IUPAP International Union of Pure and Applied Physics

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Newsletter

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THE PRESIDENTS' MESSAGE

Attendees for the Executive Council and Commission Chairs (C&CC) meeting held in Vilnius, Lithuania.

At the beginning of November we were in Vilnius, Lithuania, for the second meeting of the Executive Council and the Commission Chairs (C&CC) for 2018. From the May meeting we had a long list of items that we had to work on and report to this one, and we left this meeting with an even longer list of items to be worked on.

It has been decided that the next C&CC meeting will be held in London on 2nd and 3rd October 2019.

The May meeting concluded that the Statutes and By Laws for the Union were old fashioned and should be updated. The existing Statutes and By Laws predate our electronic age, and also predate the emphasis we now put on inclusiveness and diversity, and honesty and integrity, in our operations. Recognising that this change is a long process, it charged the Presidents, and the Secretary-General, Associate-Secretary-General and the Deputy Secretary-General to bring to this meeting the first draft of a revision. That was received, and the process has started. The draft will be redone and eventually be brought back to the next Council.

The May meeting was concerned by the fact that Commissions had not had enough input to the production of the slates of their new members prior to the meeting of the Executive Council recommending those slates to the General Assembly. The meeting also discussed the concerns expressed at the General Assembly about a large number of Commission Chairs from one member and may have produced a change which could have seen an unprepared member of a Commission become its Chair. It requested that the above group of officers provide this meeting with a proposal for how it would be possible to resolve these problems at the C&CC meeting in 2019. At the Vilnius meeting, the C&CC, were not convinced that the proposal brought to them was workable, and requested more work be done on it.

As always in October, the Executive Council, on the advice of its meeting with the Commission Chairs, determined those conferences it would sponsor in 2019. By now all of those conferences should have received instruction about the outcome. We wish them all a very successful and harmonious conference. As usual, some Commission Chairs expressed concerns about fake conferences which are usurping the titles of their major conferences. Unfortunately, our conference titles are not copyrighted, and so we encourage all conference organisers in an IUPAP series, to ask the Chair of the relevant Commission to apply for endorsement of the Conference as soon as the location is determined. This allows the organisers to put the IUPAP logo on their website, showing that theirs is not a fake conference. They will have to apply for sponsorship the year before the conference occurs, in the usual way.

It is important that IUPAP represents as many physicists as possible, in order to achieve its mission" *to assist in the worldwide development of physics, to foster international cooperation in physics, and to help in the application of physics toward solving problems of concern to humanity.* " The meeting worked on two ways to expand its representation:

- Developing a strategic approach to recruiting new members, led by Vice-President-at-Large, Nithaya Chetty, which you can read more about in this newsletter
- Connecting better with physicists in industry. The President is setting up a new working group to help us develop our strategy for this.

The Lithuanian Vice-Minister of Education and Science, Dr. Giedrius Viliūnas was one of those welcoming us to Lithuania. In his speech, he emphasised how important it was that all nations, even small nations like Lithuania, paid attention to adequately supporting basic sciences, even as they were trying to reap the benefits from applied sciences. His thoughts strongly resonated with the push, which IUPAP is leading in UNESCO to have 2022 or 2023 declared as the International Year for Basic Sciences and Development (IYBSD). Because 2022 - 2023 is also the centenary of IUPAP, we spent time considering plans for celebrating our centenary, and for campaigning for and implementing the IYBSD. These are still under development and you will hear more about them as they develop.

As our mission is *to assist in the worldwide development of physics,* it is important that IUPAP support physicists when their ability to do their teaching and research is threatened. All too often a country strongly develops its scientific capacity, and then suddenly and dramatically reduces its support. When this happens many of the excellent scientists attracted to the country in the build-up period will leave, and the hard-won scientific capacity is lost. Argentina is one such country that is facing this issue. The meeting thus resolved that IUPAP should write to President Temmer of Argentina to explain the effects that his policies of this nature will have on the scientific community in Argentina, and how they will seriously jeopardise the economic future of the country, and to publish that letter on on the IUPAP website, along with any response to the letter.

GERARD MOUROU - FIRST CHAIRMAN OF IUPAP'S WORKING GROUP 7

- The International Committee on Ultrahigh Intensity Lasers selected as the co-recipient of the 2018 Nobel Prize in Physics

Professor Chris Barty - University of California, Irvine
Chair - International Committee on Ultrahigh Intensity Lasers - IUPAP WG7

Kickoff meeting of IUPAP WG7 – The International Committee on Ultrahigh Intensity Lasers held in Great Britain February 2004. ICUIL's first chairman, Gerard Mourou, is at the center.

The IUPAP's Working Group 7, the International Committee on Ultrahigh Intensity Lasers (www.ICUIL.org) congratulates Professors Gerard Mourou and Donna Strickland on being awarded the 2018 Nobel Prize in Physics for the invention of chirped pulse amplification.

This year's Nobel Prize is of particular significance to the ICUIL community as nearly all of the 80+ facilities worldwide that are currently pursuing ultrahigh and high intensity laser research are based on the chirped pulse amplification technique cited by the Nobel committee and first demonstrated by Gerard and Donna in 1985. Full details of the award and citation can be found on the Nobel committee web site at https://www.nobelprize.org/prizes/physics/2018/prize-announcement/

The suggestion to form ICUIL as a formal working group of IUPAP was presented to the IUPAP board of directors in the fall of 2003 after a two year study conducted by the Organization for Economic Cooperation and Development's (OECD) Global Science Forum (GSF) Coordinating Committee on Compact High Intensity Short Pulse Lasers. The first official meeting of the working group occurred in February of 2004 (see photo). Prof. Mourou was a key member of the OECD GSF study that formulated the charter for ICUIL and served as ICUIL's initial chair from 2004 to 2008.

Over the years, Prof. Mourou has been instrumental in many ICUIL gatherings, workshops, studies and events. ICUIL sponsors a biennial gathering known as the International Conference on Ultrahigh Intensity Lasers. Prof. Mourou was the co-chair and organizer of the 2006 meeting, which was held in Cassis, France. It should be noted that the present billion-euro Extreme Light Infrastructure (ELI) project (www.eli.org) was discussed and formulated at the ICUIL 2006 meeting. The brainchild of Gerard Mourou, ELI consists of three state-of-the-art facilities located in the Czech Republic, Hungary and Romania. After nearly a decade of planning and construction, ELI will become the premier international user facility for the study and use of ultrahigh intensity lasers , over the next two years.

ICUIL aims to promote the international development and use of ultrahigh intensity lasers - an enterprise that currently represents ~ $5B worth of science infrastructure development worldwide.

DONNA STRICKLAND: A GRADUATE STUDENT, A RESEARCHER AND A NOBEL LAUREATE

Parinda Vasa, Tsuneyuki Ozaki and Cather Simpson

The announcement of the 2018 Nobel Prizes have been filled with surprises. Let us catch a glimpse of one of the winners and her research.

The Nobel Prize in Experimental Physics Shared by a Woman for the first time since 1903

The Nobel Prize in Physics was first awarded in 1901. In the last 117 years, it has been awarded almost exclusively to men. In fact there have been only three occasions when it has been shared by women: Marie Curie (experimental physics, 1903), Maria Goeppert-Mayer (theoretical physics, 1963), and Donna Strickland (experimental physics, 2018).

Donna Strickland, a Canadian physicist at the University of Waterloo, received the Prize jointly with Gérard Mourou from France for their work on high-intensity laser pulses. They both shared quarter of the Prize, while the other half was awarded to Arthur Ashkin, an American physicist who demonstrated the use of light beam to manipulate small biological objects without harming them. Donna was a graduate student working under Gérard Mourou at Institute of Optics, University of Rochester, USA when they published their groundbreaking research work on chirped pulse amplification in 1985. Their technique has led to the development of shortest and the most intense laser pulses ever created. These intense laser pulses are finding applications in multitude of applications ranging from eye surgery to nuclear fusion.

Being the only living woman Nobel Laureate in Physics, Donna said that though she was initially surprised, she is honoured to receive the recognition and that achievements of women physicists need to be celebrated. She hopes that there will be many more women physicists receiving the recognition in the future and at a faster rate.

- Parinda Vasa (Department of Physics, Indian Institute of Technology Bombay, Mumbai, India)

Donna Strickland – "laser jock"

Donna is undoubtedly an excellent scientist, in her words, a "laser jock". Her current research focuses on multi-frequency Raman generation and mid-infrared laser generation, as well as the application of ultrafast laser pulses in medicine. Through conferences and workshops, I have had the privilege to discuss with Donna on many topics in laser science and nonlinear optics. From such interactions, I have found that many of her questions and comments are enlightening, providing great insights into some of our experimental observations. The way she poses such questions is also very "Canadian". Polite, but nevertheless getting to the core of the subject, allowing one to look at the results in a different manner, sometimes resulting in interesting turns. At the same time, Donna is very down-to-earth and easy to talk to. We have had multiple discussions on various subjects, from women in physics (of course), to Quebec cuisines, and funding opportunities in Canada. Despite myself not being a chatty person, talk with Donna has always turned out to be lively and fun.

-Tsuneyuki Ozaki (Institut national de la recherche scientifique - Énergie, Matériaux Télécommunications, Quebec, Canada)

Prof. Donna Strickland at the Symposium celebrating the 70th birthday of Prof. Gérard Mourou.

Who'd have thought? 2018 Nobel Prize in science to sort sperm by sex for the dairy industry?

In 2011, a dairy investor brought a challenge to the Photon Factory at the University of Auckland – can you find a better way to sort sperm by sex for the dairy industry? The solution uses the laser innovations of Strickland and Mourou, and the interactions of light with particles, that led to Arthur Ashkin's sharing the 2018 Nobel Prize with them. The idea of using laser light to nudge sperm cells inside of microfluidic channels is being commercialised by Engender Technologies, a company that won the 2016 AgTech medal in Silicon Valley and has just been acquired by a global player in the livestock industry. Key to Engender's success is (1) high-intensity, ultrashort pulse laser micromachining using the clever approach developed by Strickland and Mourou, and (2) the gentle "nudging" moving cells from one laminar flow stream with Ashkin's gradient and scattering forces. Engender's technology is still new. Over the next few years, Engender will develop technology to provide dairy farmers with the tools to grow their productivity without growing their herds, and thereby reducing the impact of dairy on the environment while feeding the world. The proof is in the physics – the path to high-tech, low-impact dairy is the science underpinning the 2018 Nobel Prize in Physics.

-Cather Simpson (The Photon Factory, University of Auckland, Auckland, New Zealand)

ON THE DISCOVERY OF NEW ELEMENTS (IUPAC/IUPAP PROVISIONAL REPORT)

Corresponding Author: Claes Fahlander, (Chair, Commission on Nuclear Physics (C12)- Claes.Fahlander@nuclear.lu.se)

What is the heaviest element that can exist in Nature? Slowly, but with persistence, nuclear physicists have pushed that question to extreme limits. The past few decades have seen a tremendous progress in experimental ingenuity and theoretical methodology to study and characterise heavier and heavier elements. The search culminated in 2016 when IUPAC and IUPAP acknowledged the discovery of the element 118, Oganesson, Og. With Og, currently the heaviest known element in the universe, the first seven periods of the Periodic Table of Elements is completed.

Foundation meeting of the 'Joint Working Group', JWG, in Egelsbach near Darmstadt, Germany, 20-22 May 2017. Left to right: Sigurd Hofmann (Chair), Sergey Dmitriev, Jacklyn Gates, Natalia Tarasova (2017 President, IUPAC), Bruce McKellar (2017 President, IUPAP), James Roberto, Hideyuki Sakai (Vice Chair), and Claes Fahlander (Chair IUPAP -C12)

When claims for the discovery of a new element is being put forward it is the important task of IUPAP and IUPAC to validate them. In 2016, on the initiative by the Presidents of IUPAP and IUPAC, Bruce Mckellar and Natalia Tarasova respectively, two important actions were being undertaken. First, it was decided to overlook the whole validation procedure. To this end a document has been produced: "IUPAC and IUPAP Procedures for Validating Claims for the Discovery of New Elements and Naming those Elements". Secondly, it was realised that the criteria and rules that are to be followed in the validation procedure also were in need of a revision. The old criteria were set down almost thirty years ago by the Transfermium Working Group, a group of scientists jointly appointed by the two unions. It was now decided to establish a new Joint Working Group, JWG, consisting of three members indicated by IUPAP and three by IUPAC.

A first meeting of the JWG was held in May 2017. One year later the report was submitted to the Presidents of IUPAP and IUPAC. It has been provisionally accepted by both unions, and recently also accepted for publication in the journal of Pure and Applied Chemistry. It is open for comment for 5 months.

Comments should be directed to both Presidents, and will be accepted up to 31 March 2019:
Kennedy Reed [reed5@llnl.gov], President of IUPAP
Zhou Qifeng [qfzhou@iupac.org], President of IUPAC

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REVISION OF THE INTERNATIONAL SYSTEM OF UNITS (SI)

Stephan Schlamminger (Chair, Working Group on Newtonian Constant of Gravitation – WG13) **and Peter Mohr** (Chair, Commission on Symbols, Units, Nomenclature, Atomic Masses & Fundamental Constants- C2)

On 16th November 2018, the 26th General Conference of Weights and Measures (CGPM) voted unanimously to revise the International System of Units, also known as the SI after the French name Système International d'Unités. The revision will go into effect on 20th May 2019, precisely twelve dozen (a gross) years after the original convention of the meter was signed by 17 signatory states. Currently, sixty countries are member states and another forty-two countries are associated members.

While individual parts of the system of units have been modified before, most notably the definition of the meter that was changed in 1983 to be based on a fixed value of the speed of light, the present revision is a more fundamental change of the unit system. In total, four units are affected by this revision, but more importantly, this revision alters the underlying philosophy of the unit system. Instead of relying on seven base units with various definitions, the revised system of units depends on seven constants of physics whose numerical values have been fixed. From these seven constants, the base units may be determined.

It is helpful to revisit the definition of the meter to understand the new concept defining the SI. The meter is defined such that c=299 792 458 "m/s" . A close inspection of this equation shows that it defines the meter. On the left side of the equation is a fundamental constant, the speed of light, which is given by the universe. The numerical value on the right side of the equation, has been assigned by us humans. The second, is given through another definition (related to the hyperfine transition frequency in cesium). So, the only free parameter is the length of the meter, which is hence defined. A characteristic of a constant that defines a unit is that it has no uncertainty associated with it. This is not true for the value of other fundamental constants, e.g., the Newtonian constant of gravitation, whose current value is given by $G=(6.674\ 08\pm0.000\ 31)\times10^{-11}\mathrm{m^3kg^{-1}s^{-2}}$ according to the website physics.nist.gov/constants that gives values recommended by the Committee on Data for Science and Technology (CODATA).

On November 16th, four additional constants were elevated into the circle of defining constants - the Avogadro constant N_A, the Boltzmann constant k, the elementary charge *e*, and the Planck constant *h*. From the Avogadro constant, the amount of substance measured in the unit mole can be obtained. The Boltzmann constant can be used to determine the unit of the thermodynamic temperature, the kelvin. The elementary charge can be used to obtain the unit of electrical current, the ampere. The Planck constant will lead to the unit of mass, the kilogram.

The previous definitions of the units were abrogated with the 16th November vote, effective on 20th May 2019. The international press focused mostly on the kilogram, which was defined via an artifact, the so-called international prototype of the kilogram (IPK). The IPK has been in use since 1889. However, the change of the unit of electrical current is even more substantial for the following reason.

The former definition of the ampere relies on the attraction of two current carrying wires which produced the electromagnetic interaction. Realizing this unit is challenging. With the prediction of a superconducting tunneling effect by Brian Josephson in

Figure 1 Gert Rietveld, chair of the consultative committee (CC) for electricity and magnetism (CCEM), talks at the 26th meeting of the General Conference of Weights and Measures (CGPM) shortly before the vote on the revision of the international system of units was taken.

1962 and the discovery of the quantum Hall effect by Klaus von Klitzing in 1980, electrical units could be realized more straightforwardly and more precisely by using these two quantum effects.

The Josephson Effect appears when, two superconductors are separated by a thin barrier and current passes through the barrier. This happens via tunneling in the presence of both a microwave field with the frequency f and a voltage of $hf/(2e)$ across the barrier. In the quantum Hall effect, a current through a 2-dimensional electron gas in a strong magnetic field produces a transverse voltage that is an integer fraction of h/e^2 times the current. The quotient $2e/h$, was named the Josephson constant and the quotient h/e^2 the von Klitzing constant to honor the prediction and discovery of the respective effects.

Electrical metrologists embraced both quantum effects to provide exact and stable values of the volt and the ohm. However, the dependence of the Josephson and von-Klitzing constants on the currently accepted values of h and e means that electrical devices would have to be calibrated every four years when new values of these fundamental constants are made available. In addition, the uncertainty in the measurements is smaller than the uncertainties of the values of the constants. The numerical values of fundamental constants are recommended by the Task Group on Fundamental Constants within the Committee on Data for Science and Technology (CODATA). In recent decades, the Task Group has recommended values for fundamental constants every four years. In 1990, the electrical community decided to fix the values of the Josephson and von Klitzing constant to the best values known at that time, and they have remained standard values up to the present. Hence, most electrical units are outside the SI, and these units are called conventional units to differentiate them from the SI units. The relative difference between the SI volt and the conventional volt has fluctuated by up to 1×10^{-7} in the years from 1990 to 2018. The relative difference between the conventional ohm and the SI ohm has fluctuated up to 2.2×10^{-8}.

With the CGPM vote, the conventional units were abrogated, and since h and e are fixed in the revised SI, the Josephson and von-Klitzing constants will also be fixed and can provide the basis for quantum electrical units in the revised SI. Electrical metrologists will not have to worry that the values of these fundamental constants will change again.

The quantum electrical effects play an essential role in realizing the kilogram in the new SI. Masses of order 1 kg can be realized via two independent methods, via the Kibble balance or via the X-ray Crystal Density (XRCD) method. The Kibble balance is a mechanical device that allows the comparison of mechanical power (weight times velocity) with electrical power (voltage times current). Electrical power is measured with the quantum effects discussed above as the product of two frequencies and the Planck constant. In the XRCD method, a single silicon crystal made of isotopically enriched silicon-28 is ground and polished into a perfect sphere. From a measurement of the sphere's diameter and the lattice spacing in silicon, the number of silicon atoms can be inferred. The mass of an atom of silicon-28 relative to the electron mass is well known. The mass of an electron is given by $m_e=2hR_\infty/(a^2\,c)$. In the end, this equation connects the mass of the silicon sphere to the value of the Planck constant. Note that the Rydberg constant R_∞ and the fine-structure constant α are known with small uncertainties, well below 1 part in 10^9.

The revised SI delivers a promise given before the French revolution to provide a set of units "for all times and for all people." Unlike an artifact, a fundamental constant of nature is believed to be stable in time. Furthermore, it is in principle, possible for everyone, given sufficient measurement resources and skill, to access the SI units. They do not depend on an object locked away in a vault as the international prototype of the kilogram was for the last 129 years.

Figure 2 The logo of the revised SI. The seven base units are obtained from seven defining constants shown on the inner circle.

Defining constant	Symbol	Numerical value	Unit
Hyperfine transition frequency of Cs	$\Delta\nu_{Cs}$	9 192 631 770	Hz
Speed of light in vacuum	c	299 792 458	ms^{-1}
Planck constant	h	$6.626\ 070\ 15\times10^{-34}$	$J\,Hz^{-1}$
Elementary charge	e	$1.602\ 176\ 63410^{-19}$	C
Boltzmann constant	k	$1.380\ 649\times10^{-23}$	JK^{-1}
Avogadro constant	N_A	$6.022\ 140\ 76\times10^{23}$	mo^{-1}
Luminous efficacy	K_{cd}	683	$lm\ W^{-1}$

Table 1 The seven defining constants of the SI.

CONSOLIDATING AND GROWING IUPAP MEMBERSHIP

Nithaya Chetty (Vice President at Large (New Members))

At its C&CC meeting held in Singapore on 03-04 May 2018, the IUPAP Executive Council resolved to develop a strategy which will be more proactive in attracting new members, while retaining existing members.

There are currently 56 members of the Union, up from 13 at the beginning of IUPAP, 95 years ago.

Driving new membership is not seen in isolation as a separate endeavor, but as an intrinsic part of consolidating the current membership and ensuring that all current members benefit from membership and see the importance of being a part of the Union.

Strengthening IUPAP marketing

A comprehensive survey on the membership is being drawn up, to determine, (1) members' satisfaction level, (2) areas of perceived strength, (3) areas of perceived weakness with suggestions for improvements, and (4) suggestions for new directions of growth. The survey will be circulated to members within the next 18 months and the findings will be reported to the next General Assembly. The outcomes of the survey will not only provide us with ideas to strengthen members' satisfaction but also to market the Union better to potential new members. The introduction of this survey is timely as it coincides with the recent establishment of the merged International Science Council and the upcoming IUPAP Centenary celebrations in 2022.

The accomplishments of the Union, including its illustrious history, need to be more widely marketed and communicated in a sustained manner, not only to member states, but broadly internationally through the website, newsletters, IUPAP-related meetings, etc. Here, the Commission Chairs have an important role to play in their engagements with the scientific community.

The mission and the goals of the Union must be clearly enunciated in public statements about the Union. Beyond scientific excellence, membership of the Union is closely coupled with the development of physics and hence the development of the country. The *International Year of Basics Sciences for Development* provides a natural opportunity to strengthen the role of physics for development. Physics is correctly portrayed as '*canary in the coal mine*' insofar as scientific development is concerned – when physics is weak, science and hence technology and development are weakened.

The Union must continue to be apolitical in its stance and closely align itself with democratic principles, openness, fairness, and commitment to equality and social justice. This is important and a necessary condition to enable us to reach out across political boundaries and to ensure the free circulation of scientists which are the corner stones of Union activity.

Reaching out to new countries

A detailed analysis of the physics outputs and key indicators for success in physics of all countries over the past decade is being undertaken. This is helping direct our efforts to engage with countries about joining the Union.

Obviously, accidental opportunities to engage with countries about joining the Union are always being actively pursued as a matter of course, and this is the basis of many a side-bar discussion at IUPAP-related meetings.

The cost for membership can, only under special circumstances, be ramped up over a grace period of two to three years to the full cost as a part of the negotiations for joining the Union. This can only be done if appropriate guarantees are put in place that the new member will, after the aforementioned grace period, pay the full amount due.

New members will be given the opportunity, to participate and express their views in the IUPAP General Assembly, to nominate members to commissions, working groups, etc., commensurate with their share and to propose the hosting of IUPAP-related meetings

We find that a useful way to engage with the governments of various potential member countries is to arrange to meet with the science attachés at embassies or high commissions. This has largely been an untapped potential and is the least costly means of initiating the conversations with high-level officials. Traveling to the potential member country to meet with key personnel will be considered only when circumstances permit, but only after sufficient advanced work has been done.

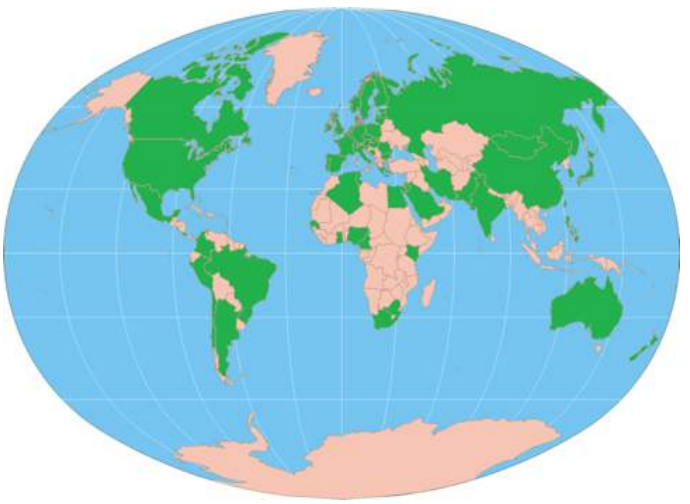
Before a new member joins the Union, sufficient background checks need to be conducted to ensure the commitment to funding for several cycles into the future.

Developing countries

Special focus is essential for developing countries and regions where a better understanding of physics and its needs is vital; particularly in regions that have been historically excluded. IUPAP is working closely with organizations such as the putative African Physical Society, the ASEAN Federation of Physical Societies, International Centre for Theoretical Physics, etc., to help drive IUPAP memberships.

Union activities must include strengthening physics research and collaborations in a sustained manner, enhancing mobility, driving education, interacting with governments, meeting with funding organizations, engaging with society and facilitating industrial cooperation. These activities are a pre-requisite to engaging with these countries and regions about joining the Union. In this area, C13 and C14 have an important role to play. The Union is taking an active lead in supporting and actively working with the Regional Offices on areas of common interest.

The option of two or three countries in a geographical region sharing a single share is being explored. A 50% discounted price for a single share is being afforded to countries listed on



Global membership distribution of IUPAP

the United Nations list of Least Developed Countries and/or physics nations that are deemed as being too small (e.g. countries with less than 100 physicists), pending, approval by the General Assembly.

There is an implicit understanding that the bigger physics countries will, through the IUPAP, aid in developing physics in smaller physics countries, thus enticing them to join the Union.

Final remarks

If we are confident in satisfying the needs of our current members, we will have a strong means for reaching out to potential new members. The Developing World is an important expansion area for the Union. The Union must be seen to be doing more now to reap the long-term benefits of new members from the Developing World.

Bringing in more young people into the activities and the affairs of the Union is an important way to ensure its long-term future.

Political cycles are short and people in positions of power move on quickly. What changes on a slower time scale is the body of scientists, and in here lies hope: IUPAP must continue to keep the body of scientists of non-member countries strongly coupled to IUPAP activities in the anticipation that their leaders will come around to prioritizing funds for membership.

THE 20TH INTERNATIONAL SYMPOSIUM ON VERY HIGH ENERGY COSMIC RAY INTERACTIONS (ISVHECRI)

Participants of ISVHECRI 2018

The 20th International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI) sponsored by the IUPAP was held at Nagoya University in Japan during 21–25 May 2018. Of 122 attendees (12% females) over 60% came from 18 overseas countries. 65 invited and contributed talks were presented in an interdisciplinary atmosphere. In the inaugural session Sunil Gupta (Chair, C4) mentioned the tribute paid to late Prof. Oscar Saavedra by C4 which was published in the June 2018 issue of the IUPAP newsletter (http://iupap.org/wp-content/uploads/2018/06/IUPAP-Jun2018-web-ilovepdf-compressed.pdf).

Following the long tradition of this symposium series, the main topics were properties of extensive air showers, secondary cosmic rays, and role of hadronic interactions in their interpretation. The scope of the symposium was expanded to include multi-messenger observations which included neutrino and gamma-ray astrophysics. New results from the Pierre-Auger Observatory and Telescope Array at highest energies, as well as from IceCube, Super-K, CTA, HAWC, and space-borne experiments AMS, Fermi, CALET were presented.

The relevance of cosmic ray interactions for addressing current problems in high-energy astroparticle physics from a multi-messenger point of view were discussed; for example, the propagation and production of positrons or anti-matter relevant to indirect dark matter search, or atmospheric neutrino production relevant to neutrino oscillations and neutrino astronomy. In this light, a new motivation to study cosmic ray interactions was established.

Improvements in several models of high-energy cosmic ray interactions, and their verification by accelerator measurements were an important highlight since they offer a unique opportunity for the developers of major interaction models, such as EPOS, SYBILL, QGSJET, DPMJET, and PYTHIA, to engage in valuable discussions.

Other highlights were the many interesting talks on accelerator data relevant to cosmic ray observations reported by large LHC collaborations as well as fixed-target experiments such as NA61. A comprehensive summary of forward measurements in ATLAS and CMS, remarkable progress achieved by LHCb SMOG gas-jet target measurements, and very forward measurements by CMS, CASTOR, LHCb, and LHCf were presented.

As a successful outreach activity, a public lecture on "Exploring the Invisible Universe" was delivered by Nobel Laureate Prof. Takaaki Kajita one evening with over 250 participants in the audience. The participants were also offered a tour of the advanced nuclear emulsion facility at Nagoya University.

On the final day, there were numerous discussions on future cosmic ray interaction studies. Hans Dembinski summarised future prospects in collider experiments of possible proton-oxygen run at the LHC to study very high energy interactions. The cosmic ray community is very enthusiastic about such a proton-oxygen program since even with a short run of 100 million events, the charged particle and pion spectra could be measured to 10% accuracy, a five-fold improvement over current model uncertainties. This will bring us a step closer to unveiling the mystery of cosmic accelerators of the highest energetic particles in the universe.

After a summary by Ralph Engel, the symposium closed with an announcement for the next ISHVECRI to be held at Ooty in India in June 2020.

PHOTO-PHYSICS OF ORGANIC-INORGANIC 2D PEROVSKITES

Jean-Christophe Blancon (2018 C8 YSP winner), Rice University, USA

The unique physics found in semiconducting nanomaterials and organic molecules is foreseen to be key in achieving the next frontier in optoelectronic and photonic technologies. Despite years of research such revolution has yet to happen, which can be explained by the lack of robustness at the scale of a practical device of the physics observed in those systems at the nanoscale and at the individual object level (such as the two dimensional physics observed in single-flake, monolayer materials). On the opposite end of the spectrum, the classic inorganic semiconductors such as silicon and III-V materials (e.g. GaAs usually in the form of artificial multi quantum wells) are still dominating the global high-tech market. Organic-inorganic (hybrid) two-dimensional (2D) perovskites, formed of nanometer-thick layers of perovskite stacked and separated one from another by insulating organic layers, has recently emerged as a new class of semiconductors which is at the cross-road of monolayer 2D semiconductors (such as MoS2, WS2, MoSe2, etc.) and inorganic artificial multi quantum wells. Indeed, while 2D perovskite semiconductors exhibit exciton 2D physics similar to monolayer of transition metal dichalcogenides, these materials can be also orderly assembled in a macroscopic device to make efficient semiconductor structures for light emission and photovoltaics.

To make hybrid 2D perovskites serious candidates for next generation semiconductor-based technology, the unique structural and physical properties related to the hybrid nature of their crystal lattice need to be understood. In particular, probing the fundamental properties of photo-excited states in these 2D materials is primordial to develop general models describing the physics of hybrid 2D materials as well as to understand the mechanisms at the origin of the 2D-perovskite-based optoelectronic devices. My studies have used optical spectroscopy and 60-Tesla magneto-absorption supported by modelling to elucidate the dependence of the formation, dynamics, and recombination of exciton states on the structural and compositional details of hybrid 2D perovskites.

The study of single hybrid 2D perovskite crystals has demonstrated strongly bound electron-hole pairs (excitons) in these materials with exciton binding energy of the order of a few milli-electronvolts. My work provides the first accurate measurement of the exciton reduced mass in hybrid 2D perovskites and reveals the scaling of the exciton properties (Fig. 1a) with varying perovskite layer thickness. More precisely, the exciton reduced mass and binding energy decrease, respectively, from 0.221 m0 to 0.186 m0 (m0 is the free electron mass) and from 470 meV to 125 meV with increasing 2D perovskite thickness from 0.65 and 3.1 nm. This work demonstrated that photo-generated carrier can still show excitonic behaviour up to a perovskite layer thickness of about 12 nm, and that this 2D exciton physics applied from the monolayer to bulk crystals of hybrid 2D perovskites which make this class of semiconductor promising for next generation optoelectronics making use of exciton physics.

The other important findings of my recent work was the discovery that in certain hybrid 2D perovskites, there exists a direct pathway allowing efficient dissociation of the excitons to free-carrier like entities, accompanied by energy relaxation of few hundreds of milli-electronvolts. This process takes place due to the presence of intrinsic low energy electronic states located at the edge-surfaces of the 2D perovskite layers (Fig. 1b). More importantly, the free charge carriers are longer-lived after being captured at the layer edge-surface states as they are protected from non-radiative decay mechanisms. Both these processes of exciton dissociation and protected free carriers are extremely beneficial for both carrier relaxation after light absorption and bright light-emission as these charge carriers can either be collected efficiently in a photovoltaic device or radiatively recombine in a light-emitting diode (Fig. 1c). These results have drawn interest in hybrid perovskite semiconductors for the understanding the role of emergent surface states and their role in improving the efficiency of optoelectronic devices.

More generally, hybrid halide perovskites are promising for next generation of energy and optoelectronic technology, it is crucial to develop the materials design principles enabling such technology in order to further improving the control of the transformation of matter and energy in these materials.

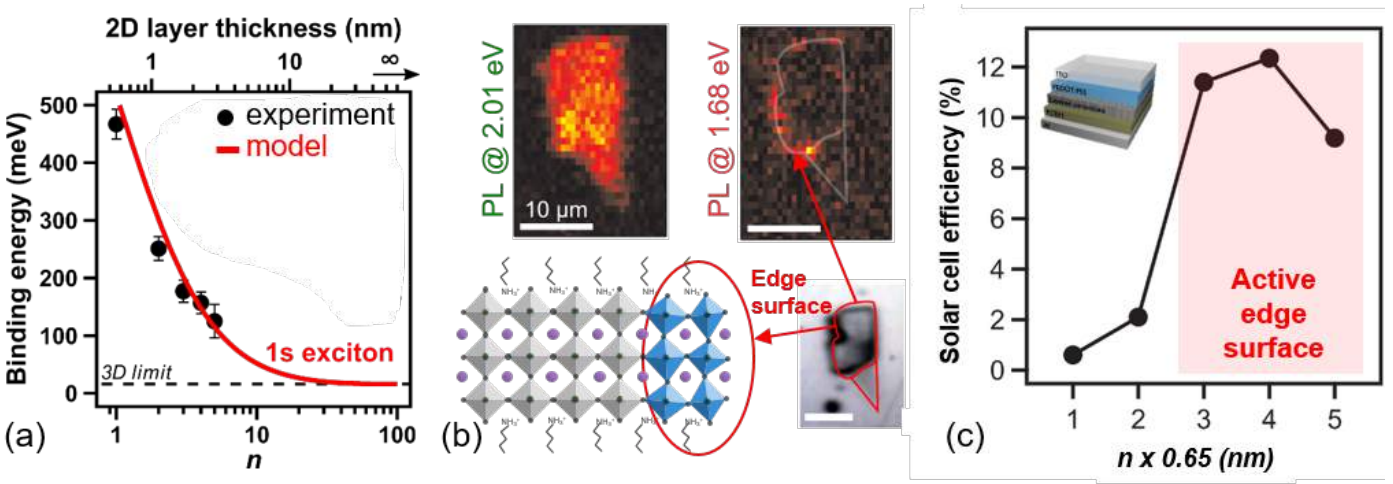


Fig. 1: Photophysics of hybrid 2D perovskites. (a) Scaling of the exciton binding energy with the perovskite layer thickness. n represents the thickness of the perovskite layers in terms of number of octahedra PbI6 units in the out-of-plane direction, where the perovskite real thickness is about n times 0.65 nm. (b) Observation of active edge-surface states in certain hybrid 2D perovskite due to local distortions at the edge of the perovskite layers. The top color pictures are maps of the photoluminescence (PL) detected at two wavelength. The bottom images sketch the location of edge-surfaces in 2D perovskite layers. (c) Proof-of-concept of efficient thin film solar cells with hybrid 2D perovskite as absorber.

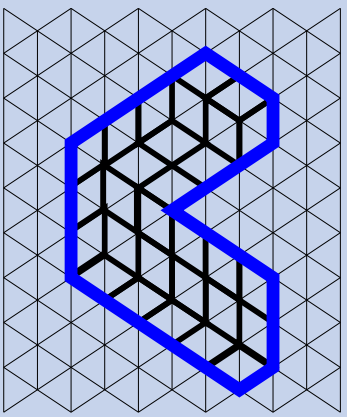
SURPRISING BRIDGES AND UNIVERSALITY IN EXACTLY SOLVABLE SYSTEMS

Vadim Gorin (2018 C18 YSP winner), MIT, USA

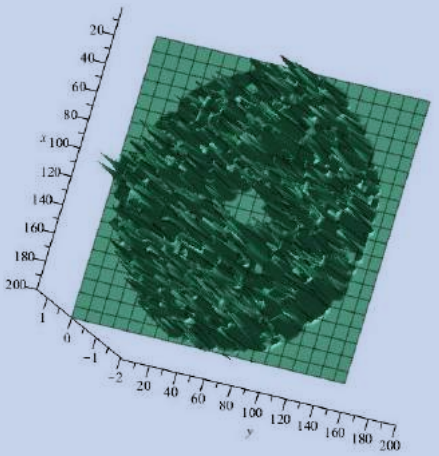
The central theme of the research of Vadim is the asymptotic analysis of large stochastic systems of 2d statistical mechanics and asymptotic representation theory. A unifying feature of the studied systems is the existence of exact formulas for the expectations of observables describing them, which paves a way for delicate limit theorems. The resulting theorems provide much more precise and refined information than those available for general situations. An important feature is that rather than being isolated examples, these systems become representing members of large universality classes, and therefore, their asymptotic analysis leads to exact predictions in a variety of situations, potentially reaching the real-world applications. Therefore, the research agenda of Vadim has two equally important components: finding new exactly solvable systems and types of their asymptotic behaviors on one side; developing more robust methods allowing extension of the results to wide classes of systems on the other side.

Let us mention two recent advances in the first component. The study of a particular stochastic case of the celebrated six-vertex (or square ice) model revealed the connection of its fluctuations to Tracy-Widom distribution (universal scaling limit for largest eigenvalues of random Hermitian matrices) in one regime and to a stochastic version of the classical telegraph equation in another regime. Investigation of gaps between swaps in the model of uniformly random sorting networks has led to a surprising appearance of another random matrix distribution - Gaudin-Mehta law (put forward by Wigner as a model for spacings between energy levels of heavy nuclei).

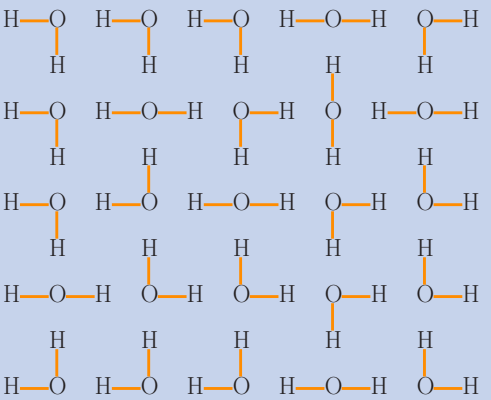
For the robust methods, recent development by Vadim and collaborators of a toolbox based on Schur generating functions and Nekrasov equations has led to the universal description of macroscopic fluctuations in discrete particle system by the two-dimensional Gaussian Free Field and its sections, confirming earlier predictions. This approach applies, in particular, to random lozenge and domino tilings, non-colliding random walks, measures governing decompositions of tensor products of representations into irreducible components. In a parallel and complementary work Vadim has demonstrated universality of the local correlations for random tilings and non-colliding random walks in a variety of situations.



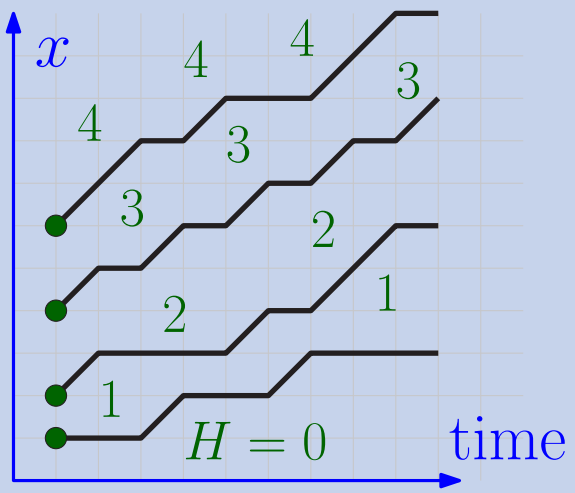
Domain 2



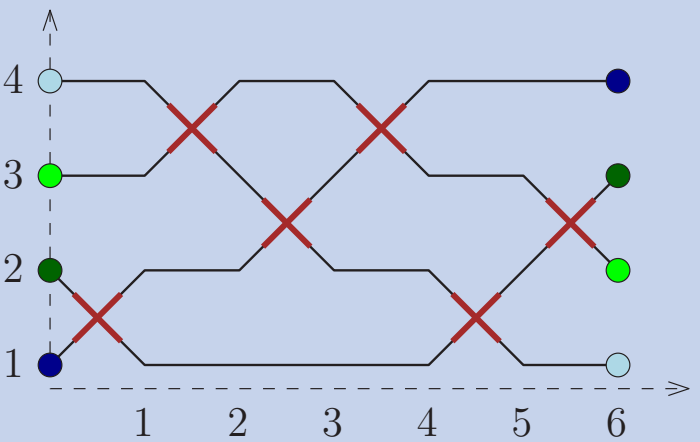
GFF Hole



Ice Model



Non-Col Heights



Wiring

NEW GENERATION PHOTOVOLTAICS

Giulia Grancini (2017 AC1 YSP winner),EPFL

I am a Team Leader at the École Polytechnique Fédérale (EPFL) Valais, awarded with the Swiss Ambizione Energy Grant, which provided me the ideal platform for leading a team and an innovative project at the forefront of energy research. My work focuses on the current scientific challenge of exploring the fundamental photophysical processes underlying the operation of advanced materials for optoelectronic application, with special attention to new generation photovoltaics. Solar energy promises to be a major electrical power source covering up to 20% of the global energy demand by 2050. To meet such expectations, a paradigm shift towards an innovative low-cost, efficient, and stable technology is paramount. Nowadays, organic and hybrid technologies, such as organic and perovskites solar cells, are revolutionizing the photovoltaic scene. However, poor device stability and still lack of knowledge on device physics substantially hampers their take-off. My research targets the fundamental scientific questions behind the operation of those nanostructured hybrid semiconductors to sustain a smart device development. To fulfill this goal, I exploited state of the art ultrafast spectroscopy to investigate the interface physics, core of the device function, both in polymer blends, hybrid polymer/oxide systems and hybrid perovskites. ***I contributed with pioneering work to the understanding of the ultrafast interface physics that governs the operation of organic and hybrid perovskite solar cells.*** Owing to these seminal work, I was awarded the IUPAP-ICO Young Scientist Prize in Optics 2017 for my ***"deep knowledge on photophysical properties and ultrafast light-induced dynamical processes***".

More in details, examples include the visualization of the charge transfer and exciton dissociation dynamics at polymer:fullerene (donor: acceptor) interfaces aiming at unveiling the primary events responsible for the interfacial charge generation mechanism [1]. By means of cutting-edge ultrafast spectroscopy systems with extreme time resolution (sub-10 fs) and broad spectral range, I demonstrated that charge generation occurs at ultrafast time scale, with a time constant of 30 fs, beating thermalization. On the other end, aiming at correlating the charge dynamics to the local scale, I have pioneered a new ultrafast confocal microscope in-house developed that enabled the dynamical imaging of the interface physics with simultaneous 150 fs temporal- and 300 nm space- resolution [2,3]. By linking the photoexcited state dynamics to the local environment I was able to highlight peculiar charge transfer state dynamics at polymer:fullerene interfaces, as well as, more recently, demonstrated how the local environment can impact on the electron-hole correlation and their dynamics in hybrid methylammonium lead iodide perovskites. With this regard, in particular, I have personally contributed to the significant explosion of hybrid perovskite solar cells unveiling the exceptional photophysical properties (i.e. nature and dynamics of photoexcited species, long carrier diffusion length) of the materials, as well as monitoring the interface dynamics in a working device [4]. More recently, my team and I have pioneered innovative concepts in perovskite materials and interfaces, with a special attention to new low-dimensional perovskites, which we utilized to develop world-record stable perovskite solar cells [5-7].

Understanding device physics behind state of the art efficient solar cell is currently the ultimate goal of the research of my team. This knowledge is essential to advance in device development in a timely manner. Controlling the material optical properties, interface photophysics, including those processes such as charge trapping and recombination crucial for optimizing the light to current conversion mechanism, is the subject of my present work. This will enable the take-off of next generation hybrid perovskites optoelectronics, for photovoltaics and beyond, involved in the photovoltaic action by developing state-of-the-art sub 10-fs ultrafast spectroscopy systems and the determination of the nature of the photoexcited species in hybrid perovskites and their dynamical evolution in the femtosecond/nanosecond timescale. In addition, I was very recently awarded the ERC Starting Grant 2018, which will be used to focus on the design of hybrid nanostructured multi-functional interfaces for advanced photovoltaics and the study of the physics therein.

1. G. Grancini et al. " Hot exciton dissociation in polymer solar cells" Nature Mater. 12, 29 (2013)
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3. G. Grancini,* et al. "Lattice Distortions Drive Electron–Hole Correlation within Micrometer-Size Lead-Iodide Perovskite Crystals" ACS Energy Lett. 2, 265 (2017)
4. S. Gharibzadeh, F. Valduga de Almeida Camargo, C. Roldán-Carmona, G. C. Gschwend, J. Pascual, R. Tena-Zaera, G. Cerullo, G. Grancini*, M. K. Nazeeruddin "Picosecond Capture of Photoexcited Electrons improves Photovoltaic Conversion in MAPbI3:C70 doped Planar and Mesoporous Solar Cells", Adv. Mater. 30 (40), 1801496 (2018)
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6. I. Garcia-Benito, C. Quarti, V. I. E. Queloz, S.Orlandi, I. Zimmermann, M. Cavazzini, A. Lesch, S. Marras, D. Beljonne, G. Pozzi, M. K. Nazeeruddin, G. Grancini* "Fashioning Fluorous Organic Spacers for Tunable and Stable Layered Hybrid Perovskites" Chem. Mater., DOI: 10.1021/acs.chemmater.8b03377
7. K. T. Cho, Y. Zhang, S. Orlandi, M. Cavazzini, I. Zimmermann, A. Lesch, N. Tabet, G. Pozzi, G. Grancini*, M. K. Nazeeruddin "Water-Repellent Low-Dimensional Fluorous Perovskite as Interfacial Coating for 20% Efficient Solar Cells" Nano Lett. 18 (9), 5467 (2018)

WOMEN IN PHYSICS (WG5) IN THE NEWS

It has been an interesting few months for women in physics with some high profile announcements, both good and bad. First, there was the award of the Breakthrough Prize to Prof. Dame Jocelyn Bell Burnell and her subsequent donation of the prize money to the UK's IOP to fund under-represented groups to become physics researchers. This was followed by the astonishing outburst at a CERN gender in physics event by Alessandro Strumia who claimed that physics was invented and built by men and that the system was biased towards women, with "evidence" to back it up. One trusts that his physics research follows more rigorous standards of research! It was heartening to see the rapid response across the physics community to denounce his statements. But one wonders how much damage is already done to those girls around the world who are already unsure whether physics is for them. As an antidote the next day there was the announcement of the Nobel Prizes for Physics, with Prof Donna Strickland becoming the first woman in 55 years to win it.

IUPAP continues to support women in physics, both in word and deed (see travel grants announcement), often, but not necessarily, through its Working Group on Women in Physics, WG5. One of those ways was the adoption of the resolution that Feb 11th be declared as the International Day of Women in Physics. We are launching this in 2019, 20 years after the setting up of WG5. It is a day to celebrate women in physics in the past, to support women in physics now and to inspire future women in physics. We'll be sharing activities globally through social media. So we invite all IUPAP committees and groups to work with their regional women in physics group and/or ICWIP country team to find ways of celebrating their local heroines and sharing it with the wider community.

Dr Gillian Butcher
Chair WG5

UPCOMING SUPPORTED CONFERENCES 2019

- **27 – 29 March 2019 Nepal**
  Second Regional Conference on Women in Physics – Nepal (RCWP-N 2019)
- **20 – 25 May 2019 Puebla, Mexico**
  LHC Physics Conference (LHCP 2019)
- **10 – 15 June 2019 Bari, Italy**
  18th International Conference on "Strangeness in Quark Matter" (SQM 2019)
- **10 - 14 June 2019 Tihany, Hungary**
  International Conference on Precision Physics and Fundamental Physical Constants (FFK-2019)
- **1 - 5 July 2019 Budapest, Hungary**
  GIREP-ICPE-EPEC– Eötvös Year 2019. (Research and practice in physics education to celebrate Eötvös centenary)
- **1 - 5 July 2019 Szeged, Hungary**
  International Conference on Attosecond Science and Technology (ICAST 2019)
- **7 - 12 July 2019 Valencia, Spain**
  22nd International Conference on General Relativity and Gravitation (22nd GRG)
- **7 - 12 July 2019 Valencia, Spain**
  13th Edoardo Amaldi Conference on Gravitational Waves (13th Eduardo)
- **8 - 12 July 2019 Buenos Aires, Argentina**
  27th International Conference on Statistical Physics (STATSPHY-27)
- **14 - 19 July 2019 Sapporo, Japan**
  International Conference on Phenomena in Ionized Gases (ICPIG 2019)
- **20 - 24 July 2019 Madrid, Spain**
  12th EBSA and 10th ICBP-IUPAP Biophysics Congress. Biophysics for Life and Technology (EBSA+10th ICBP-IUPAP)
- **21 - 26 July 2019 Seattle, WA, USA**
  30th International Conference on Defects in Semiconductors (ICDS 2019)
- **22 - 26 July 2019 Montreal, Canada**
  Quantum Theory and Symmetry (QTS 2019)
- **23 - 30 July 2019 Deauville, France**
  XXXI International Conference on Photonic, Electronic and Atomic Collisions (ICPEAC 2019)
- **24 July – 1 August 2019 Madison, WI, USA**
  36th International Cosmic Ray Conference (ICRC 2019)
- **29 July – 2 August 2019 Glasgow, UK**
  International Nuclear Physics Conference (INPC 2019)
- **5 - 10 August 2019 Toronto, Canada**
  International Symposium on Lepton Photon Interactions at High Energies (ISLPIHE 2019)
- **7 - 13 August 2019 Edmonton, Canada**
  International Symposium on Quantum Fluids and Solids (QFS2019)
- **10 - 17 August 2019 Cologne, Germany**
  International Conference for Physics Students (ICPS 2019)
- **25-29 August 2019 Hong Kong, China**
  31th IUPAP Conference on Computational Physics in 2019 (CCP2019)
- **1 – 5 September 2019 Carthage, Tunisia**
  ICO & IUPAP-C17 Topical Meeting on OPTIcs and Applications to SUstainable Development (OPTISUD 2019)
- **8 - 11 September 2019 Santiago de Chile**
  International Conference on Medical Physics (ICMP 2019)
- **8 - 13 September 2019 Zatoka, Odessa Region Ukraine**
  International Workshop on "Nanomagnetic Materials, Applications & Properties" (nMAP-2019)

- **9 - 13 September 2019 Aachen, Germany**
  23rd International Congress on Acoustics (ICA 2019)
- **9 - 20 September 2019 Nairobi, Kenya**
  Biophysical approaches to macromolecules and cells: integrated tools for life sciences and medicine (BAMC 2019)
- **9 - 13 September 2019 Toyama, Japan**
  16th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2019)
- **22 - 27 September 2019 Osaka, Japan**
  International Conference on Inertial Fusion and Science Applications (IFSA 2019)
- **21 - 25 October 2019 Costa Rica**
  XIII Latin American Symposium on Nuclear Physics and Applications (XIII LASNPA)
- **3 - 9 November 2019 Wuhan, China**
  Quark Matter (QM 2019)
- **2 - 6 December 2019 Sydney, Australia**
  2019 TeV Particle Astrophysics (TeVPA 2019)
- **15 - 20 December 2019 Portsmouth, UK**
  Texas Symposium on Relativistic Astrophysics (TEXAS 2019)

UPCOMING ENDORSED CONFERENCES 2019

- **23 – 26 January 2019 Vancouver, Canada**
  Testing Gravity 2019 (TGR 2019)
- **17 – 20 May 2019 Odense, Denmark**
  The Physics League Across Numerous Countries for Kickass Students (PLANCKS 2019)
- **15- 19 July 2019 South Korea**
  28th Annual International Laser Physics Workshop (LPHYS'19)
- **25 - 30 August 2019 Wilhelmshaven, Germany**
  6th International Conference on the Chemistry and Physics of Transactinide Elements (TAN 2019)
- **1 - 6 September 2019 Prague, Czech Republic**
  57th European High Pressure Research Group Meeting on High Pressure Science and Technology (EHPRG2019)

ANNOUNCEMENTS

Women in Physics (WG5) Travel Grants

We have received funding to launch a new round of the IUPAP Travel Grants Program. This program was created to help fund women from developing and low-income countries, who may not have another opportunity, to attend a regional or international conferences, workshop or school. We expect to be able to fund approximately 20 to 25 grants, depending on the amounts awarded, with a maximum of $750.00 or less per grant.

Grant applications should be received no later than March 8, 2019. Recipients will be selected by the IUPAP Working Group on Women in Physics by the end of April 2019, and all applicants will be notified of the outcome by the first week of May 2019.

Full information can be found at http://wgwip.df.uba.ar/2019_travel_grant.htm.

Working Group on Soft Matter (WG15) ISMC

The 5th International Soft Matter Conference (ISMC2019) will be held in Edinburgh, United Kingdom from 3-7 June 2019.
More information at: https://www.ismc2019.ed.ac.uk/