Mars on the agenda. Ambitious programmes on Mars exploration, Mars Sample Return (MSR) missions and the prospect of future manned missions have been recently presented by the main space agencies – ESA (European Space Agency), NASA (National Aeronautics and Space Administration), Roscosmos (Roscosmos State Corporation for Space Activities, Russian Federation) and JAXA (Japan Aerospace Exploration Agency) – often in partnership with private companies.

Travelling to Mars is an extraordinary endeavour. The distance between Earth and Mars varies between 55 and 400 millions of kms, depending on the position of the planets on their orbits. The correct conjugation of trajectories implies that there is an optimal window for launching approximately every two years, corresponding to a launch along the Hohmann transfer orbit represented in figure 1, for a trip of around six months, and that in a manned mission astronauts would have to stay on Mars for about one year. Clearly, any local resources that can be used will reduce the logistics and costs of the mission, increase self-sufficiency and reduce risks to the crew. Hence the interest devoted nowadays to *in-situ resource utilisation* (ISRU), the harnessing of resources in the exploration site that would have to be brought from Earth otherwise.

The main component of the Martian atmosphere is CO_2, accounting for about 96% (with approximately 2% Ar and 2% N_2). This is the resource of interest here. Indeed, carbon dioxide can be used as a raw material to locally produce oxygen, which can be collected and made available for breathing. The process relies on the decomposition of carbon dioxide

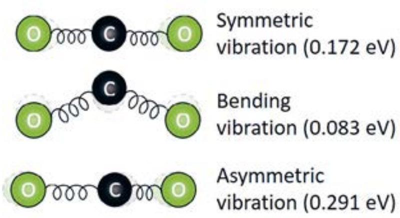


▲ **FIG. 1:** Spacecraft trajectory along the Hohmann transfer orbit, the trajectory that uses the least energy. Launch windows are periodic according to the synodic period, 780 days in the case of Mars.

into carbon monoxide and oxygen and would constitute a major breakthrough towards the establishment of an outpost on the red planet. The decomposition procedure comes with a bonus: not only would it provide a stable, reliable supply of oxygen, but a source of fuel as well, as carbon monoxide and oxygen have been proposed as to be used in a propellant mixture in rocket vehicles. In the long run the decomposition can even be sought to go all the way down to carbon, that can be used as a building block for different carbon structures and organic molecules.

A major challenge is that CO_2 is a very stable molecule, hence very hard to decompose. In other words, CO_2 dissociation is a strongly endothermic process, requiring the supply of a considerable amount of energy, at least 5.5 eV. Current technology for CO_2 dissociation on Earth is based on Solid Oxygen Electrolysis Cells (SOEC), which has the advantage of being a very robust technology. However, it has very low energy efficiency and often uses scarce and expensive rare-earth metals. Moreover, it operates at high pressure and high temperature, which will further decrease its efficiency in Martian conditions. Despite these drawbacks, NASA's exciting MOXIE programme for oxygen production on Mars is an electrolysis experiment based on SOEC, to be included in its Mars 2020 mission [1]. Biological solutions, based in algae or bacteria, seem to remain purely speculative to date. A radically different and new approach to the question, proposed very recently, would be to use low-temperature plasmas [2].

▸ **FIG. 2:** Vibration modes of the CO_2 molecule.



Why plasma?

Low-temperature plasmas or non-equilibrium plasmas are ionized gases where only a fraction of the gas is ionised. The different particles – electrons, positive ions, neutrals and photons – have very different properties and energies.

Electrons are light and are easily accelerated by applied electric fields. They become very energetic and create different chemically reactive species, while keeping the background gas temperature low enough to limit the losses into gas heating. Low-temperature plasmas are thus formidable convertors of electrical energy into chemical energy.

The required power for discharge operation is typically ~100 W but can be as low as ~25 W, depending on the operating conditions. These power requirements are perfectly feasible on Mars. For instance, the Mars Exploration Rover solar arrays generate, when fully illuminated, about 140 W of power for up to four hours per sol (a Martian day, 24h40'). Another merit of the plasma technology is the possibility of instant start and stop of operation, perfectly adapted to the cycles of supply of power to an ISRU unit on Mars.

The technology can take advantage of the non-equilibrium nature and energy efficiency of low-temperature plasmas and use optimal conditions to selectively use the electron energy to drive the chemistry towards the desired products, O_2 and CO. High energetic electrons can break the CO_2 molecule upon direct impact. It is a good step, but it might be not good enough. On the one hand, the process goes via the excitation of electronic states with energies of 7 eV or more, well above the dissociation energy of CO_2; on the other hand, only a small fraction of the electrons has enough energy to decompose the molecule. To make it unbeatable there is one magic ingredient missing: "making the molecules sing."

The song of the molecules

In a molecule like CO_2 the bonds between the carbon and the oxygen atoms can be bent or elongated and, as such, the molecule starts vibrating (see figure 2). These vibrations store energy. A plasma created on Martian conditions can easily produce electrons that transfer more than 90% of their energy into vibrational excitation of the CO_2 molecules. This feature, which could be thought as a drawback at first sight, since the energy is not being used to decompose CO_2, turns out to be a major asset. First, to put the molecules to vibrate requires about 10 times less energy than to directly dissociate the molecule by electron impact. Second, it is possible to favour energy transfers between vibrating molecules along the asymmetric stretching mode, in such a way that some of them gradually increase their amplitude of vibration. It is not the same phenomenon as breaking a crystal glass by singing, but this simplistic image is good enough for a first impression: if the molecules are vibrating significantly, they become easier to break!

The "song of the molecules" is known as the *vibration-vibration* (V-V) *up-pumping* mechanism [3]. When two vibrating molecules with about the same vibrational excitation collide, there is a relatively high chance that they will exchange vibrational quanta, since this is a nearly resonant mechanism. The word "nearly" is essential. The energy spacing between two consecutive vibration levels decreases as we move up on the vibrational ladder. Thus, the exothermic sense of the exchange of quanta is the one where the molecule with a higher degree of vibrational excitation becomes even more excited, increasing further its amplitude of vibration, at the expense of the vibration of the less excited molecule. Vibrational quanta are "up-pumped" and several molecules may reach large vibration amplitudes and participate in dissociation. A schematic representation outlining how the low-temperature plasma / V-V up-pumping mechanism results in O_2 is given in figure 3.

Mars: the perfect environment for plasma!

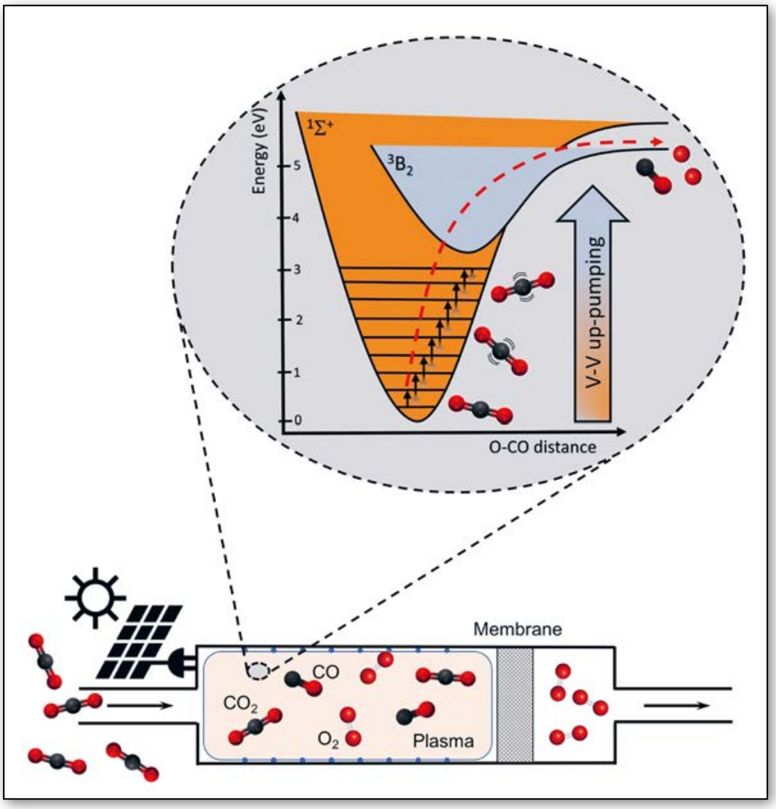
The general ideas to use plasmas to decompose CO_2 are being pursued on Earth, prompted by the problems of climate change and production of solar fuels. An overview of this research effort is available as a 2016 *Feature* at Europhysics News [4]. The challenge here is to understand if and how the results on Earth can somehow be adapted to Mars. The interesting discovery recently reported in [2] is precisely that Mars has excellent conditions for In-Situ Resource Utilisation (ISRU) by plasma. In fact, one can take advantage of the conditions on Mars, to the point that it almost looks like Mars has been designed for it.

The atmosphere is mainly CO_2, so there is no need to capture it and plasma can be ignited in ambient Martian atmosphere. The traces of Ar and N2 present can only help: argon aids shaping the electron energy distribution to higher energies, contributing to an increased efficiency of the process [5]; nitrogen favours the transfer of energy into the vibration of the asymmetric stretching mode of carbon dioxide, as in a CO_2 laser [6], further promoting the V-V up-pumping.

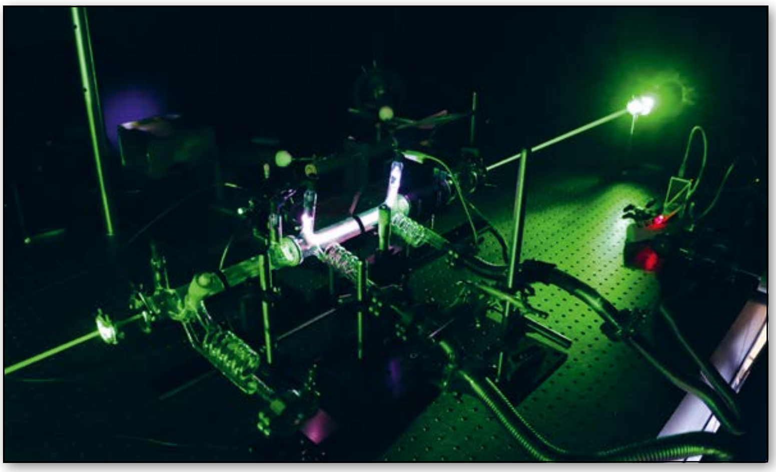
The pressure on Mars – of 600 Pa (4.5 Torr), about 150 times lower than on Earth – is close to the ideal for advantageous plasma operation, so there is no need to use vacuum pumps or compressors on the first steps of the process. A too high pressure means the electrons collide too often and, accordingly, are difficult to accelerate to the required energies. In turn, at too low pressure electrons are easily accelerated but collisions are rare, so that the transfer of energy to the heavy-particles is ineffective.

Finally, the low temperature of the Martian atmosphere – ranging from -150 °C to 20 °C, with an average value of -60 °C – slows down the back reactions (that would convert CO and O back to CO_2), giving more time for product separation. And, very important, the low-temperature also promotes the V-V up-pumping mechanism, both by favouring the exchange of vibrational quanta (V-V) due to an enhanced role of long-range attractive forces and by limiting the losses of vibrational energy to gas heating as a result of collisional deactivation.

The new results were obtained by simulations made at the N-PRIME team of IPFN (Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Portugal) [2,7] and are supported by experiments made at LPP (Laboratoire de Physique des Plasmas, Ecole Polytechnique, Palaiseau, France) and TU/e (Technische Universiteit Eindhoven, The Netherlands) in pulsed DC plasmas [8]. This early research focuses on the characterization and control of the degree of vibrational excitation, crucial to achieve an efficient plasma decomposition of CO_2. Figure 4 shows the experimental apparatus at LPP, while figure 5 depicts two critical parameters, calculated for conditions on Mars and on Earth: the ratios T_3/T_g and



▲ **FIG. 3:** Schematic representation of the O_2 production mechanism.

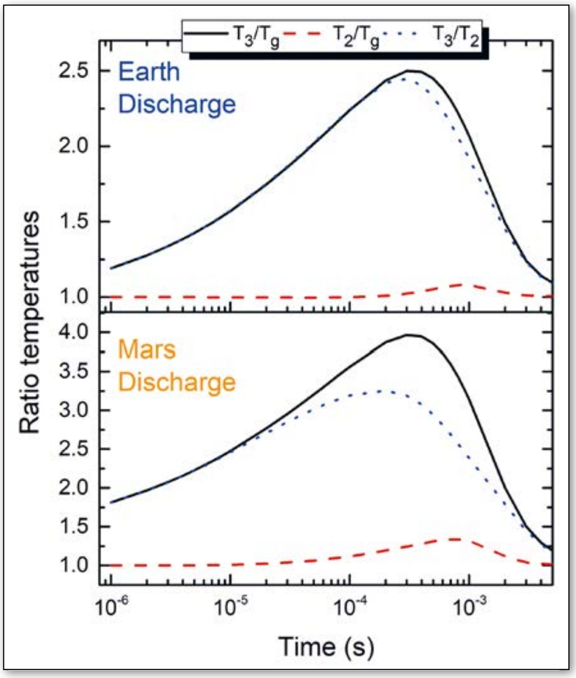


▼ **FIG. 4:** CO_2 plasma created by DC discharge at LPP, for a pressure of 600 Pa and a discharge current of 50 mA (© guaitella 2017).

T_3/T_2, where T_3 is the characteristic temperature of the asymmetric stretching mode, T_2 is the characteristic temperature of the bending mode (typically very similar to the characteristic temperature of the symmetric stretching mode) and T_g is the gas temperature [2]. These ratios characterize the degree of non-equilibrium of the plasma [9]. The higher they are, the larger amount of energy is stored in the vibrational mode leading to decomposition of CO_2. Figure 5 hence confirms the advantageous conditions of the Martian atmosphere to ISRU by plasma.

The emerging plasma technology is therefore very promising. Its efficiency on Mars will increase compared to that on Earth, as demonstrated in the foundational work [2]. On the contrary, the efficiency of solid oxide electrolysis is likely to decrease, because extra energy is necessary to heat the gas up to 1100 K and to compress it up to 1 atm. Current studies indicate that MOXIE's target of about 10 g per hour for a power of ~300 W [1] is perfectly within the reach of an optimized plasma device. A subsequent upscale may reach a production equivalent to the on-board oxygen consumption of the International Space Station (ISS), presently in the range of 2-5 Kg/day. The use of plasma activated catalysts and membranes for product separation will further enhance the efficiency of the plasma process, positioning plasmas as a viable and very interesting alternative to SOEC for oxygen production on Mars on the long run.

The installation of an In-Situ Resource Utilization (ISRU) technology on the red planet will provide a continuous production of consumable oxygen and propellants from the Martian atmosphere. A giant leap for mankind and a significant contribution towards the viability of manned missions to Mars and to the sustainability of a future colony. ■



▸ FIG. 5: Time evolution of the ratio of different characteristic temperatures on a DC pulsed discharge at pressure p=5 Torr, discharge current I=50 mA, pulse length Δt=5 ms, for conditions on Earth and on Mars. The higher values of T_3/T_2 and T_3/T_g on Martian conditions confirm the interest of the plasma technology. Adapted from [2].

About the Authors

Vasco Guerra is Associate Professor with the Physics Department at IST and researcher at IPFN. He received the PhD in Physics from IST in 1998. His research focuses on the modeling of non-equilibrium kinetics of low-temperature molecular plasmas. In 2016 he was awarded the EPS/PSST William Crookes Prize.

Tiago Silva earned his master degree in Engineering Physics at IST in 2012 and his doctorate at Université de Mons, Belgium, in 2015. He currently holds a post-doctoral position at IPFN/IST. His research interests are related to diagnostic and modeling of plasma sources in view of their optimization and plasma-based conversion of greenhouse gases into valuable chemicals.

Olivier Guaitella is a researcher at the plasma physics laboratory of the Ecole Polytechnique in France, where he also obtained his PhD in physics in 2006. His experimental work is mainly devoted to plasma/surface interaction and has applications in fields as varied as indoor air treatment, CO_2 recycling or biomedical applications.

Ackowledgements

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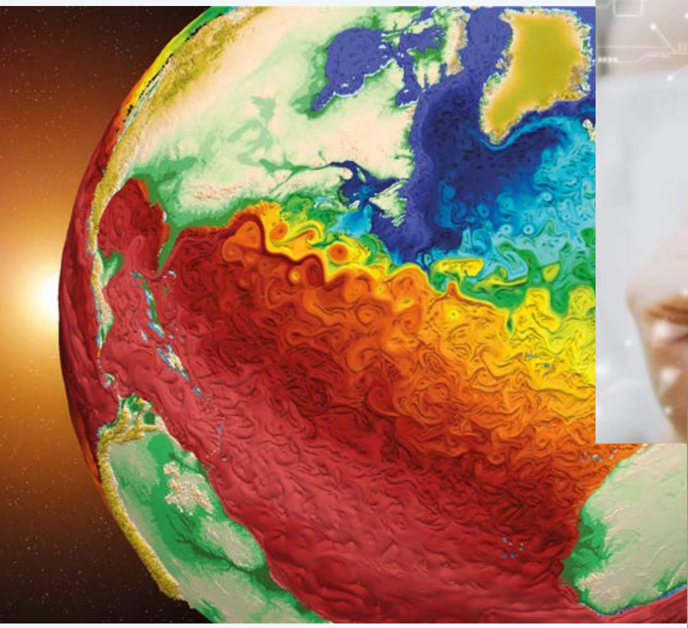
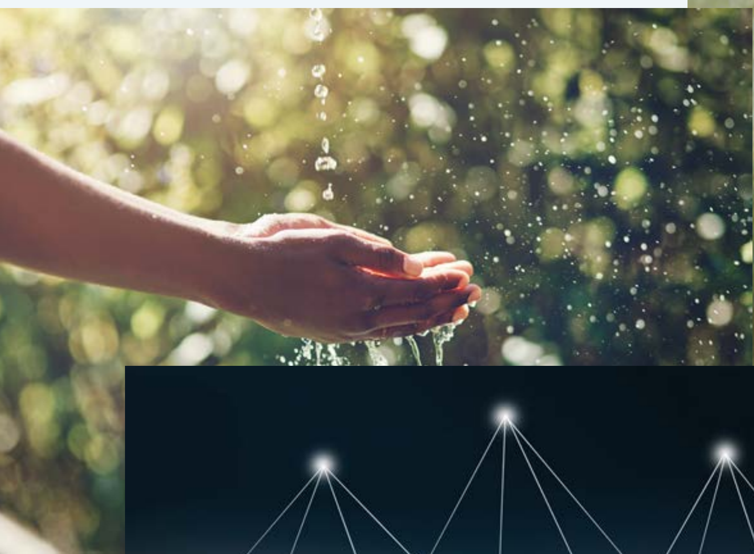
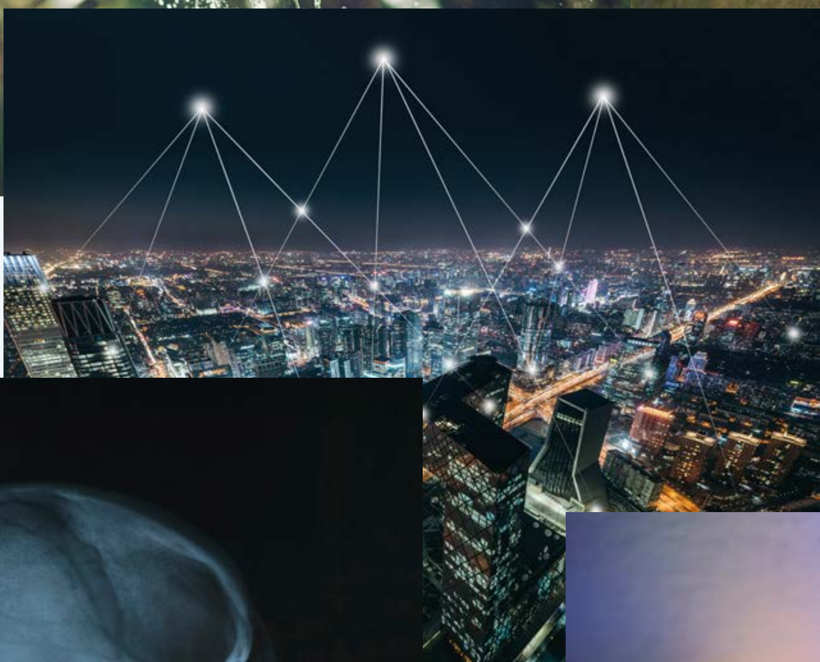
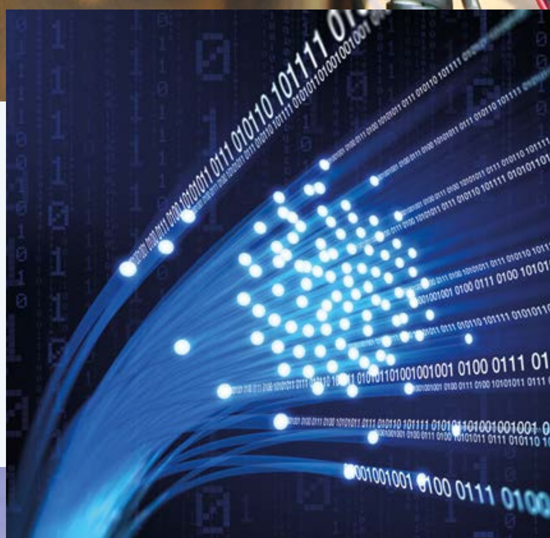




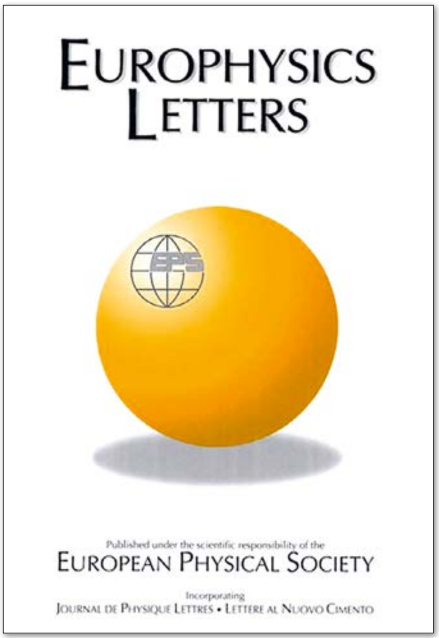




The European Physical Society is celebrating its 50th anniversary in 2018. The EPS was created as and remains a grass roots organisation, close to the main concerns of its members. There are many thousands of people who have contributed to its development and success over the past 5 decades, and we would like to take this opportunity to express our truly sincere thanks to all of you who have been involved. In issues 49/2 and 49/3 of Europhysics News, we will present the growth of the EPS, both in terms of the number of Member Societies and its Divisions and Groups, and some of the many highlights of the EPS over the past 50 years. It is interesting to see how current events have shaped the EPS, and how the EPS has contributed to the development of physics, in particular through the EPS Divisions and Groups.Thanks should also go to the group that has industriously worked to prepare these short highlights as testimony to the work of the thousands of volunteers that have been involved in the EPS and its activities. The members of the group were: Giorgio Benedek, Lucia di Ciaccio, Karl Grandin,Hendrik Ferdinande, Martin Huber, David Lee, Antigone Marino, C. Rossel.

EUROPHYSICS LETTERS - EPL

Europhysics News, volume 16, n°6, page 1 officially announced the launch of Europhysics Letters (EPL): "After years of the most thorough discussions on the needs, the means, the structure, the people... during which the physics community of Europe through the EPS Divisions and the national societies has been fully consulted, EPS is able to formally announce the publication from 1 January 1986 of a new fortnightly journal:



Europhysics Letters incorporating *Journal de Physique Lettres and Il Nuovo Cimento Lettere.*

The first proposal for a European Letters journal was made in 1980 by Antonino Zichichi, the President of the EPS at that time. The EPS Publications Committee began working in earnest in 1981and formulated the following recommendation to the Executive Committee: "The [Publications] Committee would like to see the formation of an EPS Letter Journal by the amalgamation of existing journals, and in this respect welcomes the proposals of the French and Italian Physical Societies that their existing letters journals form the basis of an amalgamation. The [Publications] Committee also welcomes the support of the Institute of Physics and looks forward to the participation of other interested bodies in such a European venture." Europhysics Letters became a reality under the Presidency of G.H. Stafford. The creation of EPL was an integral part of the effort by the EPS and its members to harmonise physics publications in Europe.

The "Euro" in the original name of EPL was a recognition of the collective European effort that went into the creation of the journal. That effort continues today and by dropping the explicit reference to Europe, reflects the fact that EPL has become a journal whose editors, authors and readers are located on all continents. Nevertheless, EPL is owned by the Europhysics Letters Association, led by the European Physical Society, the French Physical Society, the Italian Physical Society, and the Institute of Physics (UK). The physical societies of Austria, Croatia, Denmark, Finland, Germany, Hungary, Iceland, the Netherlands, Norway, Portugal, Sweden, Switzerland and Turkey are also members. ■

THE EPS SECRETARIAT IN MULHOUSE

When the EPS came to Mulhouse, it moved into offices in the Innovation Park 'La Mer Rouge' on the outskirts of the city. The offer from the city and university officials made it clear that this was only a temporary arrangement, to last not more than two or three years while waiting for EPS's permanent offices to be built on the campus of the Université de Haute Alsace.

The original proposal would have located the EPS offices in the planned building expansion of the Faculty of Science and Technology (FST) at the UHA. However, in 2000 the EPS learned that this option was cancelled in favour of creating a new campus in Mulhouse for Humanities studies. When EPS Member Societies were told of these developments, they reacted quickly, writing letters to the French Minister of Education and Research. With the notable support of the French Physical Society, funds for the construction of an independent building top host the EPS offices on the UHA campus were allocated, and construction began in March 2003.

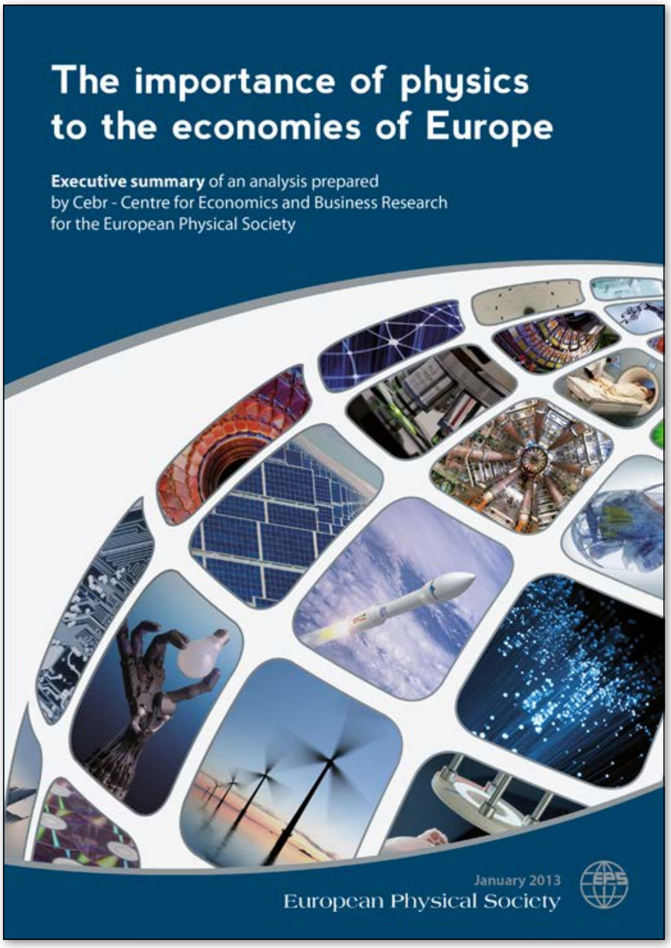
Throughout 2002, C. Rossel, the EPS Honorary Secretary participated in a number of meetings to discuss the needs of the EPS for its office space and the architectural design. These included a meeting room, as well as a reception area. The building is one of the first energy efficient buildings on the UHA campus, incorporating innovations such as a Canadian geothermal well, and a double glass wall. The move into the new building was finalised in July 2004 with the official inauguration during an Executive Committee meeting in February 2005. ■

POSITION PAPERS

EPS President Sir Arnold Wolfendale introduced the publication of *EPS Position Papers* in 1999. Numerous Position Papers have been published since then. Their topics can be divided into the following five categories:

- *Education*, including the implementation of the Bologna process, with studies along the bachelor - master - doctoral steps, as well as physics education in general;
- *Science and Research*, where the physics community helps to shape science policy in Europe by
  - raising the problem of the brain drain,
  - delving into the financing of research,
  - dealing with problems like the use of bibliometric indices during assessment,
  - discussing publication policies, and repeatedly, 'Open Access';
  - an early Position Paper promoted the use of quiet space platforms for precision tests of fundamental laws of physics, and for observing low-frequency gravitational waves, and
  - another one discussed the relation between Research Institutes and Universities and, at its time, drew attention to a problem that arose after the end of the Cold War, namely whether and how one might transfer researchers of defence establishments to Universities;
- *Physics and Society*, with recommendations for action – both to EPS and policy makers – that come out of the regular meetings of the EPS Forum Physics and Society;
- *Environment and Energy*, with papers on the intimate link between energy and the environment, on the nuclear option and on the European energy policy; and finally the broad area of
- *European Cooperation*.

The flow of Position Papers is testimony to a lively society. Its Members, Committees and Fora keep raising issues related to physics research, education and applications – including their impact on society. ■



SOURCE:
http://www.eps.org/blogpost/751263/141461/EPS-position-papers and some personal remembrances.

THE INTERNATIONAL YEAR OF PHYSICS 2005

The International Year of Physics 2005, originally called World Year of Physics WYP2005, was officially launched at UNESCO Headquarters on 12-15 January 2005 with a large international meeting entitled *Physics for Tomorrow*, in presence of more than 1200 participants. This initiative goes back to 2000 when it was proposed to the EPS Executive Committee by Martial Ducloy and adopted in December at the Third World Congress of Physical Societies. The General Assembly of IUPAP adopted a motion of support in October 2002.

The main idea was to celebrate in 2005 the 100th anniversary of the Annus mirabilis of Albert Einstein, who published his most famous articles in 1905, when living in Bern. The General Conference of UNESCO approved the WYP2005 in October 2003, and in June 2004 the General Assembly of the United Nations (UN) unanimously declared 2005 as the "International Year of Physics" (IYP2005).

The declared objective was to improve the communication between science and society, promote physics to the general public by demonstrating its major role in the socio-economic development and in everyone's life. Another important goal was to attract the attention of international media on events and celebrations organized around the world. Several preparatory meetings were organized beforehand in Graz, Montreal and Mulhouse to set up an agenda and coordinate the international events.

A general review of the IYP2005, outlining the international and national activities, was written by Martial Ducloy and published in EPN 37/6 p. 8-12. Let's mention here a few of these activities.

At the international level, the project *"Physics enlightens the world"* was very successful, with a light beam relay organized around the globe during the night of 18 April 2005, at the 50th anniversary of Einstein's death. Another well received enterprise was the international contest *"Physics talent search"* aimed to identify talented young kids, asked to present original physics projects in their country. The winners were sent as physics young ambassadors to the final symposium in Taipei, Taiwan, in December 2005. Other notable events were a Poster Contest *"Physics across the World"* organised by IoP-UK, *"Physics in School Architecture"* organised by Serbia-and-Montenegro, the *"International Physics Olympiads"* (Salamanca,Spain, July 2005), the IUPAP Conference on "Women in Physics" (Rio, Brazil, May 2005), the International Young Physicists Tournament (Winterthur, Switzerland, July 2005), the International Conference of Physics Students (Coimbra, Portugal, August 2005) and the IUPAP World Conference on *"Physics and Sustainable Development"* (Durban, South Africa, Nov. 2005). The list of national activities for the IYP2005 was impressive and concerned over 80 countries from all five continents. These actions spanned from itinerant exhibitions on physics to cultural outreach events (theatre plays, concerts, conferences, interactive shows, *etc.*), competitions, open door days in laboratories at universities and industry, special TV programs, *etc.*. Worth mentioning is also EPS13 the EPS General Conference, organised in Bern in July 2005. Additional event related to Einstein's life took place in this city, in particular the great Einstein exhibition at the Historical Museum.

A large number of promotional materials such as stamps, postcards, leaflets were also produced in various countries.

The IYP2005 definitiely achieved its goals by making the public aware of physics and creating among the young generations a larger interest for scientific studies. It was without any doubt an important milestone among the many projects initiated by EPS and played a relevant exemplary role, 10 years later, with the establishment of the International Year of Light (IYL2015), an initiative also driven by the EPS. ■

A SHORT STORY OF YOUNG MINDS

It is true that networking is important to enrich the personal career with new opportunities. However, there are also many occasions where networking becomes an exchange between generations. This is the case for the EPS Young Minds (YM) project, born from an informal meeting of Maciej Kolwas, the former EPS president (2009-2011), with Armand Niederberger, a Swiss PhD physics student working at that time in Spain. Informal because both worked in optics and I can well imagine such a meeting during a conference coffee break, or in a hotel lobby. EPS was looking for a project aimed at bringing more young physicists in the Society's activities. Armand was one of the students who built the International OSA Network of Students (IONS) 4 years before. This is how it all started. One day, Armand called Giovanni Volpe and me and we met two weeks later in Mulhouse to talk about the project.

In February 2010, around a table, the three of us together with Maciej Kolwas, Ophelia Fornari and David Lee, were looking for a simple, direct and most effective name: Young Minds (YM). Like in an artisan's workshop, EPS realised that it had to involve young people to continue the work that it has been doing for almost fifty years.

Thinking about the benefits of being a young physicist within YM, the first idea that came to our mind was the opportunity to engage in new activities, and develop a successful career as a scientist. Nowadays I look at YM sections like small laboratories, where young people interact for the benefit of the local communities.

The first years were difficult, as YM was still unknown. Expansion relied heavily on our personal networks. The turning point happened at the end of 2012, when Luisa Cifarelli (EPS President, 2011-2013) suggested integrating YM with all other EPS activities. In this way, YM went from being a project for young people, to a project including and listening to young people. The effects of this change were evident during the International Year of Light 2015: the number of YM sections and activities increased dramatically, because of their integration into the respective national physical societies and local institutions. Thanks to John Dudley (EPS President, 2013-2015), also chair of the IYL2015 Steering Committee, YM gained for the first time a strong international visibility, even outside Europe.

Perhaps, at this point the most beautiful period had come. Having reached the initial momentum, with some unavoidable initial friction, YM has begun to optimise its efficiency, like a well-tuned engine. I was really amazed by the creativity and enthusiasm of the young physicists at the last two annual meetings, not only in outreach activities, but also in their own professional development. Among the gears of this engine, was for sure the immediate past President Christophe Rossel (2015-2017), who, thanks to his "young inside" processor, came into total harmony with the YM activities and projects. Rüdiger Voss, the current EPS President, has given his strong support to the project, and we can only hope that all future presidents will contribute to the successful growth of YM, along that of EPS.

The Young Minds Action Committee is a peculiar mix of more experienced senior mentors and of younger enthusiastic PhD students and Postdocs. This composition ensures the transmission of knowhow between generations, and the planning of projects well suited to the needs of the younger committee members. From the beginning on, YMs have benefitted from the talents of the many young volunteers including Jonas Berzinš, Roberta Caruso, Adriano Conte, Bence Godo, Imran Khan, Giorgio Nocerino, Ulrike Ritzmann, Enrique Sanchez, Araceli Venegas, Giorgio Volpe, and Eva Salvador (current chair of YM). You might read this as a simple list of names, but among them, there might be one of the future EPS division chairpersons, or even an EPS future president!

What did YM bring me during my years of activity at YM (Action committee 2010-2016, chair 2013-2016)? I can simply state that it was a laboratory, where I could develop my ability not just in doing physics, but more in being a physicist. The EPS Young Minds is the right tool to grow up as a scientist. ■

Young Minds

FROM AN ACPE OVER AN IGPE TO A PED

(From an Advisory Committee on Physics Education over an Interdivisional Group on Physics Education to a Physics Education Division)

The constitutive meeting of the EPS *Advisory Committee on Physics Education*[1] (ACPE) (chair: Aloysio Janner (*Katholieke {presently Radboud} Universiteit Nijmegen* [NL]) was held in Bucharest in 1975 in the presence of 26 members and delegates from EPS Member Societies and other HEIs (Higher Education Institutions). Through its European character the ACPE assembled *information on the curricula* in different European countries. ACPE Members were asked to present papers in the Leipzig [DE] 1976 meeting giving a description of the physics teaching in their own countries at *secondary school level*. The hard data, concerning *e.g.* curricula, was complemented by more general information about the *school system* and the intended *goals of the physics teaching programme*. In 1981the ACPE investigated '*Physics Teaching at Secondary-School Level*[2]', by sending a questionnaire to Member Physical Societies on (i) general organisation of Secondary School education (very diverse), (ii) place of physics in Secondary School education, (iii) physics curricula, (iv) teaching staff, (v) student body & (vi) general situation. In 1987 the ACPE held a successful two-week *Study Conference*[3] on the applications of *microcomputers* in teaching difficult fields of physics (first a brainstorming by experts, followed by practical exercises and group studies).

The creation of an EPS *Interdivisional Group on Physics Education* (IGPE) (Carlos M. Ferreira, Universidade Técnica de Lisboa [PT]) was endorsed[4] unanimously by the 1993 EPS Council in Nice [FR] and a whole set of activities was announced. A *Forum on Education*, led by Gunnar Tibell (Uppsala universitet [SE]) covered pre-university teaching. Its activities included the selection of the winner of the *Amaldi Prize for Physics Textbooks* and the organisation of specialised meetings to shape the future of physics education in schools. A *University Teaching Section* absorbed the activities of the former EPS *Education Committee*, notably surveys and evaluation of curricula. The third leg consisted of the *European Mobility Scheme for Physics Students*, chaired by Ernst Heer (Université de Genève [CH]).

A real "*Brainstorming the Future*[5]" in physics education happened with the 1999 Malvern Seminar[6] (Malvern College [UK]) "*Securing the Future of Physics*", where a total of seventy-six participants allowed Member Physical Society Presidents to mix with physics education experts. The five Working Groups issued a set of almost 50 *recommendations* on (i) Physics and the Human Condition, (ii) The Case for Physics Research and Wealth Creation, (iii) Public Awareness of Physics, (iv) Physics Education (including *policy* recommendations), (v) Teacher and Teacher In-service Training.

The *Physics Education Division* (PED) was created at the EPS *Council* Meeting of 2000 in Dublin [IE], with first chair Aart W. Kleyn. The PED consisted of (i) a *Pre-University Education Section* and (ii) a *University Education Section*. The division was liaison between EPS and EUPEN (*European Physics Education Network*). The Pre-University section (Gunnar Tibell, Uppsala universitet [SE]) worked closely with *Physics on Stage* and supported the *International Young Physicists' Tournament* (IYPT). The University section (Urbaan Titulaer, *Johannes Kepler Universität Linz* [AT]) strongly supported the Workshops by the *Multimedia in Physics Teaching and Learning network* (Hansjörg Jodl, *Universität Kaiserslautern* [DE]).

In 2002 an inquiry concerning '*Physics teacher training and research in physics education*' was sent to the presidential representatives to the PED with unfortunately limited response[7].

In February 2005, the EPS Executive Committee held its 3rd *Journée de Réflexion* around the theme of *Physics Education*, with presentations from experts around Europe. At EPS Council in July 2005, delegates participated in a debate on EPS policy concerning issues in physics education. EPS President Ove Poulsen, with input from the Executive Committee and the PED, drafted a *position paper*[8] on the importance of a solid physics education for all students and this was adopted by the Executive Committee at its meeting of 22 November 2005.

From 2007 the PED restructured, not keeping *sections* anymore, but introducing *portfolios* for Schools, Universities, Public Understanding of Physics, Didactics & Physics Education Research.

The idea of MUSE (*More Understanding with Simple Experiments*) originated in the January 2008 meeting of EPS PED board and is still flourishing. Current MUSE members are Andreas Müller [CH], Gorazd Planinšič [SI], Zdeňka Koupilová [CZ] and Laurence Viennot [FR].

The PED also supported from the start (2009) a series of collaborative workshops at the *Abdus Salam International Centre for Theoretical Physics* (ICTP) in Miramare, Trieste [IT] on low-cost equipment and appropriate technologies that promote undergraduate level, hands-on physics education throughout the developing world.

The development of the PED in recent years consisted of, (i) supporting the two-yearly conference, labelled EPEC (*European Physics Education Conference*), organised in conjunction with either GIREP

[1] A. Janner, *The Advisory Committee on Physics Education*, *EPN* **7/1**, 10 (1976)
[2] G. Born & A. Janner, *Physics Teaching at Secondary-School Level*, *EPN* **12/2**, 9 (1981)
[3] *Council in Como, EPN* **18/4**, 45 (1987)
[4] *Education Group Launched*, *EPN* **23/4**, 61 (1992)
[5] *Brainstorming the Future*, *EPN* **31/1**, 10 (2000)
[6] *Securing the Future of Physics*, The Report on the Malvern Seminar, EPS & Malvern College (1999)
[7] M. Vollmer, *The Physics teacher training and research in physics education: results of an inquiry by the European Physical Society*, *EJP* **24/2**, 131 (2003)
[8] Position Paper on Physics Education, *EPN* **37/1**, 6 (2006)

(*Groupe International de Recherche pour l'Enseignement de la Physique*) or with MPTL (*Multimedia in Physics Teaching and Learning*) or both, or with ICPE; (ii) awarding every odd year (since 2009) an *EPS Secondary-School Teacher Prize*, coinciding with EPEC; (iii) running some small projects, *e.g.* MUSE; (iv) keeping close contact with the Board of the *European Journal of Physics* (EJP) and with the IUPAP (*International Union of Pure and Applied Physics*) Commission *C14 Physics Education*, since either the Chair and/or a Board Member was/were Member(s) of the C14 Board.

In 2012 the EPS PED highlighted points of specific concern in a *Position Paper on Physics Education*[9]. General attention was drawn to the facts (i) that students in all European nations should be engaged in an accurate and useful introduction to *physics, as a distinct discipline, by motivated and well-trained teachers*; (ii) despite the currently buoyant situation regarding the recruitment of physics students, the proportion of students entering and continuing with university-level physics studies had previously been *declining for almost two decades*; (iii) for *lifelong learning and public outreach*, a proper understanding of physics is needed, including the opportunity to gain insight into the nature and significance of the latest developments and their impacts on society and scientific culture.

Presently the PED has the *ambition* to contribute to strengthening the *perception* of the physics discipline in society, contribute to bridging the *gap* between school teachers and teachers and scientists at the universities and to *support and strengthen physics teachers* to maintain and improve the quality of physics teaching.

It is remarkable that most of the topics treated by the PED, as well as the recommendations in position papers over this period of 20 years are *still painful subject* in most European countries. ■

[9] Position Paper on Physics Education, *EPN* **43/6**, 5 (2012)

OPEN ACCESS AND THE EPS

With the development of Open Access (OA) where the research papers become freely accessible by the readers, academic publishing is changing rapidly all over the world. The general consensus is that the results of research should be accessible and in the public domain so that they will bring benefits for public services and economic growth. Two factors have driven the OA debate: the ever rising cost of journals forcing libraries to cancel many subscriptions and the growing awareness that results of publicly funded research should be available to everyone. Even if the debate started already in the 1970s, the movement gained momentum at the turn of the 21st century *e.g.*, with the launch of the full OA *New Journal of Physics* in 1998 and the *Public Library of Science* (PLoS) in 2000. The OA declarations of Budapest (2002), Bethesda (2003), and Berlin (2003), signed by major libraries, research institutions, funding agencies, museums, *etc.*, gave a large impetus to the OA policy. In 2009 EPS published a position paper, declaring its support to the Berlin declaration (http://oa.mpg.de/openaccess-berlin/berlindeclaration.html) stating that all OA models need to fulfill specific conditions, securing in particular scientific quality and peer reviewing. A second position paper on managing the transition to OA publication with detailed recommendations was published jointly with EUCheMS in 2013. The debate developed in several countries, *e.g.*, in the UK with the Finch report (2012) that recommended a clear policy direction towards a Gold OA model. In such a model, the publication costs are paid by the authors so that research articles become immediately accessible upon publication to every reader. An alternative is Green OA where the refereed manuscript is placed in a repository organized by discipline or institution, with an embargo period between 6 and 12 months.

The ongoing discussions address critical issues such as freedom of journal choice for researchers, decreasing budgets of libraries, business models of publishers and how to meet publication costs if the subscription income is removed.

The High Energy Physics (HEP) community has pioneered OA, with the creation of repositories where today about 90% of all preprints in the field are available. The SCOAP3 model, which was finalised in 2008 and includes all stakeholders in HEP, has became a milestone in the history of scientific publishing.

Science Europe, an umbrella organization of the most important research and funding institutions in Europe, published in April 2013 a declaration entitled *Principles for the Transition to Open Access to Research Publications*. It describes the benefits of OA and proposes a set of common principles agreed by all its members to support the transition to full OA by implementing the appropriate policies in Europe and worldwide. The EPS will remain strongly involved in the global discussion, lead today by the European Commission (EC) with its vision on Open Science in Horizon 2020 and beyond and with its project of a European Open Science Cloud. Via its participation in the Open Science Policy Platform (OSPP), EPS closely follows and contributes to the developments of policies related to the 8 Open Science priorities namely: *Open Access & FAIR Data, European Open Science Cloud, Future of Scholarly Publishing, Altmetrics, Rewards, Education and Skills, Research Integrity and Citizen Science*.

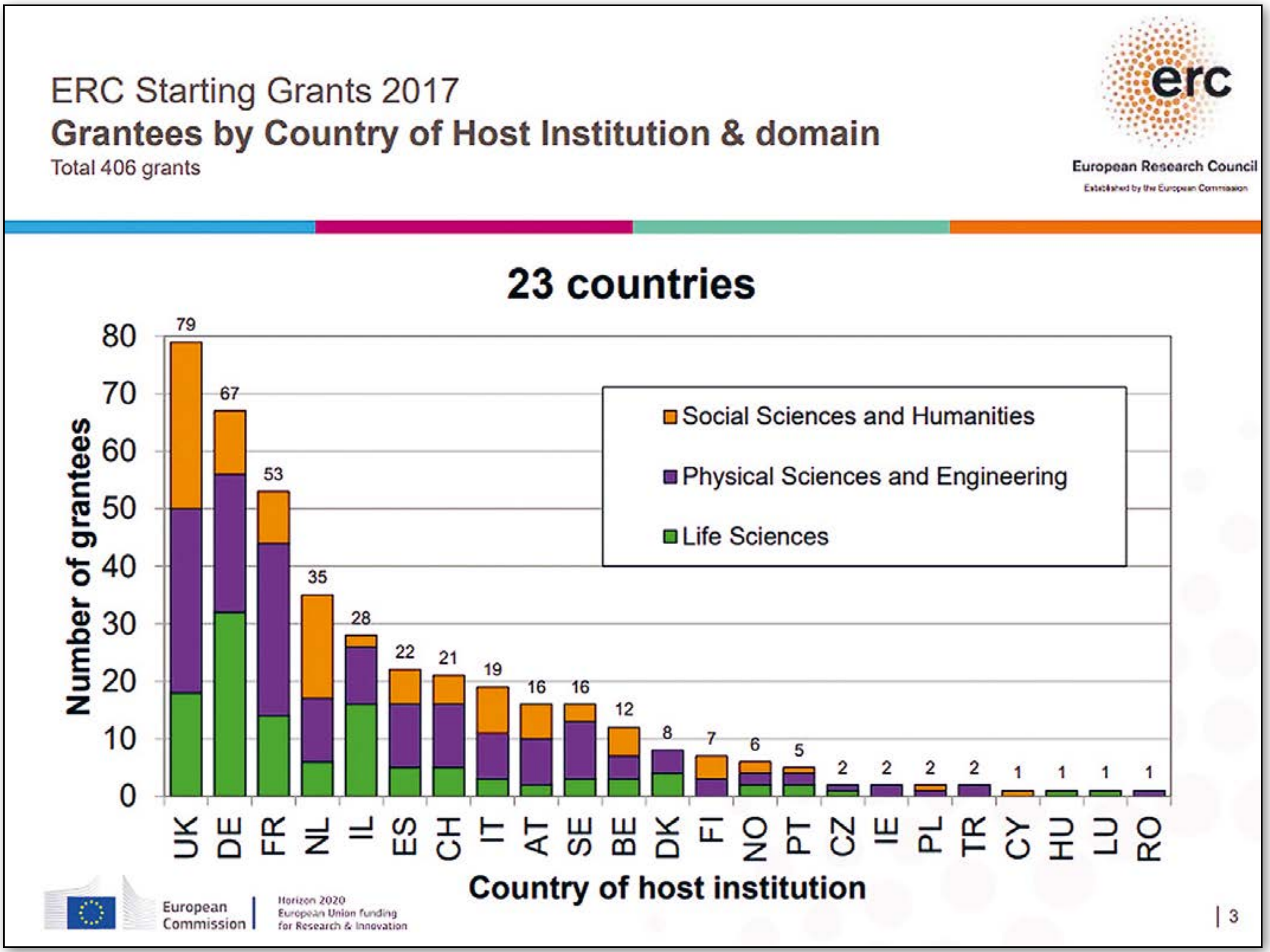
With an opinion *Survey on Open Science & Career Development for Researchers 2017-2018*, EPS will get insight on the opinion and level of knowledge of its physicist's community about this topic. ■

EPS, ISE AND THE EUROPEAN RESEARCH COUNCIL

Concrete discussions on creating a European research-funding organisation started towards the end of 2002, when an Expert Group, chaired by Federico Mayor, was set up and tasked to discuss the purpose and scope of a European Research Council, and to explore options for its possible creation. The Expert Group stressed in their findings that the ERC should be established as an independent entity within the EU budget, but should at the same time have the operational autonomy and flexibility that are important for its credibility in the research community. In short, this meant that the ERC should be driven exclusively by the requirement of scientific excellence rather than by the principle of *'juste retour'*, where each participating nation would be awarded in proportion to its input.

The report of the Expert Group was noted and discussed by a number of general science-oriented organisations, such as the Academia Europaea, the European Science Foundation (ESF) and the Heads of national Research Councils in Europe (EUROHORCS), but also by the more specialised European Life Sciences Forum (ELSF). All of these bodies agreed that ERC should cover all sciences – *i.e.* natural sciences as well as humanities and social sciences. While ELSF agreed, "the primary role of the ERC should be to fund activities." it went on "Inevitably, however, the ERC represents a new possibility for analysis of trends in sciences." This didn't sound reassuring at the beginning of the 21st century, because a peculiar view had gained some notoriety, particularly among life scientists. They thought that we had entered the century of life sciences (after the 20th century had presumably belonged to physical sciences). Although this has turned out to be an ephemeral view, it had to be taken seriously at the time.

To counter this penchant, EPS joined with other European learned societies and scientific organizations and founded the Initiative for Science in Europe (ISE), an independent platform of European learned societies in all fields of science. The aim of ISE is to promote mechanisms to support all fields of science at a European level; it insists that scientists be involved in the design and implementation of European science policies, and advocates strong independent scientific advice in European policy making. The members of ISE and their first President, José Mariano Gago, a former Portuguese Minister and one of the initiators of the concept of the European Research Area (ERA), finally saw the ERC being created according to these principles. ERC Scientific Council met for the first time in October 2005 and from then on ERC has developed into a great success. ■



THE HISTORY OF PHYSICS GROUP

The History of Physics Group started from the ambition to apply the history of physics in science education. The value of history, as an educational tool, is well established and anyone with a physics text book often finds useful historical notes and examples there. Looking into the EPS archives we learn that the History of Physics Group, "concerned with the use of historical approaches in the teaching of physics," started in 1988 as an ad hoc group emerging from the Advisory Committee on Physics Education at the EPS council meeting in Dresden. Formally the group was created at the following council meeting in Zagreb 1989.

However, there was of course a prehistory to this group that further emphasises this didactic background. The first chair of the group, F. Bevilacqua, had already organised in 1983 a conference on the history of science in physics teaching in Pavia, which was followed by meetings in Munich (1986) and in Orsay (1988) – the latter was formally the first meeting of the newly founded group. It had a wide array of themes, like history of concepts, reconstruction of historical experiments, technology and society, physics and culture, among others. The Orsay conference also had the explicit aim to invite secondary school teachers of physics. Another aim was to investigate if it was possible to produce some teaching material, using the history of physics, that could be translated or adapted into various languages.

For many years two parallel series of conferences were developed: history of physics as a means to teach physics, and history of physics as part of the overall history of scientific culture. This can be seen from the alternating series of history of physics and history of physics and education conferences organised since 1992. The latter conferences took place in Madrid (1992), Szombathely (1994), Bratislava (1996) and Como & Pavia (1999). In addition, another series of Europhysics conferences were organised on the topic: *e.g.*, one on the "Emergence of Modern Physics" in Berlin in 1995 and one on "Volta and the History of Electricity" in Como in 1999.

During his EPS presidency, D. Weaire, made a study tour with P. Brenni and C. Mollan in 1997 to see collections in Portugal, especially the magnificent ones in Coimbra. This emphasized the importance of looking after the material heritage of physics. In 1999, P. Brenni followed on F. Bevilacqua as chair of the group and made a strong case for the role of historical physics instruments. He proposed a project to study the more recent instruments from the second half of the 20th century. The tremendous development and the ever-growing field of physics mean special challenges for those interested in maintaining a representative selection of the instrumental culture of physics in this period.

After a less active period due to the lack of resources, the group was revived in 2003 with D. Weaire as chair. In collaboration with IOP, a workshop was organised in Paris in 2004. Further annual meetings of the group co-organised with conferences and workshops all over Europe invigorated the group.

An important development in the last years was the establishment of the European Centre for the History of Physics in the castle of Pöllau, Austria, under the leadership of P. Schuster, who became chair of the group in 2008. With the help of local resources he succeeded to establish an impressive collection of valuable artefacts gathered in many places that might otherwise have been lost. This centre has also been the site of many events and in 2016 of the second of a new series of international conferences on the history of physics under the auspices of the EPS. The first one started in Cambridge (2014) and the next will take place in Donostia/San Sebastian (2018).

The initial emphasis on the history of physics as a tool for teaching physics has progressively been completed by the ambition to care for the material heritage of physics. However the main challenge for the group remains the organisation of meetings where physics historians and interested physicists can meet and interact. Another goal is to alert the general public on the central importance of physics and of its history in our modern world. ■

Read more

[1] P. Brenni, *Old artifacts and new challenges: The future of history, EPN* **31:3**, 16 (2000).

[2] H. Kahlert, H. Krenn & L. Wilmes, *Echophysics: The first European Centre for the History of Physics in Pöllau (Austria), EPN* **42: 4**, 28 (2011)

EQUAL OPPORTUNITIES AS AN ESSENTIAL GUIDING PRINCIPLE AT EPS

Physics has played and plays a key role in the progress of humankind; more generally it is recognised that excellent Science and Innovation are necessary elements for the harmonious and sustainable development of our society. All talents are necessary to meet the Societal Challenges, therefore a better representation of women in Physics at all stages of their career is of the utmost importance for a better society that cares about the well being of its members.

The Equal Opportunity Committee (EOC) of the European Physical Society was established in 2013 with the mandate of promoting actions to remove or reduce the barriers, which contribute to the underrepresentation of women in physics. Since then, the EOC has launched several initiatives.

In 2013, the European Physical Society introduced the Emmy Noether Distinction, named after the famous mathematician who made ground-breaking contributions to abstract algebra and theoretical physics. The EOC manages the award. The distinction aims to bring to the wider attention of the scientific community and of the general public outstanding female physicists, identifying them as role models for the younger generation of physicists. Ten outstanding female physicists with remarkable research and mentoring activities have so far been recognised and their interviews have been published in e-EPS, the on-line news bulletin of the European Physical Society.

Another successful initiative of the EPS, managed by the EOC, was launched in 2015 and called "Visibility for Young Researchers". This programme publishes also in e-EPS, short portraits, often in the form of interviews, of female researchers in the very early stage of their career in academia or in industry. These portraits are among the most read articles in e-EPS.

The idea behind the initiative is that a young female candidate physicist (student, post-doc or young researcher) may identify herself with a person only a few years older and find positive answers to her concerns regarding a decision in pursuing a career in physics. The program benefits from a close collaboration with the Young Minds Action Committee.

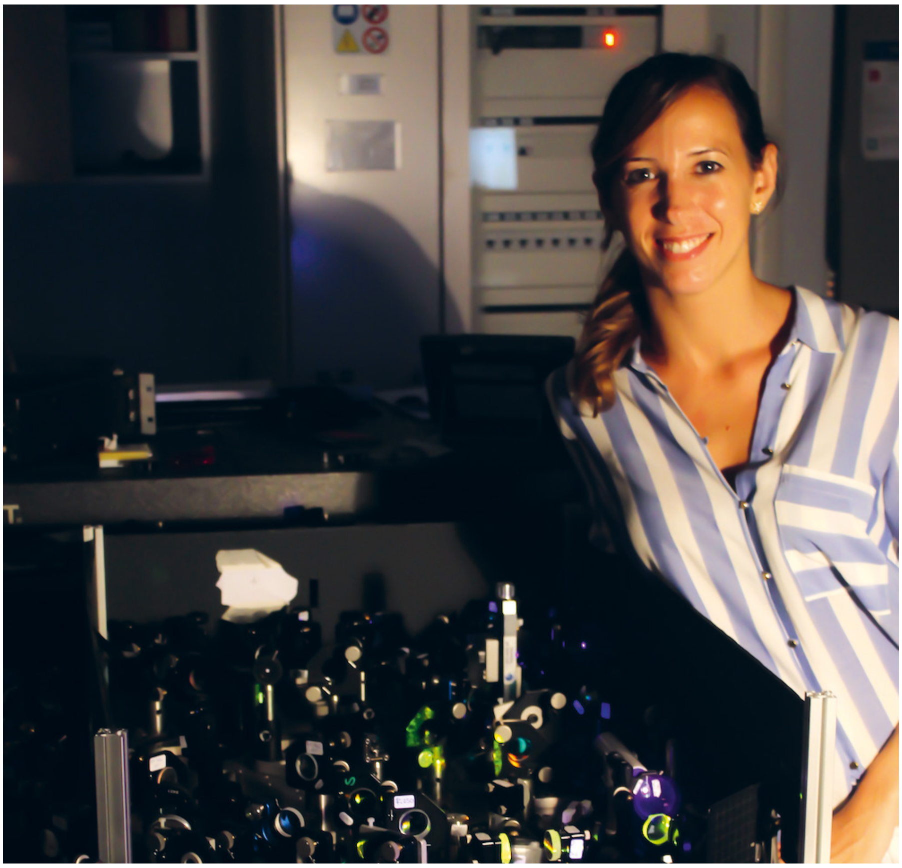
Furthermore, it is a matter of notable concern at EPS that well-qualified female physicists are underrepresented at top-level positions. Both initiatives, the Emmy Noether Distinction and Visibility for Young Researchers, have also the aim of strengthening the self-confidence of young female researchers ("Yes, I can"), one of the necessary qualities for achieving a rewarding career in physics and ultimately reaching leading positions.

To help breaking the so called "glass ceiling", the EOC proposed in 2017 a monitoring program on the gender participation at conferences, in collaboration with the EPS Conference Committee. This followed from the observation that a key element in the career development of a physicist is his/her participation at conferences as speaker, committee member and organiser. Profiting of the fact that EPS organises many premier physics conferences in Europe and worldwide through its Divisions and Groups, the program will run with their help over two years, starting in 2018. The aim is to put in place after this period a well-tuned conference charter, promoting fairness towards women attending and presenting their scientific results at national and international conferences.

Additional actions are under consideration following the observation that an Equal Opportunity Committee should include issues related to diversity.

Therefore, together with the EOC, EPS will continue to take practical steps to honour its commitment to equality of underrepresented groups. This with the strong belief that our society at large will benefit of continuous progress only when equal opportunity is guaranteed at all levels. ■

▾ Rocío Borrego Varillas



THE EPS – UNESCO AGREEMENT ON ENERGY 30 YEARS AGO

Although the greenhouse effect has been suggested by Arrhenius in 1896 [1], one of the first alerts against global warming was pronounced only in 1979 by the US Academy of Sciences. Dead letter for conservative governments, however, with the notable exception of Margaret Thatcher, who was the first world leader to voice alarm over global warming in 1988. In the same year the Regional Office for Science and Technology for Europe (ROSTE) of UNESCO was established in Venice and one of the very first acts was the agreement with EPS for the constitution of a *European Advisory Committee on Energy Storage and Saving*. There was a clear perception that the climate change could be opposed via a new energy management, based on renewable sources, efficient storage and low-loss power transmission. The discovery of high-Tc superconductivity, reported two years before, emphasized the major role that physics could play in the energy management and climate change mitigation.

The EPS-ROSTE agreement was signed on Dec. 13, 1988 by the EPS President Renato Angelo Ricci and the UNESCO-ROSTE Director Augusto Forti. President Ricci strongly advocated the agreement since the very first meeting held at UNESCO, Paris in Summer 1988. In those dramatic years facing URSS collapse, the major effort (with funding entirely provided by ROSTE) was for supporting East-West scientific collaborations and exchanges, as well as the participation of Eastern scientists in international schools and conferences, and also for the dissemination in research institutions of less-favored East Europe countries of proceedings and a series of reports on energy, environment and also brain-drain issues. A rich training activity at graduate and post-doc level co-sponsored by EPS and ROSTE was started with nine workshops during the first 4-year term. One of these was the International School of Solid State Physics at the Ettore Majorana Centre in Erice, originated from the memorable 1989 course on *Earlier and Recent Aspects in Superconductivity*, directed by Karl-Alex Müller and Georg Bednorz. Although EPS-ROSTE committee's life did not go beyond two terms of office, the Erice series chaired by Alex Müller and later by A. Bianconi was co-sponsored for many years, and is still going on, keeping pace with the development in the field.

The EPS-ROSTE initiative of exactly 30 years ago certainly suffered, politically and financially, from the temporary absence of US from UNESCO. Despite official decisions of APS in 1989 and 1993 calling for the US to resume active membership in UNESCO [2], this only occurred in 2003. In any case the EPS-ROSTE was a seed, anticipating several further initiatives of the two institutions along separated tracks. On the EPS side the Action Committee on Physics & Society organized two Heraeus Seminars chaired by Eddy Lingeman on *Balances in The Atmosphere and The Energy Problem* (1990) [3], and on *Using energy in an intelligent way* (1993) [4]. After the 2007 Fourth Intergovernmental Panel on Climate Change (IPCC) report, alerting that serious warming effects have become evident, more actions have been undertaken by EPS, as well as by the other major physics societies. Later on in 2008 a SIF-EPS international schools on energy started at Varenna, almost together with a new series of Erice courses, held every second year, on renewable energy. The two schools eventually merged in 2016 in a single big event at Erice, with a large participation of students from African universities. In 2010 the EPS Energy Group started its intense and highly effective activity. In celebrating the 50th birthday of EPS it was worth mentioning the very early, now 30-years old concern of EPS for the energy problem and the climate change, as well as its present endeavour for a sustainable future. ■

References

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[2] APS News, *Vol.* 2, *No.*7, p. 21 (1993)

[3] E. W. A. Lingeman (Ed.), *Balances in The Atmosphere and The Energy Problem* (EPS, Geneva 1990); in these proceedings see Chap. 3: G. Benedek, *The EPS, UNESCO and the Energy Problem*, p. 17-28.

[4] E. W. A. Lingeman (Ed.), *Using energy in an intelligent way* (EPS Geneva 1993).

Opinion: Research: too many indices, too much bureaucracy

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The San Francisco Declaration (2013) and the Leiden Manifesto (2014) rightly highlighted the abuse of numerical indicators for measuring the worth of scientific papers or researchers' projects. In itself, this is an almost obvious observation, since papers are meant to be read and appreciated on their own merit; their evaluation should rely on expert judgement, not on indices. The 'scientometric mania' has grown so much that even a PC could now select a candidate if told what to *count*. Another example is the trend of requesting authors to quantify their contributions in papers with multiple authorship. Impact factors and metrics, originally meant to favour research, may now hamper it. They could *e.g.*, discourage long-term or ground-breaking research as being too risky to undertake, something unthinkable when Planck was at the helm of Annalen der Physik and accepted Einstein's 1905 relativity paper.

On the other hand, ignoring these indices altogether may run into unexpected undesirable effects. For instance, in an ideal world selecting committees, all very competent, would easily appreciate the merits of candidates by reading their papers and considering their contribution to them. But committees may be overloaded with work and prone -even required- to apply pre-established numerical criteria. Thus, removing all impact factor considerations could provide, in the absence of a proper analysis, a perverse rationale for considering all papers of essentially equal value. At least, in a first order approximation, a good impact factor allows a not-so-good committee to rely on the presumably better judgement of the journal referees who accepted the paper. But low-impact journals also contain very good articles; therefore, a healthy skepticism towards indices is essential. There is no good substitute for scientists delving into papers, reading carefully grant proposals, and interviewing candidates.

The rise of numerical indicators, supposedly providing 'objective' criteria to judge, is not unrelated to the increasing prominence of 'Research Administrators', high-level bureaucrats whose procedures are not always in the best interest of research. Of course, today's Science is a huge, costly and complex enterprise requiring (good) management, and scientists are accountable for the funds they receive. But although metrics and other initiatives may please some administrators, reality is more nuanced. For instance, is it really necessary to force publication in Open Access Journals when in many areas such as physics we have the 'golden access-like' arXiv repositories since 1991? Further -there is no free lunch- OA merely shifts publishing costs. Thus, does OA promote good refereeing? What is a better 'measure' of a country's excellence in Science, the yearly number of research papers or of its Nobel prizes? Science Administrators frequently develop rules – often changed at their whim – more suited for them than for research (or for having the general public properly informed). Pierre-Gilles de Gennes, in his delightful *Petit Point: A Candid Portrait of the Aberrations of Science*, gives an example of the negative effect on research of Polymorph, a high ranking Science Administrator. Polymorph prefers large laboratories because they are easier to manage – and control – than many smaller groups. Therefore, he forces productive but fiercely independent teams to merge and to collaborate against their will. Soon group A starts feuding with group B with disastrous consequences, but Polymorph is happy because his workload is lighter.

What is a better 'measure' of a country's excellence in Science: the yearly number of research papers or its Nobel prizes?

Science is advanced by human beings. Well-meant or 'politically correct' regulations ignoring this obvious fact and the realities of research will not foster it. Further, detailed regulations and controls often cost time and much more money than they pretend to save; analytical accounting would produce here quite a few surprises. Thus, although the degree of nonsensical bureaucracy is different in every country and national Scientific Councils may help restraining it, some de-regulation in research administration is urgently needed. Because, as always, the devil lurks in the detail. ■

COMING EPS EVENTS

- **EGAS 50**
  09 » 13 July 2018
  Krakov, PL
  https://egas50.org/
- **MOLEC 2018**
  26 » 31 August 2018
  Dinard, France
  https://molec2018.sciencesconf.org
- **MORE ON:**
  www.eps.org