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EPS 50 years
Interview with J.-P. Bourguignon
Windows to the nanoscale
Historic sites: les Bastions
Opinion: AI and scientific intelligence

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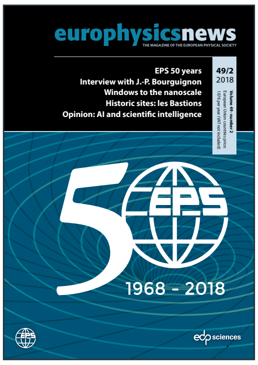

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Cover picture: European Physical Society 50th anniversary logo. See p.18.

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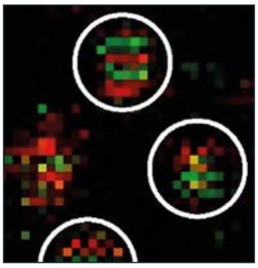
Interview with J.-P. Bourguignon



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Windows to the Nanoscale

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EPS 50 years Part 1

[EDITORIAL]

Happy birthday, EPS!

In 2018, the European Physical Society will celebrate its 50th anniversary

1968 was a year that changed the face of post-war Europe like few others. Amongst the pivotal events that will remain on record in the history books is one of the most dramatic crises of the Cold War period: on August 20, more than 500'000 Warsaw Pact troops with 2'000 tanks, led by the USSR, invaded Czechoslovakia and set an end to a period of political liberalization which had become known as the "Prague Spring". Against this background, it seems like a miracle that only a few weeks later the European Physical Society was born with strong participation of Eastern Bloc countries, which included Czechoslovakia and the Soviet Union.

In retrospect, it is no accident that the EPS was founded under the strong impetus of physicists involved in research at CERN, most prominently first President Gilberto Bernardini. In fragmented post-war Europe, CERN had pioneered international cooperation for the double purpose of advancing basic science and promoting European unity, under the motto "Science for Peace". In the same spirit, CERN had been a pioneer of East-West collaboration, starting to build solid scientific bridges across deep political divides. The CERN paradigm had a strong impact on the establishment, the membership, and the early mission of the EPS. For many years and throughout the Cold War period, the EPS remained the only scientific society federating physicists and physical societies from all parts of divided Europe.

For fifty years, the EPS has been successful in building and supporting a physics community of universal stature, which today counts more than 130'000 members, principally through our 42 national Member Societies. Along the way, we have strongly relied on the established activities of a learned society: promote scientific communication and exchange through conferences and publications, reward scientific talent and excellence through prizes and distinctions. Complementing these classic instruments, initiatives have been developed to promote collaboration in specific areas; examples are the Committee on European Integration and the Young Minds Project. Promoting physics research, physics education, and public awareness of physics have invariably remained at the heart of our mission. A short editorial cannot pay tribute to 50 years of EPS history; therefore, in this and the following issue of EPN, eminent authors have joined forces to retrace the most significant aspects of our Society's history and achievements in a series of individual articles.

A milestone anniversary is a reason to celebrate, and an opportunity to look ahead

A milestone anniversary is not only a reason to look back and to celebrate; equally important, it is an opportunity to look ahead. The political framework in which we do science in Europe has changed dramatically over the past 50 years, mostly for the better. Successive Framework Programmes of the European Union have helped to create a level playing field, and to advance cross-border collaboration and mobility. Still, preserving the cohesion and integrity of our community remains a challenge: research and funding opportunities are still unevenly distributed across Europe, and the Brexit has added a threat of a new kind. In the future, we will need to watch that a robust balance between basic and applied research is not sacrificed to research and innovation policies which are increasingly centred around societal, rather than scientific, challenges.

In line with the EPS Strategy Plan of 2010, last reviewed in 2016, our Society will need to invest in raising its science policy profile, without neglecting the traditional mission and activities of a learned society. This includes continued investments into our point of presence in Brussels. To be a credible actor in the science policy arena who can give reliable advice to policy makers, we need to expand in parallel our evidence base, notably through the framing document "Grand Challenges on the Horizon 2050" (EPN 48-5&6). An important milestone on this way will be the next meeting of the "EPS Forum Physics and Society" planned to be held in Geneva on 29 September. It will follow a birthday ceremony in the afternoon of September 28, in the same *Aula Magna* of the University of Geneva's historic Les Bastions building where our Society was founded fifty years ago. All EPS members are cordially invited to attend and to celebrate "Happy Birthday, EPS"! ■

Rüdiger Voss,
EPS President

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EPS HISTORIC SITES

Les Bastions

Geneva University, Switzerland

The EPS Historic Sites Award commemorates places in Europe important for the development and the history of physics. This initiative is a genuine success: until May 2017, 33 places have been distinguished and so many commemorative plaques inaugurated.

On 29 March 2017, the building Les Bastions of the University of Geneva hosted the unveiling of its Historic Sites plate celebrating the activity of two distinguished Genevan professors, Ch.-E. Guye and E. C. G. Stueckelberg. The ceremony was a success: University officials, SPS and EPS boards members, together with some noteworthy guests (most of them Stueckelberg's former students, collaborators or just admirers), happily enjoyed the speeches and admired the plate. Before I describe the respective achievements of the two Genevan scholars and how they shaped local physics, let me briefly comment on the Bastions building itself. Indeed, it is intimately related to the history of the University and, since its erection until the middle of the 20th century, of Geneva physics. In today's perspective this latter fact may come as a surprise, as the Bastions building is mostly known for hosting the activities of the Humanities. But the scientific investigations that made Genevan academic physics famous in the era of relativity and quantum revolutions, all happened in the Bastions premises.

To start with, let us recall that the University of Geneva, in the form we know today, is a rather late creation. It originates from Calvin's Academy founded in 1559 by the protestant leader as an institution aiming at educating future city's elite, preachers, clergymen, lawyers and civil officers. The introduction of science teaching came much later and was established only during the 18th century. In spite of some efforts to expand the university's scope, one had to wait until 1872 and a substantial revision of Geneva's higher education system to see it finally granted the status of full university. For centuries Calvin Academy did not have at its disposal any own premises and one had to wait until the 1870's for the inauguration of the very first building specifically dedicated to academic activities. What is called today the Bastions building, together with its adjacent wings, was started in 1868 in the perspective of transforming the Academy into a University. Achieved four years later it hosted most of the academic activities, and in particular physics. Two wings were added to the central building, one hosting the scientific and naturalistic collections of the City, soon named the Musée académique, and the other one hosting the Library. The physics collections, then called the Cabinet de Physique and consisting essentially of scientific instruments, were moved to the basement of the central building. Its first floor hosted the physics laboratories. These premises proved soon too exiguous and when chemistry moved into a building of its own in 1880, the laboratory of experimental physics took possession of the vacant space in the basement.

Until recently, much of Geneva physics and its organization still reflected the touch given from the 60's on. Therefore the plaque inaugurated last March in Geneva not only honors outstanding scientific achievements with international impact, but also pays a tribute to the local founders of the 20th century physics in Geneva. ■

■ **Jan Lacki**
Geneva University

NEW EDITOR-IN-CHIEF FOR EPJD – PROF. TOMMASO CALARCO

The publishers of European Physical Journal D: Atomic, Molecular, Optical and Plasma Physics are delighted to announce the appointment of a new Editor-in-Chief, Professor Tommaso Calarco of the University of Ulm, Germany.
As Director of the Institute for Complex Quantum Systems and of the Centre for Integrated Quantum Science and Technology at Ulm, Prof Calarco's research interests cover a broad range of topics in quantum and atom optics, quantum control and quantum information, and he is a member of the High-Level Steering Committee for the Quantum Flagship of the EC.

Prof Calarco has recently joined the Editorial Board for EPJD, and will take on the Editor-in-Chief role from January 2018, succeeding Prof Vladimir Buzek, who comes to the end of his five-year term.
EPJD has three Editors-in-Chief, and Prof Calarco joins Prof Andrey Solov'yov (MBN Research Center, Frankfurt am Main) and Prof Holger Kersten (Christian-Albrechts-Universität zu Kiel) who have responsibility for sections in atomic and molecular physics and plasma physics respectively. ■

The world pendulum @São Tomé

Maybe because the pendulum is so hypnotic, the very first contact to modern physics begins with the pendulum differential equations and its approximate solution. As a matter of fact pendulums are the ultimate richness experiment related to its simplicity.

▲ The STP's Minister of Youth and Sports and the Portuguese minister of education visiting the premises hosting the world pendulum - seen in the right side - in the Portuguese secondary school at São Tomé guide by the board of directors prof(as). Manuela Costeira and Eva Carvalho.

But the pendulum is related as well with the Earth's physics geoid as it allows local gravity's measurement. Today, remote controlled laboratories (RCLs) and Internet of Things (IoT) emerge, providing a framework for sharing experimental resources all-over the world. At São Tomé it was installed recently such kind of experiment as part of one over many pendulums in other latitudes. This experiment was sponsored by the European Physical Society (EPS) through the Portuguese Physical Society (SPF) and Instituto Superior Técnico (IST).

The remote controlled laboratories (RCLs) allow the access to experiments which are uncommon or rare in given laboratories. They allow to share in the community those experiments, adding value to the investment and democratizing the access to physics. The effort in RCLs should focus on the deployment of specialized apparatus for unusual, difficult to set up or dangerous to manipulate. Nevertheless, even simple experiments can benefit to be exposed in the internet giving a meaning to learning without borders.

Since 1999, the e-lab RCL at Instituto Superior Técnico, pursuits a continuous development of specific experiments with this philosophy and since 2012 it begun to expand with distributed experiments in other schools or science centres. Nowadays more than twenty experiments have been developed and deployed.

The São Tomé e-lab pendulum was one of such experiments, being installed in September 2017 at the Portuguese school in São Tomé and operational since then for any remote access. It is one element of the "CPLP world pendulum" (CPLP- Comunidade dos Paises de Lingua Portuguesa) and was inspired in Dr. Jodl's design to allow even more world coverage by using similar experiments. As a matter of fact IST does not host any e-lab pendulum as it hosts one from Germany colleagues [http://rcl-munich.informatik.unibw-muenchen.de/]. Conversely the e-lab pendulum is at Lisbon's Planetarium.

First results were in agreement with the theoretical gravity determined by the World Geodetic System (WGS) model, giving 9.78± 0.01 ms^{-2}. But the statistical error can go up to 0.0004 ms^{-2}, allowing the measurements of fluctuations which relates with tides. In conjunction with the other pendulum the WGS model can be fully interpreted and explored as a world experiment, giving to students learning competences not only relative to the universal gravitational attraction force but as well relative to the geoid shape and centripetal force.

But São Tomé has not only the advantage of zero latitude where any Foucault's precession will not occur: being an island in the middle of the ocean almost at constant temperature, the cable length is maintained with no need for cable lengthening compensation!

So, how we detect 1g in 100kg to excel minor changes in local gravity?

Size matters: is just necessary to build a sufficient long pendulum, ceasing to be clinging to the beauty of 1m / 2.00s! If we make a rigorous measurement of the cable and the mass diameter, keeping the resolution bellow half a millimeter, one can measure the local absolute gravimetric field easily with 10^{-3} accuracy and relative fluctuations with 10^{-5}.

Taking the advantage of the project coordinator's presence for the pendulum's installation and being him a Physics' professor, this activity was complemented with a 35h training course for local teachers.

Acknowledgements

The e-lab project has been sponsored by several sources such as FEDER and Pos-Conhecimento (European Union), EIT KIC-InnoEnergy, Fusenet and DGAE-Ministry of Education.

But in the end, *e-lab* is a joint undertake of many people most of them regular students at IST Physics Engineering MsC who voluntary contribute to the e-lab development eventually as an electronic instrumentation's dissertation. Even after a leave of several years they are always available to resend code sources, give advices or identifying potential financial sources. For them the coordinator leaves here a particular recognition and gratitude.

In particular this experiment was and is assisted locally by the teacher André Freitas, developed by Tiago Pereira and the construction being held at Cenfim's workshop. ■

■ **Horácio Fernandes**
Associate Professor to IST and SPF member
■ **Maria Abreu**
LIP researcher and SPF President

The word pendulum project can be visited at:
www.e-lab.tecnico.ulisboa.pt

Highlights from European journals

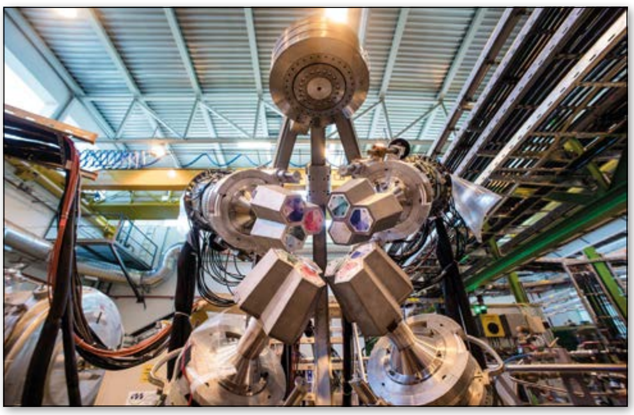
NUCLEAR PHYSICS

Nuclear-structure studies of exotic nuclei with MINIBALL

Investigations of exotic nuclei at the ISOLDE facility of CERN are pursued with reaccelerated radioactive ion beams by means of high-resolution g-ray spectroscopy. The experimental programme covers a range of topics, which are addressed with beams ranging from neutron-rich magnesium isotopes up to heavy radium isotopes. The nuclear-structure and nuclear-reaction studies provide important insights into collective properties and single particle excitations. The most important outcomes of these measurements include: discoveries of rare nuclear shapes like octupole deformation in the actinide region; the coexistence of different intrinsic nuclear shapes at low excitation energy, and within a very narrow energy range in strontium and mercury isotopes, for which nuclear shell model investigations yielded considerable discrepancies from theory when extrapolated from known stable nuclei; and the remarkable behaviour of exotic neutron-rich nuclei with the "magic" number of 20 neutrons and in the vicinity of semi-magic chains of Ni- and Sn isotopes. The article summarized results obtained with the REX-ISOLDE facility which is the precursor of the newly inaugurated HIE-ISOLDE accelerator at CERN. The new installation allows the in-beam spectroscopy programme to be continued with higher secondary-beam intensity, higher beam energy and better beam quality. The first results have been obtained after commissioning of the super-conducting accelerator. ■

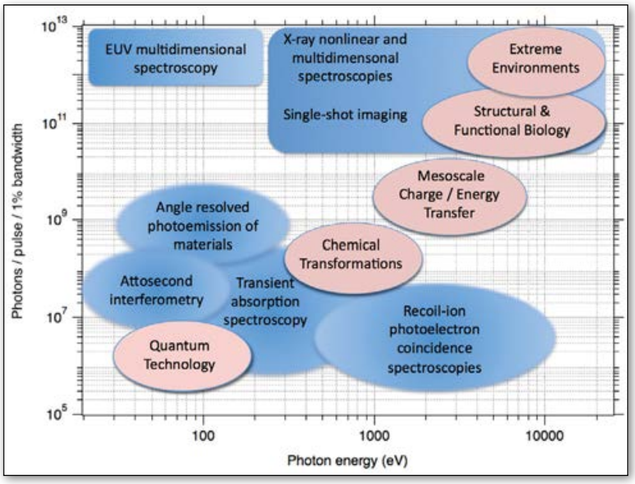
■ **P. A. Butler**, **J. Cederkall** and **P. Reiter**,
'Nuclear-structure studies of exotic nuclei with MINIBALL',
J. Phys. G: Nucl. Part. Phys. **44**, 044012 (2017)

▼ The MINIBALL spectrometer comprises 24 six-fold segmented, encapsulated high-purity germanium crystals. It was specially designed for highest g-ray detection efficiency which is advantageous for low-intensity radioactive ion beams. (picture courtesy CERN)



ATOMIC, MOLECULAR AND OPTICAL PHYSICS

Ultrafast x-rays capture: the electron and nuclear dance



▲ Experimental techniques used in ultrafast x-ray science.

There has been revolutionary progress in producing ultrafast short-wavelength radiation and dreams of visualizing electronic and nuclear motion in complex systems on their natural timescales are rapidly unfolding. Accelerator-driven free-electron-laser sources of ultrafast, ultraintense x-ray pulses that open the door to nonlinear multiphoton x-ray phenomena, though rare (seven worldwide), have basically doubled their operating number in the past year. Laboratory-based ultrafast x-ray pulses based upon high harmonic radiation from infrared lasers, present and affordable at many institutions, have decreased in pulse duration from a longstanding record of 67 attoseconds to 43 attoseconds recently, and, have increased in photon energy to >1 keV.

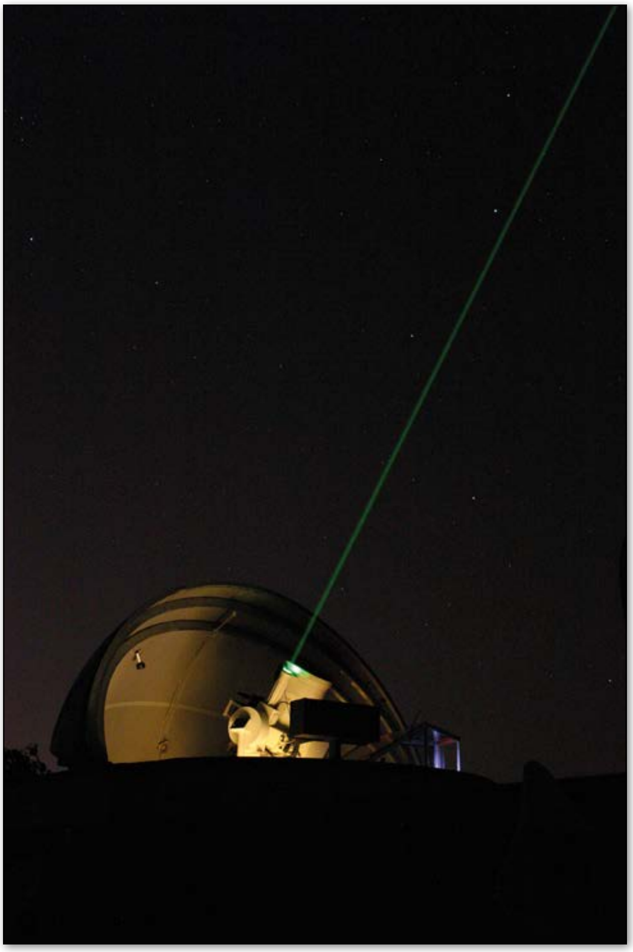
The roadmap presents *independent* perspectives from 17 leading groups on further source developments and their potential impacts on atomic and molecular physics. We start with familiar processes, *i.e.* ultrafast photoexcited molecular dynamics followed with femtosecond x-ray pulses, then discuss phenomena enabled only by intense x-ray pulses from the accelerator-based free-electron-laser sources, *i.e.* multidimensional x-ray spectroscopies, nonlinear scattering and single-shot imaging, and conclude with the attosecond frontier where new source developments enable fundamental understanding of how charge migrates and how electrons are ejected. ■

■ **L. Young** and **26 co-authors**,
'Roadmap of ultrafast x-ray atomic and molecular physics',
J. Phys. B: At. Mol. Opt. Phys. **51**, 032003 (2018)

RELATIVITY

Laser-ranged satellite measurement now accurately reflects **Earth's tidal perturbations**

The most precise ever laser satellite measurement method provides new clues to relativity



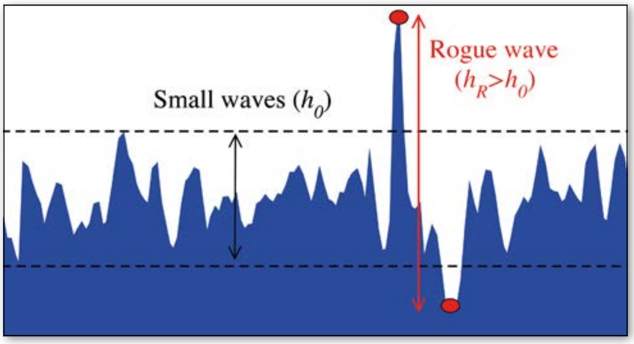
▲ Lustbühel Satellite Laser Tacking. Credit: Jörg Weingrill (CC BY 2.0 [5])

Tides on Earth have a far-reaching influence, including disturbing satellites' measurements by affecting their motion. This disturbance can be studied using a model for the gravitational potential of the Earth, taking into account the fact that Earth's shape is not spherical. The LAser RElativity Satellite (LARES), is the best ever relevant test particle to move in the Earth's gravitational field. In a new study published, LARES proves its efficiency for high-precision probing of General Relativity and fundamental physics. By studying the Earth's tidal perturbations acting on the LARES, the authors demonstrate the value of laser-range satellites for high-precision measurements. ■

■ **V.G. Gurzadyan**, **I. Ciufolini**, **H.G. Khachatryan**, **S. Mirzoyan**, **A. Paolozzi**, and **G. Sindoni**,
'On the Earth's tidal perturbations for the LARES satellite', *Eur. Phys. J. Plus* **132**, 548 (2017)

STATISTICAL PHYSICS

Rogue waves as negative **entropy events**



▲ Illustration of a rogue wave in the Japan Sea.

It is commonly stated that oceanic rogue waves appear from nowhere and quickly disappear without a trace. A new approach to the complexity of wave surfaces could work out a thermodynamic framework to predict rogue waves. Attributing to each wave a local entropy, we find that negative values are closely linked to rogue waves and positive ones to small wave heights. Strikingly, the statistics of these entropy values altogether follow the integral fluctuation theorem. This law is known to hold for microscopic systems, and holds quite surprisingly for our macroscopic wave systems, too. We address the concrete examples of the North Sea, with no rogue waves, and of the Sea of Japan, which include a measured rogue. It is shown how these two sea states can be well distinguished by their entropy statistics. Such a comparison opens the possibility for better predicting the occurrence of rogue waves in specific ocean spots. The whole work is based on a stochastic multi-point approach unfolding a hierarchical order of height fluctuations of the wave surface, which also allow short time forecasting of rogue wave events. ■

■ **A. Hadjihoseini**, **P. G. Lind**, **N. Mori**, **N. P. Hoffmann** and **J. Peinke**,
'Rogue waves and entropy consumption', *EPL* **120**, 30008 (2017)

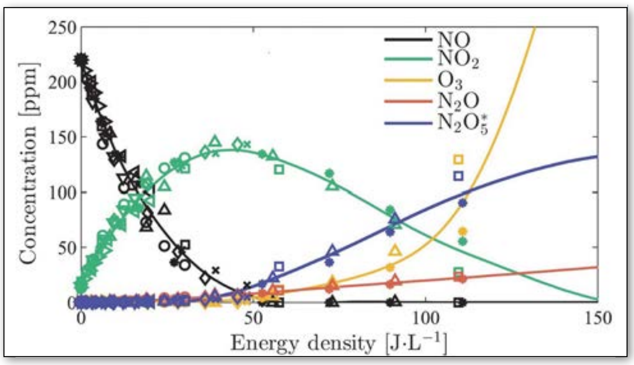
PLASMA PHYSICS

Nanosecond high-voltage pulses for air purification

Transient plasmas generated by high-voltage pulses have been widely studied and used for industrial and environmental applications for more than 100 years. The highly reactive species that are generated in these plasmas can react with particles in polluted gas and water streams. We focus on plasma for environmental applications and developed a new, very fast high-voltage pulse source for this purpose (0.5-10 ns pulse duration, 200 ps rise time and 50 kV amplitude). We showed that with this pulse source, we can achieve extremely high energy yields in ozone generation (typically used for water decontamination) and nitrogen oxide (NO) removal (a typical exhaust gas for diesel engines). Interestingly, the pulse duration, a figure of merit that has long been claimed as the key success in high-yield plasma processing (the shorter the better), had no significant influence on our yields. It appears that the key to these high yields is the very fast rise time of our high-voltage pulses. They are so fast that the complete electric field is applied to the gas while the plasma is still developing, which results in higher electron densities and ultimately in more reactive species. ■

■ **T. Huiskamp**, **W. F. L. M. Hoeben**, **F. J. C. M. Beckers**, **E. J. M. van Heesch** and **A. J. M. Pemen**,
'(Sub)nanosecond transient plasma for atmospheric plasma processing experiments: application to ozone generation and NO removal', *J. Phys. D: Appl. Phys.* **50**, 405201 (2017)

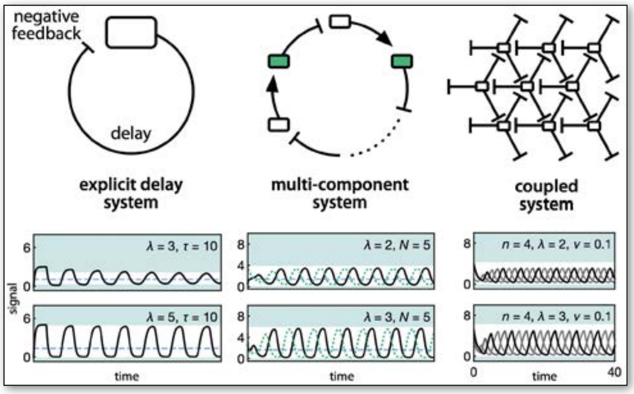
▼ NO removal (and by-product formation) with fast high voltage pulses.



BIOPHYSICS

Biological rhythms— what sets their amplitude?

Living organisms rely on internal biological timers to ensure their proper development and functioning during adult life; examples are the formation of repetitive embryonic patterns or the entrainment of activity cycles to the day-night cycle. Such timers are typically embodied as biochemical oscillators, *i.e.*, genetic regulatory networks that generate oscillations in the concentration of gene products within cells via a delayed negative feedback. Theoretical descriptions of these oscillators often rely on nonlinear rate equations that describe how the interactions between different gene products can give rise to stable limit-cycle oscillations. For a large class of such models, we here derive a method to construct analytical bounds for the minima and maxima of the oscillations, one of their functional key features besides their period. Numerical simulations of different example systems show that the oscillations saturate the bounds as the feedback delay becomes large. The results shed



▲ Analytical amplitude bounds constrain the oscillation minima and maxima for different types of biochemical oscillator systems.

light on which details of the nonlinear feedback are responsible for constraining the oscillation amplitude and can be readily generalised to similar oscillator systems. ■

■ **D. J. Jörg**,
'Amplitude bounds for biochemical oscillators',
EPL **119**, 58004 (2017)

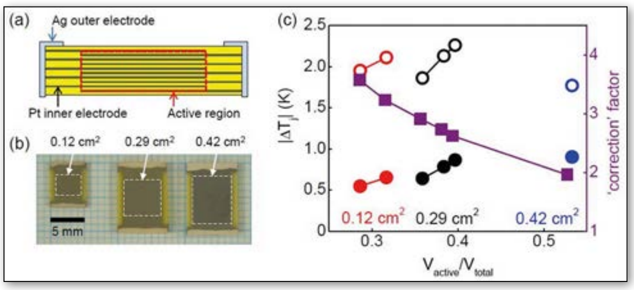
APPLIED PHYSICS

Quantifying electrocaloric effects **in multilayer capacitors**

Multilayer capacitors (MLCs) are now being exploited in prototype cooling devices because they show large voltage-driven changes of temperature that can be used to pump large amounts of heat. However, accurate quantification of these electrically driven temperature changes is challenging because only the core is electrocalorically active.

In a recent study, the authors investigated electrocaloric MLCs with different geometries. By increasing the active volume of the core with respect to the inactive surround, the authors were able to identify the temperature changes that could be driven in the core without thermalization due to the surround. This improves upon previous works, in which partial

▼ (a) Schematic cross-section of an MLC. (b) Photograph of three MLCs based on $0.9Pb(Mg_{1/3}Nb_{2/3})O_3–0.1PbTiO_3$, with active area per layer of 0.12, 0.29 and 0.42 cm^2 within dashed lines. (c) Temperature change $|\Delta T_j|$ measured directly using a thermocouple (solid circles) versus the ratio of active volume V_{active} to total volume V_{total}. Multiplying by the 'correction' factor (solid squares) that would have been hitherto assumed elsewhere overestimates $|\Delta T_j|$ (open circles).



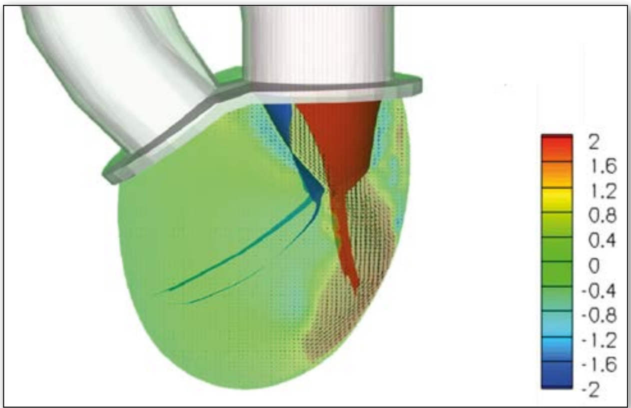
thermalization was assumed to be complete, leading to overestimates of temperature change.on of such melts, connected to the relative weight of their components. ■

T. Usui, **S. Hirose**, **A. Ando**, **S. Crossley**, **B. Nair**, **X. Moya**, and **N. D. Mathur**,
'Effect of inactive volume on thermocouple measurements of electrocaloric temperature change in multilayer capacitors of $0.9Pb(Mg_{1/3}Nb_{2/3})O_3–0.1PbTiO_3$', *J. Phys. D: Appl. Phys.* **50**, 424002 (2017).

BIOPHYSICS

The unsuspected synergistic mechanism of the human heart

3D simulations reveals that every part of the human heart works in combination with the others, while all parts influence each other's dynamics, giving clues to help prevent cardiac conditions



▲ 3D simulations of the heart mechanisms.

Did you know that the left side of the heart is the most vulnerable to cardiac problems? Particularly the left ventricle, which has to withstand intense pressure differences, is under the greatest strain. As a result, people often suffer from valve failure or impairment of the myocardium. This is why it is important to fully understand how the blood flow within this part of the heart affects its workings. In a new study the authors introduce a novel model that examines, for the first time with this approach, the mutual interaction of the blood flow with the individual components of the heart. Their work stands out by offering a more holistic and accurate picture of the dynamics of blow flow in the left ventricle. Until now, most cardiac models have considered separate components of the heart, either the ventricle or the mitral valve. But they have never approached the whole combination as a synergistic system. Another key shortcoming of previous models was their failure to take into account either the interaction between the blood and the heart structure, which can lead to deformation of the heart, or the structure of the heart chambers under the load of the passing blood flow. The authors also perform some experimental validations of their model. ■

V. Meschini, **M. D. de Tullio** and **R. Verzicco**,
'Effects of mitral chordae tendineae on the flow in the left heart ventricle', *Eur. Phys. J. E* **41**, 11634 (2018).

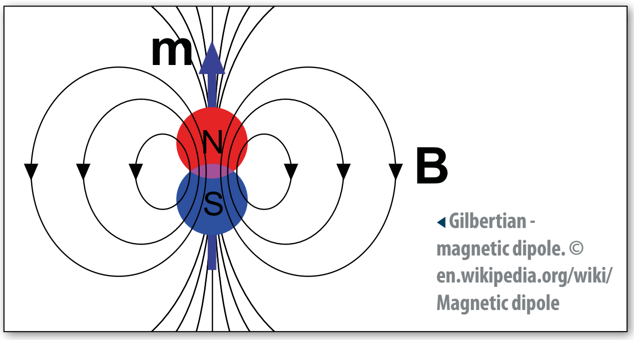
RELATIVITY

Relativity Matters: Two opposing views of the magnetic force reconciled

How magnetic force acts on charged subatomic particles near the speed of light

Current textbooks often refer to the Lorentz-Maxwell force governed by the electric charge. But they rarely refer to the extension of that theory required to explain the magnetic force on a point particle. For elementary particles, such as muons or neutrinos, the magnetic force applied to such charges is unique and immutable. However, unlike the electric charge, the magnetic force strength is not quantised. For the magnetic force to act on them, the magnetic field has to be inhomogeneous. Hence this force is more difficult to understand in the context of particles whose speed is near the speed of light. Moreover, our understanding of how a point-particle carrying a charge moves in presence of an inhomogeneous magnetic field relied until now on two theories that were believed to differ. The first stems from William Gilbert's study of elementary magnetism in 16th century, while the second relies on André-Marie Ampère electric currents. In a new study just published, the authors succeeded in resolving this ambiguity between Amperian and Gilbertian forms of magnetic force. Their solution makes it possible to characterise the interaction of particles whose speed is close to the speed of light in the presence of inhomogeneous electromagnetic fields. ■

J. Rafelski, **M. Formanek**, and **A. Steinmetz**
'Relativistic Dynamics of Point Magnetic Moment', *Eur. Phys. J. C* **78**, 6 (2018)



◄ Gilbertian - magnetic dipole. © en.wikipedia.org/wiki/Magnetic dipole

Interview with Prof. Jean-Pierre Bourguignon, President of the European Research Council

The European Research Council (ERC), set up by the European Union has celebrated its tenth anniversary last year, is the first European funding organisation for excellent frontier research. Every year, the ERC selects and funds the most creative researchers of any nationality and age, to run ambitious projects based in Europe. The ERC is led by an independent governing body, the Scientific Council, composed of 22 renowned scientists and chaired by ERC President Professor Jean-Pierre Bourguignon.

He took office in January 2014 and his mandate has been extended for two years until the end of 2019 [1]. We have asked Prof. Bourguignon to give an interview to the EPN. Our questions are motivated by suggestions of renowned physicists, who have experience in applying and winning ERC grants [2].

1. The ERC has now 10 years of existence, what is your assessment on this funding scheme?

Since its conception in 2007, the impact of the ERC has surpassed the expectations. This is thanks to the support it received from the scientific community, which delivered excellent peer review evaluators, and the dedication of the ERC Scientific Council members, as well as the very professional service provided by the ERC Executive Agency staff. We should never forget that this enterprise was initiated by the scientific community, and that it was created after a long struggle which involved a number of scientists and some forward-looking politicians, such as José Mariano Gago and Philippe Busquin, to name but a few. It was created on the basis of a strict bottom-up approach, the selection being focused on scientific quality alone. The goal was to provide long-term support to ambitious projects submitted by researchers at their own initiative, without filtering applications through any policy priority whatsoever.

Ten years down the road, the ERC has funded nearly 8 000 leading researchers across Europe, pursuing their most creative scientific ideas. Almost 6 000 of all grantees are less than 40 years of age, and more than 50 000 researchers have been financed by the ERC as team members, many of them post-doctoral or doctoral fellows. This shows the decisive impact that the ERC has had and has on empowering the next generation of researchers. It also proves that, when Europe offers a high-level competitive environment, it can be very attractive to the most promising young researchers, European and non-European; almost one third of ERC team members indeed come from outside Europe.

Moreover, research funded by the ERC has set an inspirational target for frontier science across Europe, and here the highly regarded peer review evaluators working in ERC panels make the difference. The evaluation of proposed projects is performed by renowned researchers from all over the globe. The ERC's assessment procedure is very carefully designed, and several funding organisations in Europe have adopted it as a model. As a result, after just eleven years, getting an ERC grant has become a recognised sign of quality. Usually, something like this takes several decades to achieve.

Demand is very high; the success rate in ERC competitions has been around 10%, with an improvement to an average 12% in recent years. This makes the calls extremely challenging. A string of countries have already established national schemes to fund candidates who have been positively evaluated by the ERC, but could not be supported due to ERC's budgetary constraints. This is a strong vote of confidence for the ERC's demanding peer review evaluation system – it is already highly trusted. What's more, this puts the spotlight on the wealth of talent and convincing projects that can be supported in Europe. The ERC needs more means in order to stimulate more high-level research and help to curb brain-drain from our continent. This is why the ERC Scientific Council proposed a 15% success rate as a key argument to justify the need for a larger budget in its position paper on the next EU R&I Framework Programme (FP9).

This increase is in no way to be taken for granted, so we need to speak up for science - these days more than ever. The key need to

European Research Council

Established by the European Commission

invest in frontier research often gets forgotten or is at least given a low priority. It is time for scientists to clearly explain the added value of frontier research in order to be credible advocates for increased funding at both European and national level. Discuss with your fellow scientists, but above all speak to policy-makers and political personalities, and engage with the media to get this important message across.

2. Could you explain to us the evaluation process?

For all ERC grant schemes, scientific quality is the sole criterion of evaluation. What is also crucial is the ambition of the project, ideally ground-breaking if successful. The capacity, creativity and commitment of the applicant are considered in order to check the feasibility of the project.

ERC core grants schemes follow a two-step evaluation procedure, whereas there is a third step for the new ERC Synergy grants. Once the evaluation of proposals has been completed, applicants receive an evaluation report, which includes all reports submitted to the panel and the overall opinion of the panel.

A number of universities and research organisations help the applicants with feedback on their application. However, I keep hearing panel members expressing their frustration to read proposals whose scientific content is not what they expect. This is why employing professional writers for drafting the proposals is surely not the optimal strategy. My personal advice for applicants would be to be confident, ambitious and reserve sufficient time to prepare their proposal to optimally transmit their enthusiasm for their ideas. Panel members are looking for novel ideas, which could lead to truly ground-breaking science.

The responsibility of defining and implementing the peer review evaluation lies with the ERC's governing body - its Scientific Council. It is indeed the 22 Scientific Council members who select the panel members and give the guiding principles throughout the evaluation. Still it never interferes with the panel decisions. In the second step, remote referees are chosen by the panel members to get the most expert opinion on the proposals already selected for further scrutiny.

3. What do you see as the major challenges facing the ERC in the next few years?

One of the things that the ERC has achieved is to make the case for 'blue sky research' at the European Commission level and the value of a bottom-up approach to research. This has to be done even better and at a broader scale, and for this the scientific committee has to mobilise itself at this critical moment of preparation of the next framework programme. The opportunity must not be missed.

An obvious challenge for the ERC is to keep its world-leading position. We must continue to convince some of the best researchers in the world to submit their most ambitious projects and to join ERC panels and evaluate proposals – it is important for scientists to be encouraged to do so.

It goes without saying that the ERC is not immune to the problems that the scientific community in Europe are facing, such as fostering a healthy gender balance across all disciplines. Overall the gender balance slowly improves with time, but very slowly. Among younger researchers the percentage of women is getting closer to 40%. The ERC was very proud that in 2017, for the first time, the percentage of women Starting grantees was over 40%. A number of measures have been put in place at the initiative of the Scientific Council to deal with practical issues known to make the situation of women scientists more difficult. In ERC calls, the situation has been improving over the last years. This was of course achieved without departing for the commitment to have quality as sole selection criterion.

The ERC is also confronted with quite different levels of support that governments in various countries give to research. This is another reason for concern, namely the low success rates of

applicants based in some countries. This situation has a number of aspects: fewer resources available for research, sometimes less exposure of young people to the international scene, less supportive infrastructures. We will continue to encourage researchers from these countries who tend to be less present in ERC calls. This is why members of the ERC Scientific Council regularly engage with local research communities and national authorities to better understand the obstacles, which can have different facets. It is a fact that countries' performances are closely linked to the level of national spending on research.

In this context it is worth clarifying that the ERC has a very specific mission – funding cutting-edge, risky ideas submitted by researchers. With a budget representing about 1% of the overall research spending in Europe, the ERC can certainly not solve all the problems. It is one component of an eco-system which needs to address different issues; the support for institutions to help them develop at the level of the international competition is evidently one of them. The ERC has been created with the clear ambition to make Europe more attractive, and this requires sticking to the search for the best possible projects. Other EU-supported programmes have the responsibility of covering other objectives. Still, this does not mean that the ERC Scientific Council is not doing its outmost to suggest and implement measures that will contribute to overcome this problematic situation.

4. Are you evaluating the work accomplished thanks to the grants?

The ERC Scientific Council indeed decided to put in place an ex-post evaluation of completed projects and to follow it over time. It is keen to assess what comes out of the ERC funding. The third ex-post study has just been completed, and it seems to confirm what the first two studies found, namely that over 70% of ERC-funded projects led to a breakthrough or a major scientific advance. This is a very remarkable achievement, which goes beyond the most optimistic expectations placed on the ERC.

Another measurable outcome is that over 100 spin-off companies have already come out of ERC projects. A striking figure is also that 29% of patents produced with some support under the previous EU Framework Programme (FP7) came from ERC projects, whilst the ERC budget share was not even 17% of the overall FP7 budget. This shows that researchers are not all, if at all, in the ivory tower that some often evoke when speaking of researchers. Here, the ERC's top-up grant, called Proof of Concept, which the Scientific Council decided to introduce back in 2011, plays a key role in helping ERC grantees on their way to bring their scientific successes closer to the market or to societal needs. Grantees explore the commercial and social potential of ideas arising from their ERC projects appearing along the way, most of the time a development totally unanticipated at the outset. ■

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[2] We thank to Jean-Sebastian Caux, Olli Ikkala, Norbert Kroó, Robin Ras, Luis O. Silva, Marc Türler and Julia Yeomans for suggesting questions.

SINGLE MOLECULES AND SINGLE NANOPARTICLES AS WINDOWS TO THE NANOSCALE

Martín Caldarola and Michel Orrit – DOI: https://doi.org/10.1051/epn/2018201
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Since the first optical detection of single molecules, they have been used as nanometer-sized optical sensors to explore the physical properties of materials and light-matter interaction at the nanoscale. Understanding nanoscale properties of materials is fundamental for the development of new technology that requires precise control of atoms and molecules when the quantum nature of matter cannot be ignored. In the following lines, we illustrate this journey into nanoscience with some experiments from our group.

General background

According to Richard Feynman, the single most important insight science brought us is that "matter is made of atoms". Throughout the 20th century, we have grown accustomed to more and more direct atomic and molecular manifestations, starting with Brownian motion and X-ray diffraction, and eventually ending with electron micrographs showing single atoms and molecules, or scanning tunneling microscopy images, which routinely allow us to 'feel' individual atoms and molecules on solid surfaces in an immediate way. But what about 'seeing' atoms and molecules with light? This century-old dream was born with fluorescence experiments by Jean Perrin [1] around 1910, but only came true in the 1970s with attenuated atomic beams and later with single trapped ions in ultrahigh vacuum. For molecules in condensed matter, the limit of optical single-molecule detection was reached only in the late 1980s, essentially because of two technical problems: background emission from the molecule's surroundings and limited total number of fluorescence photons for each molecule because of bleaching, *i.e.*, photo-induced degradation of the emitter. Both problems were solved by cryogenic experiments at liquid-helium temperatures, through resonant absorption cross sections and thanks to the excellent photostability of molecules held in a rigid cage. These cryogenic experiments gave rise to many striking observations in nanophysics and quantum optics. However, single-molecule optics only turned into a real revolution with ambient conditions. The loss of a factor 100,000 in cross section upon warming from liquid-helium to room temperature is compensated by an equivalent improvement in optical quality and selectivity by the diffraction-limited spots of modern microscopes. Thanks to objective lenses with large numerical apertures, single-molecule techniques became readily applicable in material science and biology.

A typical single-molecule fluorescence experiment at room temperature requires a confocal microscope, laser excitation of a small, diffraction-limited volume of some hundreds of nm in size, and a photon-counting detection of the Stokes-shifted fluorescence emitted by the excited spot, often collected by the excitation objective lens. The Stokes shift allows for easy and efficient spectral filtering of the signal. Critical points for a high signal-to-background ratio are a tiny (diffraction-limited) excitation volume, clean samples and optics, and a high stability of setup, laser, and sample. With this basic setup, a large number of time- and space- resolved experiments can be conducted on nanometer scales. In this article, we would like to share our enthusiasm for the novel physics that the signals of single molecules have opened and illustrate them with some work from our group.

> **Single-molecule experiments are superb testing grounds for quantum optics and nanoscience**

Single molecules as single-photon sources and nanoprobes

Cryogenic single-molecule experiments are superb testing grounds for quantum optics and for nanoscience. A single molecule's emission on its lifetime-limited zero-phonon line (a purely electronic molecular transition with no phonons involved) provides indistinguishable photons one at a time, in a so-called Fock state of the electromagnetic field, *i.e.* a state with a well-defined number of photons. These states can be used to perform fundamental tests on quantum mechanics, as done in the group of R. Hanson [2]. Moreover, single molecules can be used to probe the local properties of the surrounding material, since they are extremely small and highly sensitive to their nano-environment. For example, one may exploit the high sensitivity of a single-molecule spectral line to its environment to detect a mechanical deformation of the crystal embedding the molecule [3]. In a recently started project, we are trying to detect single charges in a metal island through the Stark effect, *i.e.*, the shift of the molecule's transition by the charge's electric field. This optical access to charge would be complementary to standard current measurements and will give researchers new insight into the workings of electronic components, and help them design new methods for information storage and transfer.

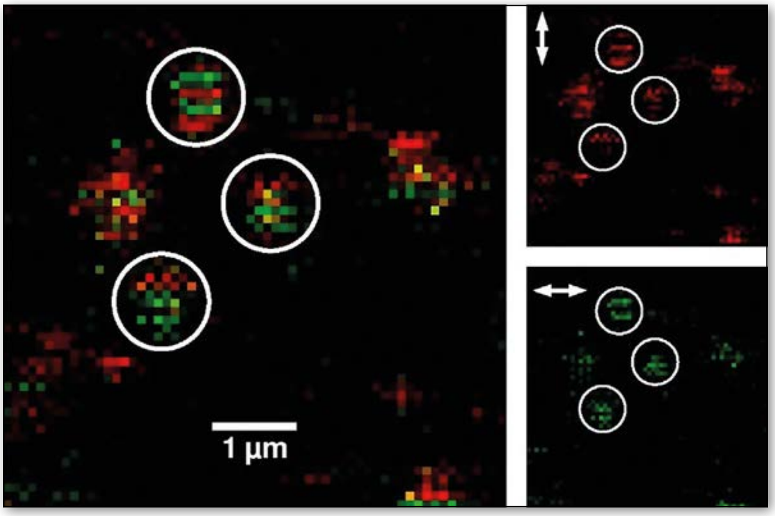
Molecular fluorescence is generally polarized along one of the molecular axes. By following this polarization as a function of time for individual molecules, one can explore the rotational diffusion of the molecules, and thereby the local rheological properties of their environment at nanometer scales. We have studied this rotational diffusion in a molecular glass former, glycerol, whose viscosity increases by more than 10 orders of magnitude between room temperature and the glass transition, at about 200 K. The first unexpected result was that single dye molecules at different positions in the material, although chemically identical, were tumbling at widely different rates. These differences reveal changes in local viscosity, which must be related to changes in local structure. A second surprise was that for samples kept a long time at low temperature, the viscosity fluctuations did not relax even over days or longer, whereas the molecular relaxation times were on the order of seconds [4]. Figure 1 shows examples of confocal images of single molecules in a glass matrix, where the polarization of the emitted light is split to infer the molecular rotation dynamics of the molecules. More recent work with larger particles, gold nanorods, has confirmed this dynamical heterogeneity on even larger length and time scales. The picture of a glass former conveyed by single molecules is that of a strongly disordered medium, in which local density fluctuations lead to large fluctuations of viscosity. Due to the large viscosity, these heterogeneities cannot relax on the time scale of the experiments, leading to very long memory times of the viscosity fluctuations.

The latter two examples illustrate how optically detected single molecules can be used to extract local information about a medium at nanometer scales. Consistently, observations at molecular scales unveil a surprisingly large heterogeneity and much larger disorder than was expected from conventional ensemble experiments.

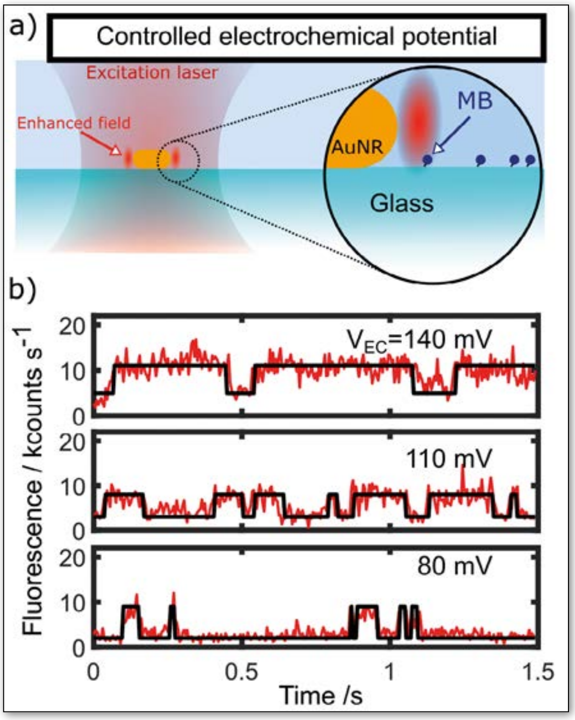
Plasmonics: single-molecule sensing and enhanced light-matter interactions

Small metal nanoparticles (smaller than 100 nm) present a very strong optical mode called plasmon, in which conduction electrons oscillate collectively around the heavy, nearly immobile ions. This mode, which is responsible for the specific optical properties and for the strong colors of metal suspensions in water, can be tuned by changing the aspect ratio of the particles during synthesis. For example, gold nanorods can be synthetized with aspect ratios ranging between 1 (spheres, plasmon at 530 nm) and 5 or longer (rods, plasmons at 900 nm or longer). The large surface charge densities developed in plasmon oscillations lead, via Gauss' theorem, to highly localized oscillating electric fields, which are much higher than the field of the incoming excitation wave. Moreover, the field is extremely confined in a tiny volume around the tips of the particle. This enhanced and highly localized field can be useful for many applications of light-matter interactions, and we have explored two examples with gold nanorods: plasmonic sensing of non-absorbing protein molecules and single-molecule fluorescence enhancement. The former example is based on the detection of the plasmon spectral shift due to the binding of a single protein, some nanometers in size, at the tip of a nanorod [5]. The latter one relies on the enhanced excitation of a fluorescent molecule diffusing or fixed near the tip of the nanorod. In addition to the excitation enhancement (which can be as high as 300 for a gold nanorod), the emission of the dye is enhanced because the gold nanoparticle acts as a resonant antenna, improving the coupling of the molecular dipole with the propagating optical wave, leading to an increase by about 10 times in the emission. In this way, the fluorescence intensity of a molecule in the near field can be enhanced more than 1,000 times compared to the emission of the same molecule away from the gold nanorod [6].

Recently we took the next step in fluorescence enhancement and used it to tackle another problem: study a single molecule's electrochemical properties optically [7]. We successfully combined the electrochemical control of the oxidation state of a redox sensitive dye, methylene blue (MB), with an enhanced-fluorescence readout. This dye has the interesting property of being absorbing but



▲ **FIG. 1: Single molecules as probes for local rheological properties.** (left) Single PDI molecules in glycerol at a temperature of 209.6 K. The red and green images correspond to the two orthogonal polarization channels, shown separately on the right. Extracted from [4].



▸ **FIG. 2:** Enhanced fluorescence for single-molecule electrochemistry. **(a)** Scheme of the experimental configuration to detect single methylene blue (MB) molecules. We placed one molecule in the enhanced field near the tip of a gold nanorod (AuNR) immobilized on a glass substrate. We put this slide on our confocal microscope to detect the emitted fluorescence photons. **(b)** Enhanced-fluorescence time traces from the same MB molecule at different electrochemical potentials, showing a clear change on the blinking times with the potential V_{EC}. After Ref. [7].

weakly fluorescent in the oxidized state and non-absorbing in the reduced state. Thus, it can be used as a redox indicator. The main limitation for this application is the dye's very low fluorescence quantum yield. However, we overcame this limitation by enhancing the fluorescence with a gold nanorod, thus reaching single-molecule sensitivity. Figure 2 a) shows the schematic representation of the experiment where we externally control the electrochemical potential and simultaneously detect MB molecules optically. Figure 2 b) shows the enhanced-fluorescence time trace of the same single MB molecule at different electrochemical conditions. These plots demonstrate that the blinking cycles are redox-induced, and provide the mid-point potential of the molecule.

The mentioned examples show how metallic nanoparticles can be used as bridges between molecular sizes and the optical wavelength. By enhancing light-matter interaction, plasmonics enable the detection of biological species and reveal their chemical properties at the single-molecule level.

Magnetic properties of gold nanorods

Nanoparticles can be also used as nanoprobes to gain knowledge about the properties of matter at the nanoscale. Although metal nanoparticles have been studied extensively, they still present some intriguing properties that require detailed investigation. Studies of single particles would provide a better understanding of the physical mechanisms involved. In the course of our work on gold nanorods, we have explored their magnetic properties in the high-field magnet in Nijmegen [8]. Surprisingly, the nanorods showed preferential orientation along the magnetic field, much more so than was expected from the diamagnetic susceptibility of bulk gold metal. The observed orientation was consistent with giant magnetic dipole moments induced in the metal nanorod by the change of magnetic field. These currents do not relax, as the dimensions of the rods are much less than the mean free path of electrons in the metal. In the future, we plan experiments on single rods, in which theory predicts large variations of the amplitude of these persistent currents. These experiments would test the presence and strength of this intriguing effect in structures different from the metal loops investigated earlier by atomic force microscopy [9].

> **Resonant metallic nanoparticles can be used to bridge molecular sizes with optical wavelengths to enhance light-matter interactions and allow optical detection of single molecules**

Explosive dynamics of vapor nanobubbles

Our recent study of nanobubble formation is another example of complex physics that can be accessed with single nanoparticles. Excitation of plasmons leads to currents in the metal and therefore to Joule dissipation. Thus, metallic nanoparticles have been extensively used as nanoheaters for different applications, including photothermal cancer therapy. The temperature increase can be several hundreds of degrees and thus it can be used to bring a liquid surrounding the particle to boiling. We try to understand how this nanoscale boiling differs from the one we are familiar with at macroscopic scales. One of the differences is due to surface tension because the bubble is very small (the gas in a 100-nm-radius bubble has a pressure of about 10 atm). We find that the liquid can become superheated, leading to explosive boiling. This is a violent phenomenon, taking place in some tens of nanoseconds at 100-nanometer scales, which is accompanied by the release of sound waves. These waves can reflect on nearby interfaces and further interfere with the transient bubble [10]. Figure 3 a) shows the schematic design of our experiment for nanobubble generation and detection, while Figure 3 (b, c) presents measurements of the explosive behaviour of the system. We assign the observed quasi-periodic bubble explosions to relaxation oscillations of this highly nonlinear system, where optical energy is first stored in hot water layers close to the particle, before being released in a bubble explosion. On the one hand there are possible applications for the emitted sound waves, for example to kill cancer cells, on the other hand, it is intriguing to explore phase transitions on smaller and smaller scales, eventually testing the validity of the thermodynamic limit.

Conclusion

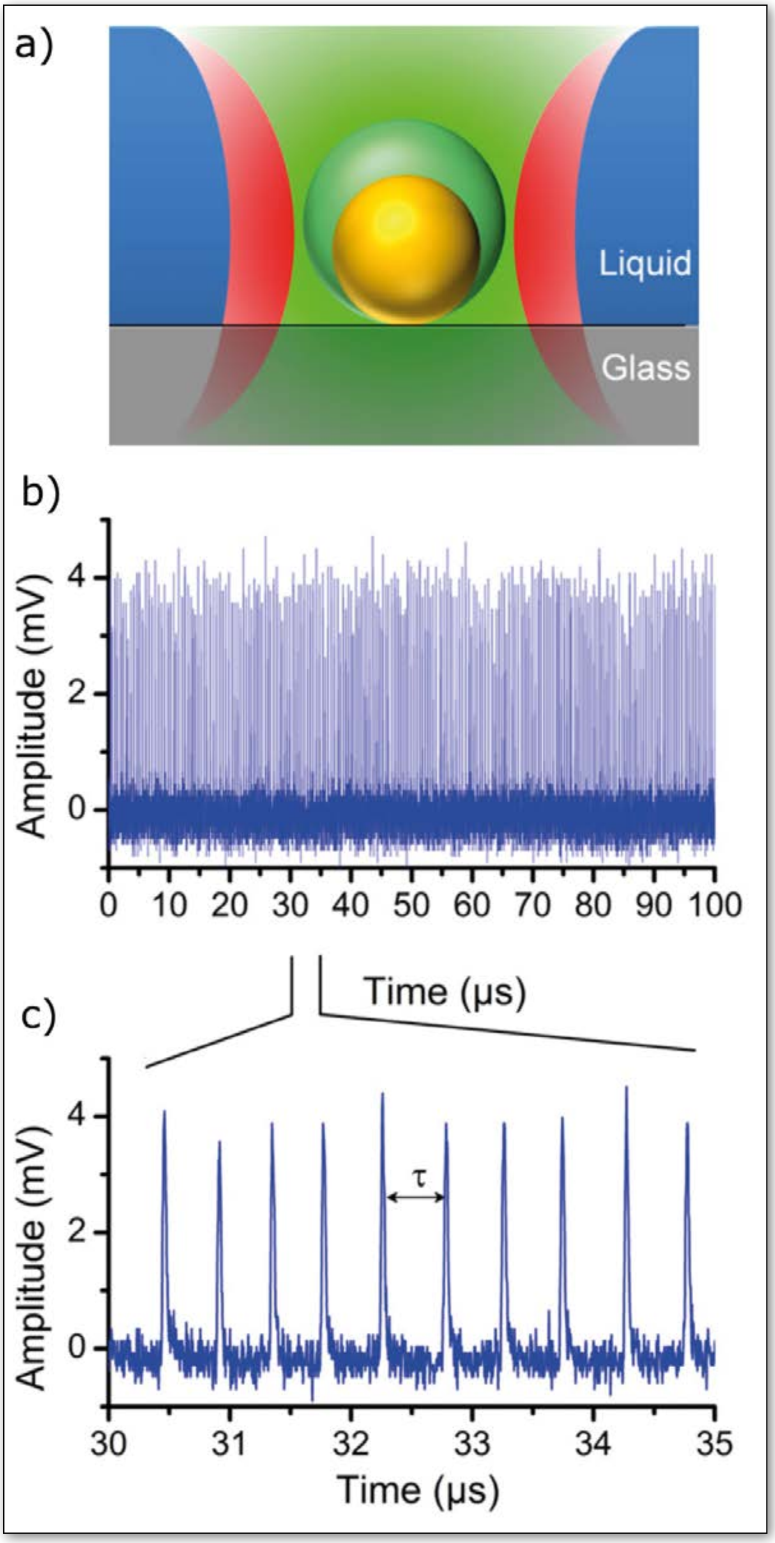
The optical detection of single molecules and single nanoparticles opens up nearly non-invasive exploration of matter at nanometer scales. In this sense, we can say that those experiments open windows to the nanometer scale. Most experiments on single molecules and single nanoparticles reveal unexpected variety and heterogeneity in the physical and chemical properties of matter at the smallest scale, which up to now had been hidden in ensemble experiments. Such exquisite sensitivity is all-important for complex and heterogeneous systems, particularly biological ones. The development of embryos or tumors dramatically demonstrates how determining tiny numbers of molecules can be for the ultimate fate of a whole living organism. ■

About the Authors

Martin Caldarola is a postdoctoral researcher at the Single-Molecule Optics group at Leiden University. He holds a PhD in physics from the University of Buenos Aires and his expertise is in the field of nanophotonics. His research interests include light-matter interactions, specifically the interaction between single molecules and nanostructures.

Michel Orrit's scientific field is the interaction of light with organic molecules in dense matter. His scientific breakthrough was the first observation of a single molecule using fluorescence. Orrit moved to Leiden in 2001, where his group applies single-molecule spectroscopy to molecular photophysics, solid-state dynamics, and nonlinear optics. His current interests include gold nanoparticles and molecules as nano-probes of structure and dynamics of soft condensed matter.

“We can think of single molecules as windows to the nanoscale. Using their exquisite sensitivity to the local environment, we can unravel the mysteries of matter in the nanoscale”



▲ **FIG. 3:** Nanobubble generation. **(a)** Scheme of the setup to create and probe nanobubbles. We use a focused green laser beam to heat the particle and a red one to detect the bubble. **(b)** Time trace of the scattered red light showing explosive events at the sub-microsecond time scale. **(c)** zoom of the time trace showing the quasi-periodicity of bubble formation. From Ref. [10].

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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: H. Ferdinande, K. Grandin, M. Huber, H. Kubbinga, D.Lee, P. Melville, C. Rossel and R. Voss.

1968 THE FOUNDATION OF EPS

The origins of the European Physical Society date back to Italian Physical Society's Annual Conference in Bologna in November 1965. Gilberto Bernardini, Rector of the Scuola Normale Superiore di Pisa persuaded his colleagues of the benefits of such an organization. As a result a meeting called in Pisa on 16–17 April 1966 with Bernardini in the chair brought together about 100 physicists from all over Europe. There was an enthusiastic address by Sybren de Groot (Amsterdam), and the meeting unanimously approved the resolution 'The meeting is strongly of the opinion that steps should be taken towards the foundation of a European Physical Society'. A Working group for further action was set up and subsequently known as the Steering Committee.

The Steering Committee called a meeting of its members and representatives of National Physical Societies at CERN on 25 November 1966, with Bernard Gregory (Director-General of CERN) in the chair. Alternative structures were proposed – a completely new society based on individual membership, or a federation of existing national bodies. No solution was found until the Steering Committee met again in London on 16 May 1967 at the Institute of Physics and the Physical Society (IPPS), presided by Sir James Taylor (president of IPPS). A compromise agreement was reached that membership would be based on both individual membership and collective membership of National Societies, and that laboratories could also become members. It was also proposed that English be the working language of the Society. It was agreed that the Society be founded at an inaugural conference in Florence in autumn 1968.

The Steering Committee next met on 30 January 1968 in Geneva at the Institut Battelle, with H Thiemann (Director-General of the Institute) presiding. It was agreed that there was not enough time to arrange the Florence Conference for autumn that year, and that instead the society would be legally founded in Geneva in September 1968, with Geneva as the official seat.

The next meeting of the Steering Committee was held at the Univerzita Karlova in Prague on 3-4 May 1968 because of the importance of involving both Eastern and Western Europe. Eastern Europe had been poorly represented at previous Steering Committee meetings, but behind the scenes the Czechoslovak Academy of Sciences managed to ensure that there was good representation, only Bulgaria was not represented. The Soviet Union had been against participation but agreed for the sake of unity in the Eastern Bloc. It was decided to establish a branch secretariat in Prague to facilitate financial transaction between Eastern European countries. The legal foundation for the Society was fixed for 26 September in Geneva. However, Soviet tanks rolled into Czechoslovakia on 21 August, and there were grave personal and political difficulties for those Czechoslovaks citizens like František Janouch, who had been involved in the establishment of EPS. These political events precipitated an emergency meeting of the Steering Committee on 12 September at CERN, but it was decided in the interests of Europe in the future to go ahead as planned.

▲ G. Bernardini at the EPS Inaugural Meeting

And so, on 26 September 1968 the European Physical Society was formally founded at a constitutive assembly at CERN in the morning and later that same day a foundation ceremony took place in the Aula Magna at the Geneva University. Gilberto Bernardini became the first president of the EPS. The secretariat, organised by Lorette Etienne-Amberg, who had played a crucial role during the previous negotiations, was set up first at CERN and then moved to the Institut Battelle, subsequently to Petit-Lancy, a suburb of Geneva, before eventually being moved to Mulhouse. A branch secretariat was established at the Czechoslovak Academy of Sciences in Prague and remained there until 1973. The EPS logo, designed by the Czechoslovak Physical Society, remains in use 50 years on.

What had been envisaged as the inaugural conference became the first of the triennial conferences on Trends in Physics, held in Florence on 8–12 April 1969 and included the first General Meeting of the Society. This meeting was particularly successful in bringing together many young physicists, which might account for the future success of the EPS.

Looking back at what made the EPS come into life, some points need to be emphasised. The importance of CERN in the establishment of the EPS cannot be overstated, both as an experience of international cooperation in Europe and as an existing infrastructure for the newborn society. In his talk at the inauguration Bernardini stressed this and two other important issues that had fuelled the project: one related to the existing and future international laboratories in Europe and the second one to the many physics journals in Europe. Coordination was needed to improve these issues. Another important aspect of the need for strengthening the European collaboration, was to counter the brain drain from Europe to the USA. Bernardini mentioned also that it was crucial to secure the active participation of the Eastern European countries. He ended his talk with the belief that the foundation of the EPS was a 'demonstration of the determination of scientists to collaborate as closely as possible with a view to making their positive contribution to strengthen European cultural unity'.

Since its inception the EPS has been confronted with organisational or institutional questions such as the role of individual membership versus national member societies. Many of the above-mentioned issues and challenges have been at the centre of EPS attention ever since. ■

Further reading

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DEVELOPMENT OF EPS MEMBER SOCIETIES

From the outset, the EPS knew that to be successful in creating a truly European physics community, it was necessary to include countries from the whole of Europe, and those that could claim strong European roots. Currently the EPS has 42 Member Societies ranging from Iceland to Turkey, and extending to Israel.

EPS Member Societies vary widely in different aspects. First, the number of members ranges from less than 50 (the Association of Physicists in Liechtenstein) to over 60,000 (Deutsche Physikalische Gesellschaft). While all EPS Member Societies engage in the traditional activities of learned societies (the organisation of conferences, public understanding of physics, promotion of physics *etc.*), their priorities and focus will depend on their members and resources. ■

MEMBER SOCIETIES OR ORGANISATIONS LISTED BY THE YEAR THEY ENTERED OR LEFT THE EPS:

1968

- Austrian Physical Society
- Belgian Physical Society
- Swiss Physical Society
- Physical Section of the Union of Mathematicians and Physicists of Czechoslovakia
- Deutsche Physikalische Gesellschaft
- Royal Spanish Physical Society
- Finnish Physical Society
- Société Française de Physique
- Eötvös Loránd (Hungarian) Physical Society
- Irish Physical Society
- Israel Physical Society
- Società Italiana di Fisica
- Netherlands Physical Society
- Romanian Physical Society
- Swedish Physical Society
- Turkish Physical Society
- Academy of Science USSR
- The Institute of Physics (UK)
- Physical Section of the Union of Mathematicians and Physicists and Astronomers of Yugoslavia

1970

- Ampère Group (France)
- Union of Physicists in Bulgaria
- Danish Physical Society
- Norwegian Physical Society
- Sociedade Portuguesa de Fisica
- Institute Ruder Boskovich (Croatia)

1971

- Physical Society of the German Democratic Republic

1972

- Polish Physical Society

1974

- Hellenic Physical Society

1982

- Icelandic Physical Society

1990

- The Physical Society of the German Democratic Republic merged with the Deutsche Physikalische Gesellschaft

1992

- Albanian Physical Society
- Estonian Physical Society
- Croatian Physical Society
- Lithuanian Physical Society
- The Institute Ruder Boskovic is replaced by the Croatian Physical Society

1993

- Armenian Physical Society
- Belarusian Physical Society
- The Physics Section of the Union of the Czech Mathematicians and Physicists
- The Slovak Physical Society
- Physics Section of the Union of Mathematicians and Physicists and Astronomers of Slovenia
- Mathematicians and Physicists of Czechoslovakia ceases to exist

1994

- Society of Physicists of Macedonia
- Ukrainian Physical Society

1995

- Latvian Physical Society

1996

- United Physical Societies of the Russian Federation becomes the Representative from the Russian Federation

2001

- The Ampere Group leaves the EPS

2002

- Georgian Physical Society

2003

- Moldovan Physical Society
- Physical Society of Serbia and Montenegro
- Physical Section of the Union of Mathematicians, Physicists and Astronomers of Yugoslavia ceases to exist

2006

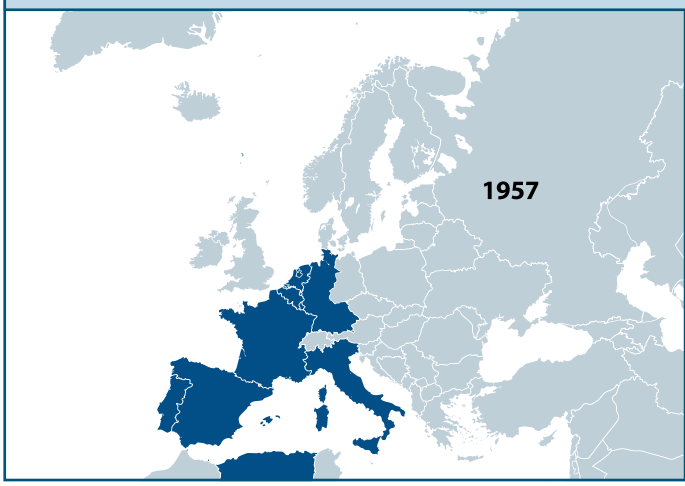
- Liechtenstein Scientific Society
- Physical Society of Montenegro
- Serbian Physical Society
- The Irish Physical Society is now represented by the IOP and leaves the EPS
- The Physical Society of Serbia and Montenegro ceases to exist

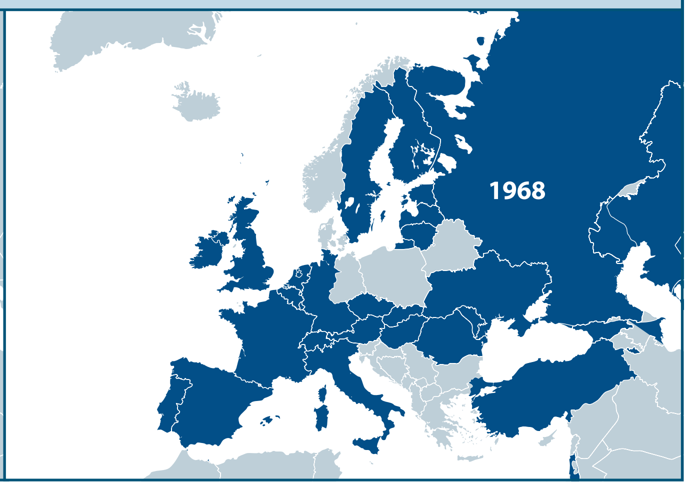
2009

- Association Luxembourgeoise des Physiciens

2013

- Cyprus Society of Physicists





DEVELOPMENT OF DIVISIONS AND GROUPS

Most academic learned societies engage in a set of core activities, which include promotion of their field, defense of their members' interests, publication and sponsorship of journals, and the organisation of conferences to communicate recent advances in their field.

The EPS Divisions and Groups organise many of Europe's leading conferences in physics recognised internationally for the high quality of their program. These conferences were (and many still are) organised through a wholly volunteer effort of the physicists and institutions involved.

EPS Divisions and Groups provide the scientific credibility that supports the European Physical Society in all of its endeavours. Divisions represent specific fields in physics, while Groups are interested in topics, techniques and technology that cut across all fields of physics. Physics research continuously improves our understanding of Nature and the Universe, and the scientific community, like our EPS Divisions and Groups, changes and evolves accordingly. ■

LIST OF THE MAJOR DEVELOPMENTS OF THE EPS DIVISIONS AND GROUPS WITH THE YEAR OF THEIR CREATION, CHANGE OR DISSOLUTION:

1969
- Atomic Spectroscopy Division
- Condensed Matter Division
- Low Temperature Physics Division
- Plasma Physics Division
- Quantum Electronics Division

1970
- High Energy and Particle Physics Division
- Nuclear Physics Division
- Physics and Astronomy Division
- Computational Physics Group

1971
- The Atomic Spectroscopy Division changes its name to Atomic Physics Division

1972
- The Low Temperature Division merges with the Condensed Matter Division
- The Physics and Astronomy Division changes its name to Astronomy and Astrophysics Division

1981
- Optics Division
- The Atomic Physics Division changes its name to Atomic and Molecular Physics Division

1986
- Experimental Physics Control Systems Group
- Physics for Development Group

1989
- Accelerators Group
- History of Physics Group

1991
- The Optics Division is closed (to become the nucleus of the European Optical Society)
- The Quantum Electronics Division changes its name to Quantum Electronics and Optics Division

1992
- The Astronomy and Astrophysics Division joins forces with the European Astronomical Society, offering joint membership and changes its name to Astrophysics Division

1994
- Physics Education Group

1995
- Applied Physics and Physics in Industry Group

1998
- Statistical and Non-linear Physics Division

2000
- The Physics Education Group becomes Physics Education Division
- The Applied Physics and Physics in Industry Group changes its name to Technology and Innovation Group

2002
- Environmental Physics Division
- Physics of Life Sciences Division

2008
- The Atomic and Molecular Physics Division changes its name to Atomic, Molecular and Optical Physics Division

2009
- The Astrophysics Division is closed and where possible, its activities are included in the High Energy and Particle Physics Division
- Energy Group

2010
- European Solar Physics Division

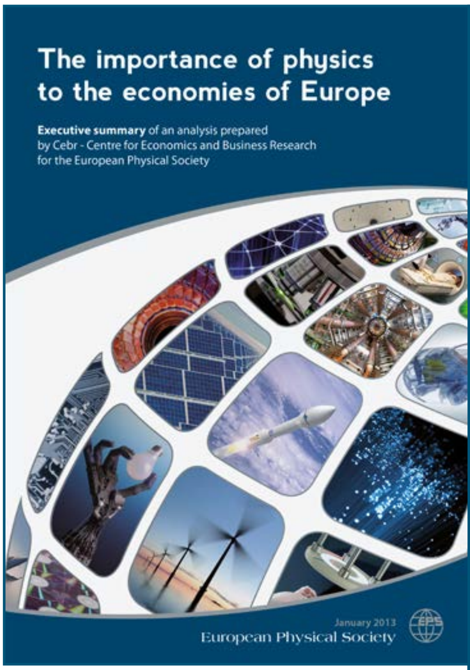
2017
- Gravitational Physics Division

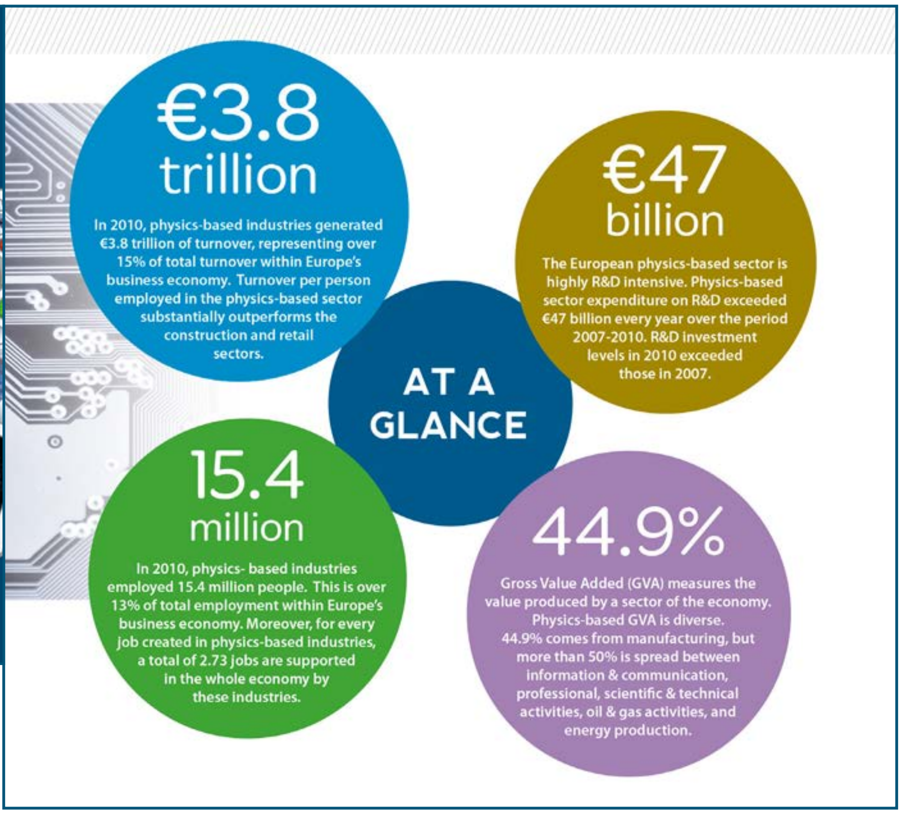
DEVELOPMENT OF ASSOCIATE MEMBERS, APPLIED PHYSICS AND PHYSICS IN INDUSTRY

The importance of Associate Members was realised in the founding of EPS at the meeting of the Steering Committee on 16 May 1967 in London. A compromise arrangement was agreed whereby membership of EPS would be both Individual Members and National Physical Societies, and that laboratories would also be able to join as members. No Associate Members are listed in taking part in the inaugural meeting in Geneva on 26 September 1968, but the Associate Membership increased steadily, reflecting the enthusiasm of major European laboratories to be involved in EPS. At its meeting in Budapest, in October 1970, Council approved seven applications for Associate Membership, and the Council meeting in March 1971 in London noted a rapid increase in the numbers of Associate Members. This reached 41 in October 1974. The number of Associate Members has fluctuated over the years, reaching over 70 in the 1980s, but in 2018 stands back at 43. Representation of Associate Members at Council was introduced in 1982. Currently Associate Members are able to elect five delegates to Council, the same number as the Individual Members.

The importance of applied physics was recognised at the outset and the idea of an Applied Physics Division was discussed, but rejected as it would have emphasised a difference between pure and applied physics at variance with the need to mingle and share experience and problems. Instead, an Advisory Committee on Applied Physics and Physics in Industry (ACAPPI) was established with O.G. Folberth as its chair and met for the first time in Zurich in January 1969. One of the responsibilities of ACAPPI was to provide the link with Associate Members, and in doing so to help look after the interests of individual physicists in the applied and industrial activities of the Associate Members, particularly in smaller companies. ACAPPI organised a number of conferences in applied physics aimed primarily at the Associate Members. In 1989 ACAPPI was changed from an Advisory Committee into an Action Committee, maintaining the acronym, but increasing the scope. Much of the activity consisted in organizing technology transfer workshops. Eventually because of the need to better involve individual physicists, whether as Individual Members of EPS or Members of National Societies, ACAPPI was changed into an Interdivisional Group on Applied Physics and Physics in Industry in 1994. This became the Technology Group in 2001 and is now called the Technology and Innovation Group.

EPS Associate Membership is an exclusive opportunity to showcase Associate Members sustainability vision for strategies and practices. Associate Members benefit from a unique EPS platform to create partnerships with key stakeholders, industry insiders and leading decision makers in physics, technology, sustainable development, culture and education. The EPS Associate Member policy preserves the possibility of joining our Society as regular Associate Member. In addition, Associate Members can join and become a Prestige Sponsor, supporting one of the EPS prizes, or they can be a Societal Challenges Sponsor, supporting EPS activities in fields such as education, physics for development, and the next generation of physicists. ■





▸ Physics makes significant contributions to European economy in industry and commerce. Source: "The Importance to the Economies of Europe 2012

EAST WEST RELATIONS

1968-1980

In 1968, Europe was divided by the "iron curtain". There were sharp political, economic and ideological differences between Western and Eastern Europe and the Berlin Wall was the physical manifestation of these differences. The founders of the European Physical Society recognised that historically, Europe is the cradle of a great civilisation, which has made significant contributions to human progress. G. Bernardini stated in his opening address at the EPS's inaugural meeting on 26 September 1968 that "...we (the physicists involved in the creation of the EPS) still firmly believe that the deep cultural and intellectual affinities on which this civilisation is based do still exist... In the existence of the cultural and moral unity of ...Europe... the EPS is deemed to give a marginal but tangible contribution in years to come."

The best, indeed the only way that the EPS could fulfil this ambitious goal was ensure an active participation of the European "socialist countries". A measure of success is that of the 19 original Member Societies of the EPS, 5 were from Eastern Europe: Czechoslovakia, the Loránd Eötvös (Hungarian) Physical Society, the Romanian Physical Society, the Academy of Sciences of the USSR, and the Physics Section of the Union of Yugoslav Societies of Mathematicians, Physicists and Astronomers. This made the EPS the only scientific society in Europe, which encompassed the West and the East during the Cold War.

Until about 1980, the EPS enjoyed a peaceful and constructive relationship with its Member Societies in Eastern and Central Europe. Physical Societies were welcomed as EPS Member Societies from Bulgaria, Croatia, East Germany and Poland. Europhysics News ran reports on new and ongoing collaborations in physics (*e.g.* "Collaboration CERN-JINR (Dubna), and CERN-USSR 1955-1975" (EPN vol. 6, n° 7, p. 1) and on the state of physics in various Eastern and Central European Countries. The EPS also launched efforts to increase the number of Europhysics and EPS Sponsored Conferences in Eastern Europe, and to ensure fair access to publications.

1980-2004

In 1980, the government of the then Soviet Union decided to commit the Soviet physicist A.D. Sakharov to "internal exile". A report of these moves was given by the delegate from the USSR Academy of Science to the EPS Council in 1980, informing the EPS that "the Academy of Science is taking steps to ensure that Academician Sakharov is in a position to continue his work in collaboration with his colleagues (EPS, April 1980)." However, as reported by the EPS President at the time in his article "The European Physical Society and Scientific Freedom" (EPN vol. 24, n°6, p. 118), "the EPS Secretariat received a telegram from the Soviet authorities demanding the replacement of the agreed statement with another statement, which... bore little relationship to what had actually been said". A.R. Mackintosh wrote several letters to the Soviet authorities requesting for humane treatment of A.D. Sakharov. The complexity of these issues, and the increasing number of protests of the treatment of physicists, particularly in the USSR, led the EPS to create an Action Committee on Scientific Freedom in 1981. The Committee remained active defending physicists from around the world until it was discontinued in 1989.

Throughout 1989, there was intense political and social unrest in many Warsaw Pact countries, including Poland, Hungary, East Germany, Bulgaria, Czechoslovakia and Romania. These culminated in November 1989, when the East German Government announced that all citizens of the German Democratic Republic (GDR) could visit West Germany and West Berlin. Over the next few weeks, the wall was dismantled.

The dissolution of the USSR in 1991 led to the creation of 11 new countries, 5 of which, Armenia, Belarus, Georgia, Moldova and the Ukraine today are represented in the EPS.

Following the reunification of Germany in 1990, the EPS supported the reunification of the physical societies of West and East Germany. The Presidents of both societies acknowledged that the rapid move towards a merger — one that is being held up as the first of its kind in Germany — would not have been possible without the EPS's role in providing a forum within which both parties were able to meet over many years. (EPN, vol. 21, n° 4, p.79).

In contrast, the split-up of former Yugoslavia into several successor states led to the creation of new national physical societies, of which five (from Croatia, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia and Slovenia) are now EPS Member Societies. Czechoslovakia split peacefully into the Czech Republic and Slovakia in 1992, which today are also represented in the EPS with national Member Societies.

In total, the political developments which followed the fall of the Berlin Wall in 1989 led to the addition of 12 new Member Societies. Another result of the events of 1989 on the EPS was the creation of the East West Coordination Committee (EWCC) in 1992. The EWCC looked at questions such as the organisation of research in Eastern and Central European Countries (E/CE) and the Former Soviet Union (FSU). It also organised joint meetings, symposia and statements with the American Physical Society and its Committee on International Scientific Affairs (CISA) and UNESCO to discuss the challenges facing many E/CE and FSU countries.

As the relations with E/CE and FSU countries normalised, through the integration into EPS activities the EWCC was discontinued, but the East West Task Force (EWTF) continued to play an important role in supporting the development of the Member societies in these countries. The programme, funded by the EPS, made grants available to EPS Member Societies in E/CE and FSU countries to finance the participation of early career researchers to attend EPS Europhysics and Sponsored Conferences. This programme reinforced the sense of belonging in the EPS, and provided economically beleaguered Member Societies from the region to offer tangible benefits to their members. The expansion of the EU, in particular in 2004 led the EPS to change again its strategy with respect to E/CE and FSU countries.

2004-Present

The challenges facing many E/CE and FSU countries today are similar to those in 1989: lack of funding for research, insufficient number of well-trained physics teachers, brain drain, *etc.* New challenges however arose, particularly due to the rising importance of research funded by the EU through its framework programmes. Better integration of countries on the periphery of the EU into the framework programmes and into the EU research community became the focus of the Committee on European Integration (CEI).

In 2014, the CEI, together with the International Centre of Theoretical Physics (ICTP) in Trieste (IT) and the UNESCO Venice Office, funded in part by the Central European Initiative ran a series of workshops that looked at integration of the physics community in South East European countries into the European Research Area. The workshops covered the following topics: Widening Participation of CEI Countries in the EU Research Programs; Promotion of physics in the South East European countries and Integrating Access to Research Infrastructures in Europe; Workshop on Physics Education. (http://see-cei-era.seenet-mtp.info/).

In 2015, the Institute for Nuclear Research, the Wigner Research Centre for Physics, the Hungarian Academy of Sciences and the European Physical Society jointly organised the workshop "Integrating Access to Pan-European Research Infrastructures in Central and Eastern Europe". The workshop looked at the formation of consortia of governmental shareholders from small and medium-size countries to the best European Research Institutions in physical and engineering sciences. (http://w3.atomki.hu/inarie/scope.html)

The latest effort by the EPS to be involved in greater integration of the European Physics Community was to be involved in the Forum on New International Research Facilities in South East Europe in January 2018. This meeting explored options for the establishment of a state of the art research facility in the region, focusing on either a fourth-generation synchrotron light source or a hadron therapy facility. (http://indico.ictp.it/event/8408/). ■

THE EPS STAFF 1968-2018

What started, in 1968, with modest means under the umbrella of CERN and was governed from Geneva grew to become the financially fully independent European Physical Society of today, now established in Mulhouse, on the campus of the University of Haute Alsace. Governing in the beginning consisted in both countless and endless phone calls by President Gilberto Bernardini, assisted only by Lorette Etienne-Amberg, in Geneva. She was succeeded in 1974 by Gero Thomas who stayed on until the move from Geneva to Mulhouse, in 1997, when David Lee assumed the duties of Secretary General. Pascaline Padovani, the first staff member to be hired in Mulhouse, oversees the EPS accounts. Many volunteers have been involved in EPS over the years as well. Perhaps we may single out one: Eddy Lingeman. He was in charge of the information technology (member administration, *etc.*), before the employment of Ahmed Ouarab (1999). The website, existing since 1993, is now in the joint care of Gina Gunaratnam (2004) and A. Ouarab. G. Gunaratnam also coordinates communications and produces the monthly electronic news bulletin e-EPS. Under David Lee's direction the decisions of the Executive Committee and the annual Council meeting are implemented *e.g.*, the creation of a Conference Services Department in 2000. Numerous conferences have been organised by Patricia Helfenstein (2000) assisted by Ophélia Fornari (2002). Sylvie Loskill (2001), on loan from the UHA provides administrative assistance and member management for the Secretariat. The Editorial Office of EPL (former Europhysics Letters) was earlier run by Edith Thomas, moved to the Secretariat in 2004, and is today directed by Frédéric Burr and his assistants Kevin Desse and Soufiane Fila. The EPS magazine Europhysics news is also produced by the EPS Secretariat, with professional design assistance from Xavier de Araujo (2004). The content is managed by the actual editor Victor R. Velasco and science editor Ferenc Igloi. D. Lee is its executive editor.

All visitors to the EPS, either through the website or, in person, at Headquarters, Mulhouse, will be received with hospitality and courtesy. ■

▲ from bottom left: Frédéric Burr, Soufiane Fila, David Lee, Sylvie Loskill, Ahmed Ouarab, Ophélia Fornari, Kevin Desse, Patricia Helfenstein, Pascaline Padovani, Gina Gunaratnam, Yassin Najibi (trainee).

STUDENT MOBILITY

One year after the foundation of EPS, the first President, Gilberto Bernardini, stressed in an editorial article[1] the (possibly most important) role of EPS in supporting a Student Exchange programme and '*in the long term the more difficult and ambitious task of the equivalence of university titles and degrees*'. (see also articles on *Physics Education Networks* and *Bologna Process*).

In 1987 the European Community established the ERASMUS (*backronym for **E**u**R**opean community **A**ction **S**cheme for the **M**obility of **U**niversity **S**tudents*) mobility programme in education and training. In 1990, following the fall of the Berlin Wall in 1989, the programme was complemented by the TEMPUS (Trans-European Mobility scheme for University Studies) programme for central and eastern European (CEE) countries. Both actions were helped by the *European Credit Transfer* (and *Accumulation*) *System* (ECTS) in comparing and recognising the "*volume of learning based on the defined learning outcomes and their associated workload*".

Some local student mobility initiatives in physics[2] emerged. The EPS *Executive Committee* decided in March 1992 in Athens [GR] to set up a *Working Group* to formulate and implement a *Convention*[3] for a *European Mobility Scheme for Physics Students*[4] (EMSPS or emsφs). Since 1990 Ernst Heer[5] (*Université de Genève* [CH]) had obtained experience with a student mobility initiative in the Swiss 9 Higher Education Institutions (HEIs) among the different language groups. He gave a true impulse to the EMSPS activity which became EPS's flagship action. By a short questionnaire, some 400 physics departments were called, via electronic mail, for an expression of interest. The scheme needed a central computerized database (*The University of Manchester* [UK] H.G. James) which contained "*information packages*", giving details of the courses being offered, hence remote-accessible to students. EMSPS found financial support in the frame of ERASMUS (where it was the largest project during that period) and administrative support by EPS. There appeared interest in the scheme by almost 40 % of the 400 qualified HEIs. One hundred twenty-one institutions (universities or technical universities) decided to participate and adhered to the *Convention*.

▲ The EMSPS Mobility Committee at a Meeting in UGent April 1993.

In the autumn of 1993 their physics departments gained an insight into the structure of the physics studies, when sending out (for one semester or one academic year) about (in total) one hundred students[6], with **full recognition** of studies by the **home** institution. The scheme relied on significant support, notably for student grants for partner HEIs in the European Community and in EFTA countries via an *Inter-University Co-operation Project* (ICP, coordinated by Universiteit Gent [BE] H. Ferdinande) (1993/97, ~ 100 000 ECU) but also *via* a set of five *Mobility Joint European Projects* from the TEMPUS Programme for CEE countries (MJEPs, coordinated by *{Leibniz} Universität Hannover* [DE] P. Sauer), covering the partner HEIs first in Hungary and Latvia, later also in Poland, Lithuania and Romania.

The project was monitored by a *Mobility Committee* (figure), comprising 15 members-coordinators, chosen to cover the various parts of Europe and chaired at the start by Ernst Heer. As expected, student flow[7] was rather unbalanced with respect to home and host countries, being particularly strong towards the United Kingdom. In 1994 EPS President Norbert Kroo was approached by the well-known philanthropist Dr. Georges Soros. The *Soros Foundation*[8] provided the sum of US$ 500 000, to be spent within two years, on financing the participation in EMSPS of up to 40 physics students from CEE partner-institutions to study at west European universities for a period of 5/10 month. Students[9] from 24 EMSPS institutions in Austria, Hungary, Poland, Slovakia and Slovenia were also eligible for mobility grants awarded by the *Central European Exchange Programme for University Studies* (CEEPUS).

The network expanded, but from 1998 the mobility grants were gradually taken over from a project mobility to a centralised institutional one. At the dawn of the millennium 181 institutions in 30 countries made up the scheme[10] in 2000. Of those, 135 HEIs were from the European Union or the European Economic Area (EEA) countries, 36 were from CEE countries, 7 were from the Russian Federation and Ukraine and 3 from Israel and Turkey. From 2000 on the task to manage the mobility of students in universities was taken over by the administration in the respective *Offices of International Relations* (or equivalent names) at the different HEIs. Hence, the last *Mobility Committee* Meeting was held in Bern [CH] in July 2005.

This project had as impact[11] that the ERASMUS coordinator was invited during a three-month stay in 2012 as guest professor at the *Institute for the Advancement of Higher Education at the Hokkaido University*, Sapporo [JP]. ■

[1] "Student Exchange Programmes. The role of the EPS", G. Bernardini, EPN 1/6 (1969) p. 1/3
[2] "Not Just Trendy ", P.G. Boswell, EPN 21/10 (1990) p. 182
[3] EMSPS Convention, EPN 31/1 (2000) p. 15
[4] "European Mobility Scheme for Physics Students", EPN 22/4 (1991) p. 82
[5] In memoriam, EPN 48/4 (2017) p. 7
[6] "Over One Hundred Move in First Year", EPN 25/2 (1994) p. 44
[7] "Student Mobility Scheme Underway", E. Heer, EPN 24/6 (1993) p. 158
[8] "The Soros Foundations Cooperate with EPS", EPN 25/2 (1994) p. 44
[9] "EMSPS Scheme Continues to Expand", EPN 26/5 (1995) p. 116
[10] "Mobile Physics", EPN 31/1 (2000) p. 13/14
[11] "Tertiary Student Mobility in the European Union (EU) *vs.* that in Japan", H. Ferdinande, T. Hosokawa, K. Yamada & T. Nishimori, J. of HE and Lifelong Learning, 20 (March 2013) p. 29/40

EPS GENERAL CONFERENCES

The tradition of triennial EPS General Conferences started with the Inaugural Conference held in April 1969 in Florence, and continued until EPS 13, in the World Year of Physics 2005. About 850 people attended the Inaugural Conference, which started with Victor F. Weisskopf, who had returned to the Massachusetts Institute of Technology after his term as Director-General of CERN, and P.M.S. Blackett, Head of the Physics Department at Imperial College London, speaking about "Physics in Europe in the 20th Century" and "The Old Days at the Cavendish". Plenary and parallel sessions then followed on this five-day conference. There were invited lectures exclusively, but ample time was reserved for discussion. Clearly, the Conference was intended to give an overview of the status of the field by predominantly European physicists – from East and West.

After the Inaugural Conference, whose title was "Growth Points in Physics" there followed, with three-year intervals, eleven EPS General Conferences on "Trends in Physics". They were held in Wiesbaden, Bucharest, York, Istanbul, Prague, Helsinki, Amsterdam, Florence, Sevilla, London and Budapest. The 13th EPS General Conference had the title "Beyond Einstein – Physics for the 21st Century", and was the last one – so far. To celebrate the centenary of Albert Einstein's *annus mirabilis* 1905, EPS 13 was held on site: in Bern.

FOR REFERENCE:
A HISTORY OF EPS GENERAL CONFERENCES (ACCORDING TO EUROPHYSICS NEWS)

1969 **EPS 1** FLORENCE (ITALY), 8-12 April 1969
1972 **EPS 2** WIESBADEN (GERMANY), 3-6 October 1972
1975 **EPS 3** BUCHAREST (ROMANIA), 9-12- September 1975
1978 **EPS 4** YORK (UNITED KINGDOM), 25-29 September 1978
1981 **EPS 5** ISTANBUL (TURKEY), 7-11 September 1981
1984 **EPS 6** PRAGUE (CZECHOSLOVAKIA), 27-31 August 1984
1987 **EPS 7** HELSINKI (FINLAND), 10-14 August 1987
1990 **EPS 8** AMSTERDAM (THE NETHERLANDS), 4-8-September 1990
1993 **EPS 9** FLORENCE (ITALY), 14-17 1993
1996 **EPS 10** SEVILLA (SPAIN), 9-13 September 1996,
1999 **EPS 11** LONDON (UNITED KINGDOM), 6-10 September 1999
2002 **EPS 12** Budapest (Hungary), 26-30 August 2002
2005 **EPS 13** BERN (SWITZERLAND), 11-15 July 2005, «Beyond Einstein – Physics for the 21st Century»
2008 **14th EPS General Meeting**, MULHOUSE (FRANCE), 28 March 2008
2011 **15th EPS General Meeting**, WROCLAW (POLAND), 27 October 2011
2014 **16th EPS General Meeting**, BUDAPEST (HUNGARY), 28 October 2014

▲ E. Thomas and E. Lingeman at EPS 12 in Budapest

Why did EPS General Conferences cease to be organised? A substantial number of physicists, ranging from 360 to 1300, attended these Conferences over nearly four decades. They got an overview of the entire field of physics and – starting with EPS 2 – were given the opportunity to report on their own work in a steadily increasing number of topical symposia, where issues, such as teaching of physics, its popularisation, and its public image could be discussed as well. Lectures by distinguished researchers, among them a great many past and future Nobel Laureates, have often become indelible memories for young physicists.

Two mutually reinforcing tendencies might underlie the current lack of EPS General Conferences: (i) the number of topics in physics keeps expanding, and this leads to specialisation, and (ii) restrictions in funding prevent students and young researchers from attending general conferences and thus to achieve and maintain general literacy in physics. The present EPS community should find a way out of this enigma! ■

THE HISTORY OF EPN

By Claude Sébenne, Editor (2005-2014)
and Jo Hermans, Science Editor (2008-2017)

The first years of EPN: 1968-1976

The magazine of the European physics community Europhysics News (EPN), owned by the EPS, started as a special issue of eight pages published in November 1968. It began with a brief report on the genesis of the EPS from the 1965 discussions in Bologna to the signature of its foundation on 26 September 1968 at the University of Geneva. The issue contained the Constitution of the new Society, the composition of its first Executive Committee and the list of its first members. The text was accompanied by several pictures of the foundation meeting.

It already carried the famous head, which it kept for many years:

But the real start of EPN was its n°1 issue in January **1969** with **B. Southworth** as Editor and E. Ascher as coordinator and a 6 member Editorial Board. Six issues of 8 pages numbered 1 to 6 were published for the year. In **1970**, six issues of 8 or 12 pages were produced by the same Editor and same board, plus 2 meeting issues collected by W. S. Newman with the help of Editorial Board. These two years constitute Vol. 1 of EPN.

In the next year, **1971**, Vol. 2 appeared, consisting of 9 issues of 8 pages including two "meeting" issues. **W. S. Newman** became the Editor assisted by 5 members of the Editorial Board. In **1972**, Vol. 3 had 12 issues of 8 or 12 pages (2 meeting issues). After the first issue, W.S. Newman was replaced by **Alex H. Crawford** as Editor. This stayed the same for Vol. 4 of 1973. For Vol. 5 in 1974, **Lorette Etienne-Amberg** replaced Crawford as Editor. She stayed until **issue 6/3** of 1975 after which she was replaced by **L. Sokolec** until issue **7/2** in **1976**.

Stabilisation of EPN: the Shaw times 1976-1989

It is with **issue 7/3 of 1976** that **E. N. Shaw** became the first long-lasting **Editor of EPN** with a board of 6 members. He stabilised EPN with 12 issues per volume (year) with a progressive increase of the number of pages. Initially there were 8 pages per issue, increasing to 12 pages after 1981 and 16 after 1984. Until Vol. 20, issue 5, EPN kept its same heading, with the text starting on the front page. Before leaving, the Editor introduced a new presentation with a real cover page for each issue. The first ones had europhysics news in black on white, a picture and a light green background. **Edwin Shaw** included a picture of himself and a farewell editorial in 20/11-12 of 1989. **He is recognised as the great maker of "europhysics news"**

The Peter Boswell times 1990-1996

When arriving as Editor, **P. Boswell** and his board of 5 had to fill 12 issues each year, each with about 20 pages. But the costs of distribution were too heavy for the EPS back in 1992, so Vol. 23 was reduced to 9 issues of about 24 pages. In 1995, Vol. 25 contained 6 issues of about 36 pages. The cover had a coloured mast head, a picture and a light blue background. The year **1995** saw an increase of the Editorial Board to 14, and **M. Siegrist** became its chairman. Springer-Verlag became the publisher of EPN, and a smaller size was adopted for the Journal. Peter Boswell, who did not wish to accompany EPS when it moved from Geneva to Mulhouse, left after Vol. 27 of 1996.

The turmoil times 1997-2004

After the year 1997 which went by without an Editor, a managing Editor, **Toby Chapman** came to take care of EPN in 1998, with the 12 members board still chaired by M. Siegrist. Several members had left and some new members like G. Morrison and Claude Sébenne entered. All went well for Vol. 29 in which 6 issues where published. However, it degraded in **1999**: the complete Vol. 30, with 4 issues and 122 pages, was published in the first half of the year. Decisions had to be taken by the EPS. As a result, **G. Morrison** became chairman of the editorial board and later **Science Editor** while the Secretary General of the EPS, **David Lee**, replaced T. Chapman in the position of **Managing Editor**. Subsequently, Vol. 31 in 2000 came out in 6 issues and 180 pages, and Vol. 32 in 2001 in 6 issues and 200 pages. At the same time the publisher became EDP Sciences in replacement of Springer, and a **graphic designer, Paul Stearn**, was usefully added to the production team. It worked this way for a few years, with 6 issues per year totalling 210± 30 pages.

From 2005 to the present 2018

In 2005, **Claude Sébenne**, former Editor of the French Physical Society Bulletin, took over as **Editor** of EPN effective 36/5, (picture and editorial in 36/4). At the same time, **Xavier de Araujo** replaced P. Stearn **as the graphic designer, G. Morrison** took up the position of **Science Editor** and **David Lee** became Executive Editor (rather than Managing Editor). The new team started with the creation of "highlights", a choice of the best papers published in research journals under the scientific control of European learned societies. A process to renew the roughly 15 members of the Editorial Board, which is chaired by the Science Editor, was put into place. The Graphic Designer significantly improved the overall presentation of EPN. This worked in a satisfactory way for two years after which G. Morrison retired and was replaced by **L. J. F. (Jo) Hermans** as **Science Editor** in 2008, effective issue 39/3. In 2009 (Vol. 39) EPN returned to its standard A4 size.

The team that made and structured EPN as it has become since 2007 was therefore:

- Editor: Claude Sébenne,
- Science Editor: Jo Hermans
- Executive Editor: David Lee
- Designer: Xavier de Araujo

C. Sebenne retired as Editor in April 2014. He was replaced by **Victor Velasco-Rodriguez**. Jo Hermans retired as Science Editor in January 2017, and was replaced by **Ferenc Igloi**. These important changes did not change the structural continuity and overall presentation. C. Sébenne stepped back, providing helpful comments and input as necessary and Jo Hermans moved to the Editorial Board. It should be noted that since 2016, Vol. 47, there are 4 issues plus one double issue per year, trying to keep the same total number of pages while decreasing the distribution costs. Finally it should be mentioned that, in addition to the 25000 printed copies per issue, EPN is also freely available on the internet, see www.europhysicsnews.org. This includes free access to back issue, all the way back to the very first issue of 1968. ■

THE HUNGARIAN CONNECTION

The EPS throughout its existence has been a powerful tool for East-West cooperation. At the same time, the EPS benefitted from the goodwill of its Member Societies in Eastern and Central European Countries to help solve some of the administrative and financial difficulties faced by the EPS in a politically divided Europe.

The EPS Council meeting in 1983 approved the creation of a "Supplementary Secretariat" in Budapest (HU), which was opened in January 1985. The Budapest Secretariat provided cost effective secretarial services used particularly for member management and mailing of Europhysics News. The Budapest Secretariat, together with the Centre for Energy Research, Hungarian Academy of Sciences (KFKI) created the first computerised EPS Membership lists. It should also be remembered that at that time, many countries in Eastern and Central Europe had non-convertible currencies. Through the Supplementary Secretariat, the EPS was able to open a bank account in Hungary, which made it slightly easier to collect and use such currencies. The Budapest Secretariat also played a key role in helping the EPS resolve its financial difficulties in the early 1990s, when G. Thomas, the EPS Secretary General at that time relocated temporarily to Budapest to reduce salary costs in Geneva.

▲ Maria Lazar, head of the EPS Supplementary Secretariat (Left), J. Nadrchal, unknown guest, J. Dittrich, D. Krupa

Maria Lazar and Magdi Balla were key to the smooth running of the Supplementary Secretariat, which was closed in 2007. ■

EPS AND THE MOVE TO MULHOUSE

In 1996 the EPS Council decided to move the EPS Secretariat from Geneva (CH) to Mulhouse (FR). The decision was based on a report from the working group established in 1995 and comprising J. P. Ansermet, J. Lewis, C. Sebenne and H. Schopper as members.

The EPS was in a precarious financial situation in the early 1990's, with a slowly increasing deficit. In order to reduce salary costs and to absorb the accumulated deficit, G. Thomas, the EPS Secretary General at the time, agreed in 1991 to relocate to the Supplementary Secretariat of the EPS in Budapest. This however could not be a long term solution.

In addition, H. Schopper introduced a strategy plan in 1996 and called for an increase in spending on EPS activities. One way of achieving this was to reduce the cost for the Secretariat in Geneva. Unfortunately, the charges for office rental and the cost of salaries were (are) high in Switzerland, and the value of the Swiss Franc had been (and still is) steadily increasing in value compared to other European currencies. This automatically increased costs, leaving less and less for EPS activities.

Finally, the importance of the EU's Framework Programmes in scientific research and the funds available also increased. The funding for the 1st Framework Programme (1984-1988) that was Euro 3.1 billion, had risen to 13.1 billion in the 4th Framework Programme (1994-1998). For the EPS to fully benefit from these funding opportunities, the Secretariat would have to be located in an EU country.

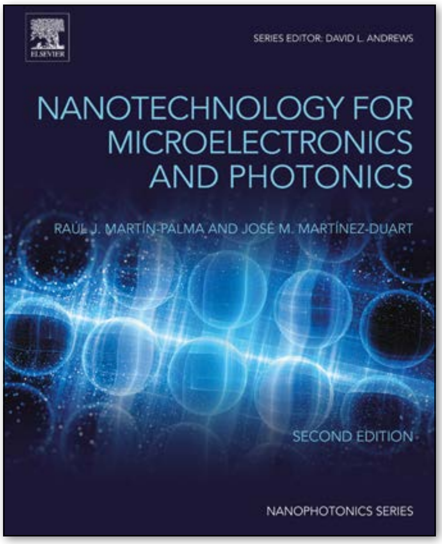
▲ Inauguration of the new building, M. C. E. Huber with other guests.

Following a call for proposals to host the EPS Secretariat, the Working Group received offers from the Institute of Physics in London (UK), the Austrian Physical Society in Graz (AT), The Loránd Eötvös (Hungarian) Physical Society in Budapest (HU), the Dutch Physical Society in Amsterdam (NL), and from the Université de Haute Alsace, in Mulhouse (FR). The Working Group also considered (and discarded) locating the Secretariat in Strasbourg (FR), Vienna (AT), Leuven (BE) and the French region adjacent to Geneva.

The proposal from Mulhouse was by far the most generous. In addition to rent free office space, the UHA also offered secretarial assistance. Since coming to Mulhouse, the finances of the EPS have remained healthy, and the EPS has been a partner in numerous projects funded by the EU's Framework Programmes, and was the coordinator of 3 main projects: The World Year of Physics in 2005, a study of the implementation of the Bologna Project in Physics Studies in 2010, and the International Year of Light in 2015. ■

NANOTECHNOLOGY
FOR MICROELECTRONICS AND PHOTONICS

The second edition of the book of Prof's R. Martín-Palma and J.M. Martínez-Duart occupies a prominent position in the rather scarce bibliography of academic texts devoted to the description of the non-ending list of novel low-dimensional semiconductor structures.



Authors: Raúl José Martín-Palma, José Martínez-Duart
Order: https://www.elsevier.com
ISBN: 978-0-323-46176-4
Price: 186.71 €

This edition contains new sections to keep up with the latest developments in this rapidly evolving field, including new topics, such as quantization of plasma oscillations (*i.e.* plasmonics, spintronic, photonic crystals, and several nanostructured materials such as graphene, silicene, carbon nanotubes and sensors). Though these materials are well consolidated in the current technology, there are few textbooks that make a detailed reference to them.

As illustrated in the book, when the dimensions of solids are reduced to the size of the characteristic lengths of electrons in the material (De Broglie wavelength, coherence length, localization length, *etc.*), new physical properties, owing to quantum effects, become apparent. These properties give rise to a long chain of technological devices and inventions that outperform the existing ones. The advantages of these new materials and devices are well recognised: depending on their application they are generally smaller in size, with higher speed response, high frequency of operation and lower dissipation power and cost.

Understanding all these effects require a strong basis of semiconductor physics, among them the dynamics of electrons in their energy bands, electron diffusion and transport, excitation, resonant processes, *etc.*, all these phenomena under the umbrella of quantum physics. The long experience of the authors in teaching university courses has led them to make easy what is conceptually complex in a comprehensive manner, giving in every chapter an introductory view of the main concepts, emphasizing the implications of the novel structures in the technology. Moreover, due to the large variety of phenomena and structures, they make a continuous cross reference in the text to other chapters to facilitate reading.

The book is mainly addressed to final-year undergraduates as well as beginners graduate students in physics, materials science and engineering (electrical, materials, *etc.*). Alternatively, the book can also be very helpful to scientists and professors as a consulting treaty on the fundamental aspects of nanoscience and nanotechnology. Actually, most of the chapters include a box for colloquial comments on other marginal concepts, such as the device fabrication techniques (vacuum, plasmas, film deposition, *etc.*), and more particularly on the main milestones (theories and experiments) that have led to the wide variety of electronic and photonic devices described in the book. Most notably, this new edition includes a large number of problems of which more than a half are accompanied by their full solutions, while in others hints are provided.

The book contains twelve chapters, which conceptually can be divided into three main parts:

- The basis of semiconductor physics, with the definition of physical concepts and terms of micro- and opto- electronic devices, necessary for the understanding of the new phenomena associated to nanostructures
- The optical and electrooptical processes of electrons confined in low-dimensional structures (*e.g.*, potential wells, resonant tunneling, *etc.*), studying the effect on electron transport by electric or magnetic fields
- The applications of the above phenomena to advanced electronic and photonic nano-structures (single-electron transistors, quantum dot lasers, superlattice photodetectors, *etc.*) including those associated to low-dimensional materials (graphene, carbon nanotubes, silicene and the like)

Of particular interest for students, researchers and industrialists is the last chapter (epilogue) where the authors give their personal view on the future prospects on this large circus of nanotechnology, which embraces numerous sectors of our current lives: communications, space, medicine, defense, energy, automatic control, *etc.* They discuss, for instance, the new trends in the use of III-V semiconductors in MOSFET transistors, or the emergence of 2D materials, such as graphene, silicene, *etc.*, or the recent developments in plasmonics, spintronic, photonics and sensing. Even more amazing is the use of DNA molecules as semiconducting nanowires which would lead to highly integrated devices, at densities far beyond those provided by current lithographic techniques. ■

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The EPS is not responsible for the content of this section.

Opinion: artificial intelligence and scientific intelligence

Marc Mézard, École normale supérieure, PSL University

By now, everybody should know that the recent progress of Artificial Intelligence (AI) will produce a dramatic impact on many sectors of human activity.

AI has obtained spectacular results that would have been considered impossible ten years ago. Last year a new algorithm beat the world's best Go player. We can now process images automatically, identify faces, segment images and provide a semantic description of their content, opening the way to self-driving cars or trucks. Voice recognition and automatic translation are progressing rapidly. Algorithms are competing with the best professionals at analyzing skin cancer symptoms or detecting specific anomalies in radiology. And physics is also concerned: AI is used to help identify new particles in accelerator physics, to analyze cosmological data, or perform quantum chemistry simulations.

The recent breakthrough is based on machine learning: the algorithms are programmed to learn from examples. They are often based on layered artificial neural networks, where each "neuron" receives information from neurons in the previous layer, performs a simple computation and in turn sends a few bits of information to the next layer. A modern "deep" network with hundreds of layers, analyzing an image, can contain hundreds of millions of adaptable parameters ruling these elementary computations. They must be determined through supervised learning: a large "training set" of examples is presented, and the parameters are adapted, typically by gradient descent, so that the intended purpose is obtained on this training set. The generalization performance of the obtained machine is then tested on new data.

The paradigm of layered neural networks has existed for over 50 years. However, until the field's recent revival, it was not successful on real-size practical applications. Its revival is due to the increase in computing power, to the availability of very large labeled data sets for training (in fact, the progress in "big-data" analysis and in machine learning are strongly correlated), and to some pre-processing and training tricks developed in the 2000's.

In spite of its practical success, the scientific understanding of deep networks lags far behind. The learning process is poorly understood. Gradient descent in a complicated 10^8-dimensional parameter space should typically be trapped in inefficient regions. Even when using large training sets, a successful training with that many parameters could lead to "overfitting", namely poor generalization on new data.

Yet, in practice, training works and finds a good-enough set of parameters, producing a machine that can be smarter than us. At a more abstract level, understanding how the information, stored collectively by the neurons inside each layer, becomes more global and more abstract when one goes deeper into the layers is a major challenge. Scientific intelligence, with input from statistics, information theory, computer science and mathematics is needed in order to come up with a theoretical framework. Because of the collective nature of information processing in these systems, one can expect that statistical physics will play a major role in these future developments.

Scientific intelligence, with input from statistics, information theory, computer science and mathematics is needed in order to come up with a theoretical framework.

Having underlined the technological and societal importance of the AI revolution as well as its scientific challenge, let me highlight that, as far as "intelligence" is concerned, these machines remain very limited. They can achieve specific tasks, characterized by simple answers, but they are far from building a representation of the world, or from any kind of creative reasoning. In science, deep networks and new data-science algorithms are extremely useful additions to our toolbox, as was the appearance of numerical simulations a few decades ago. However, these machines cannot replace modeling, *i.e.* building a concise, workable and predictive representation of the world. Contrary to some bold claims, they will not kill the scientific method that we have been using for five centuries. Rather, they will improve it. ■

COMING EPS EVENTS

- **Experimental Chaos and Complexity Conference (ECC)**
  04 » 07 June 2018
  Madrid, Spain
  http://eventos.urjc.es/go/ECC15

- **Unifying Concepts in Glass Physics**
  11 June 2018
  Bristol, United Kingdom
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