IUPAP International Union of Pure and Applied Physics

Newsletter

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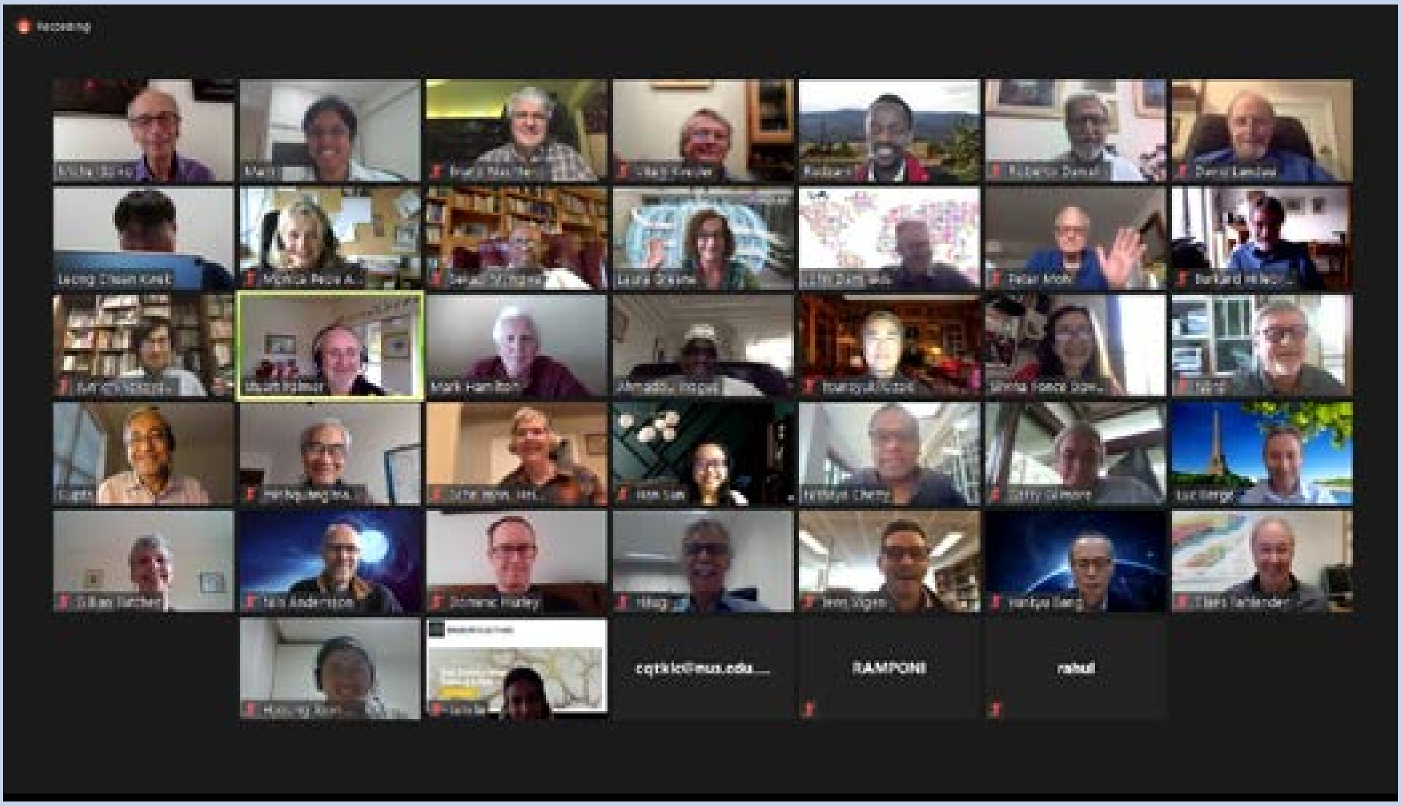
PRESIDENTS' NOTE



We are coming to the end of a very unusual year. In spite of the numerous difficulties that we have faced this year, we have made progress on several issues.

Remote Council and Commission Chairs meeting

We held our annual IUPAP Council and Commission Chairs meeting in October 2020. The meeting was remote and spanned four days over two consecutive weeks. This allowed us the ability to define time windows of no more than three hours, which could accommodate the time differences between regions and to allow participants to digest the outcome of each session before entering into a new one. The format was found to be adequate and fruitful; while attendance was a success (more than 40). We had observers from Physics Societies representing different regions, with the idea of implementing joint activities (i.e. teaching Physics in Africa, America, Asia and Europe). The International Association of Physics Students was represented and could soon become an Affiliated Commission of IUPAP.

Headquarters

It is the tradition that IUPAP rotates its headquarters (bank account, office, website, newsletter) from one continent to another. In the last six years, the administrative office and the website have been hosted at the Nanyang Technological University (NTU) in Singapore, the bank account has been associated with a company in Singapore and the Newsletter has been designed by World Scientific Publishing in Singapore as well. The agreement ends at the end of 2020. We would like to use this opportunity to change the model. We are looking for different, hopefully, permanent locations for the Office, the bank account and legal entity, the website host as well as the organization in charge of the Newsletter. The changes should occur during the year 2021, while we are hosted temporarily by a different institution in Singapore. This would make IUPAP more stable and in a better position to organize matters and stay global if the different locations are well-distributed.

We now have good contacts with a company in India to host the website. Given the advantages of having the financial office in a major international financial centre, it is likely that the financial office will move to Geneva or remain in Singapore. We are currently seeking a new institution to host the administrative office. Publication matters may still remain in Singapore. The matters relating to conferences will be handled by South Africa.

Strategic Plan

We circulated a first draft of the strategic plan with which we expect to enter a new century of existence. The draft was welcome and perceived to be timely. It received many comments from the Council, Commission Chairs and Members (Liaison officers). A group of three people (President, President Designate and Vice President at Large for the Centenary) was assigned the task to integrate all these comments and come back with a new version in the hope that it will be accepted by the next General Assembly. We should try to use this consultation procedure as a template for issuing position statements.

Member matters

We note and appreciate the excellent progress in IUPAP membership in the past twelve months and in the past ten years. We will try to get more involvement from our members in IUPAP affairs (strategic plan, joint activities) and listen to their wishes. Maybe a yearly remote meeting in between General Assemblies could be useful to this end. We will explore the possibility of expanding the different types of membership including the possible creation of new categories for companies, regional Physical Societies and Academies and individuals. In this way, we are seeking to widen our connection to the global physics community. Special attention will be paid to strengthening the connections with young physicists. All this would give new impetus to IUPAP as it enters its second century of existence.

Main decisions and discussions during the Council and Commission Chairs Meeting

- ***Conferences:*** Many IUPAP-sponsored conferences were held remotely in 2020. Some were deferred to 2021 and others were cancelled. Applications for sponsoring new 2021 conferences were also received. The Associate Secretary General Rudzani Nemtudi presented a plan for IUPAP conferences sponsoring in 2021. After intense and constructive discussions and iterations, a plan was unanimously approved. Special attention was given to getting reports after the conferences, to checking efforts related to gender balance, inclusiveness and worldwide access to the conferences (visas, on-line access…).

- ***Commission matters:*** Entering a new century, it is the right time to review the name and the mandate of IUPAP commissions and to explore the possibility of new commissions (Fluid Dynamics?) or affiliated commissions (History of Physics jointly with the International Union on Philosophy and History of Sciences and Technology and Physics students with the International Association of Physics Students). We would also like to establish a Young Interdisciplinary Prize with inputs from the community supported by more than one commission.

- ***Working groups***: The focus this time was on terms of reference and the composition of a new working group on Physics and Industry. The reason for that was that linking IUPAP with companies is a priority. We should explore all avenues to achieve this goal: by looking at the IUPAC model, the use of commissions and working groups to gain knowledge of their links with companies, using the links between IUPAP conferences and companies, a call-out for companies willing to sponsor Young Scientific Prizes, defining the status of Associate/Corporate member of IUPAP for companies among others.

- ***Projects:*** the continuation of projects like The Gender Gap (How to measure it, how to reduce it?), LAAAMP (Light sources for Africa, the Americas, Asia, Middle East and Pacific) should be continued and amplified. Agreements between many Unions, could be a good approach for that. The help of the International Science Council for that purpose would still be welcome.

- ***IYBSSD 2022***: IUPAP is leading the project of an International Year of Basic Sciences for Sustainable Development in 2022. This project received the support of about 30 International Unions and Organizations, 40 Academies, 25 Nobel Laureates, the World Science Forum and The Inter Parliamentary Union recently. The proclamation by the UN General Assembly has been recommended unanimously by UNESCO in its General Conference in November 2019. However, we did not succeed yet to bring the Resolution on the Proclamation to the Present UN General Assembly, due to its very restricted agenda caused by the Covid-19 Pandemics. We very much hope that we will succeed next year in getting the Proclamation. Due to the exceptional circumstances, the start of the International Year of Basic Sciences for Sustainable Development, initially planned for January 2022 may shift by 6 months or one year, depending on the timing of the Proclamation.

- ***Preparation of our Centenary:*** IUPAP will celebrate its centenary in 2022. Our Vice President at Large in charge of the IUPAP centenary, Monica Pepe-Altarelli gave her report. The centennial IUPAP symposium will be held in Geneva and will be live-streamed. We need a pool of communicators, using new communication tools, to help advertise the event. We need publicity material on IUPAP and the Centenary. We need to organize satellite events elsewhere in the world (we could use IUPAP-sponsored conferences). We need to involve members (through liaison officers) and non-member countries (developing countries). We need to reconstruct the IUPAP history (using our small archives) and use this opportunity to connect it to the Quantum Century initiative and more generally to the History of Physics.

Next General Assemblies

The next IUPAP General Assembly (GA) is slated for Beijing, October 20th to 22nd, 2021, instead of October 2020 which should have been the normal cycle but was postponed due to the Covid-19 pandemic. Commission members have been given extensions for one year. We hope to vote on new statutes and bylaws for IUPAP (they are in preparation), especially allowing for remote electronic meetings (yearly in between GAs and when needed) during the next GA. We would like to have the following General Assembly in 2023, in Paris or in Geneva, to celebrate the centenary of the first General Assembly in 1923. This could coincide or not with IYBSSD.

Nominations

The nomination procedure for the next General Assembly will be the same as before, except that Silvina Ponce Dawson is already acting as President Designate, Gillian Butcher is already acting as Vice President at Large and Gender Champion, Boris Sharkov (Deputy Director in JINR, Joint Institute for Nuclear Research) has been designated as acting designate Treasurer (new position that we will propose at the next GA), Laura Greene has been designated as acting Vice President at Large for Outreach and Ethics, and Jens Vigen (CERN) as Acting Deputy Secretary General for matters concerning the possible transfer of IUPAP Headquarters in Geneva and that the Commission chairs have already been designated (so that they get used to this position). The commission chairs designated at the GA 2023 will take office at the end of 2024.

Acknowledgements

The Council and Commission Chairs deeply and warmly thank Maitri Bobba and Sun Han, who ran the Office in Singapore in a way which forced our admiration. We used to call Maitri, our “*Shadow President*”!

Michel Spiro, *President of IUPAP*
Bruce McKellar, *Past President*
Silvina Ponce Dawson, *Acting President Designate*

In Memory of Prof Jorge Flores Valdés (1941-2020)

Sekazi K. Mtingwa, (Chair, C13)

IUPAP, friends and colleagues from around the world mourn the recent passing of Professor Jorge Flores Valdés, who was a towering figure in the international and Mexican physics communities. To recognize his many contributions to research, teaching, and service to physics, the IUPAP C13 Commission on Physics for Development bestowed upon Flores its Inaugural 2017 IUPAP Medal for Outstanding Contributions to the Enhancement of Physics in Developing Countries.

During his more than 50 years as a researcher, Professor Flores published over 100 papers, which have received over 3,000 citations. One of his most important research contributions has become known as the Brody, Flores et al. paper, which was published in 1981 in Reviews of Modern Physics and has received approximately 2,000 citations. His many research accomplishments earned Professor Flores Mexico's National Science Prize in 1994. His supervision of students resulted in some 30 theses, and many of his students have gone on to become key players in the Mexican scientific community.
According to one of his esteemed colleagues, Professor Susana Lizano Soberón, former President of the Mexican Physical Society (SMF):

The first position Professor Flores occupied for the development of Physics in Mexico was in 1959 when he was appointed Director of the Revista Mexicana de Física, the research journal of the SMF. After being Director of this journal for four years, he was elected President our Society. As president, he gave enormous importance to improving physics teaching in our country. In particular, two conferences devoted to elementary physics teachers were crucial to improve their lectures. In 1974, he was appointed Director of the Institute of Physics of the National University of Mexico (UNAM). He was head of the Institute during nine years, in which this institution became one of the most important science research centers in Mexico, and one of the most relevant physics centers in Latin America.

In recent years, he has been the General Coordinator of the Science Council of the President of Mexico. In this context, he has promoted many studies to determine which are the scientific fields in which our country can produce research of the largest relevance for science and also solve social problems in Mexico.

According to his UNAM colleague, Professor Luis F. Rodríguez:

He was one of the first important researchers that started emphasizing the importance of popularization and outreach at a time (the 1970s) where these activities were considered in Mexico more of a liability than an asset. He has given a large number of lectures and published several popularization books that have reached a vast non- specialized audience.

After serving as Director of the Institute of Physics of UNAM, he accepted the position of Education Undersecretary in the Government of the Republic. Science in Mexico was then (1982) passing through a very difficult time; the salaries were very low and many young people were moving abroad or simply not returning to Mexico. Dr. Flores came with the key idea of creating a system of additional salaries for the most productive researchers. His idea was concreted in 1984 with the creation of the Sistema Nacional de Investigadores (SNI) by the President of the Republic. It is not exaggerated to say that this initiative saved science in our country. Now the SNI provides a complementary salary for nearly 15,000 researchers and helps to create much more attractive working conditions .

He later accepted the compromise of starting inside the National University a science museum that could compete with private *museums already working successfully in Mexico. He was the founder and first Director of the Science Museum "Universum" that continues operating inside the Mexico City facilities of UNAM and receiving tens of thousands of visitors every year.*

Professor Flores' outstanding work in the popularization of science earned him the 1992 UNESCO Kalinga Prize. Indeed, Professor Flores will be dearly missed by his many friends and colleagues around the world. However, his enduring legacy will inspire generations to come.

In Memory of Prof. Mikhail Igorevich Panasyuk

Sunil K. Gupta (Chair, C4)

It was a sudden shock for us to learn that Prof. Mikhail Igorevich Panasyuk passed away on 3 November 2020 in Moscow. Prof. Panasyuk was an active member of C4 and his amiable nature made him a close friend for all of us. He was an outstanding scientist with broad interests which ranged from space physics to high-energy cosmic rays. Besides being a highly-acclaimed scientist, what was even more remarkable was that he was an excellent organizer who led some of the biggest scientific missions in Russia. He played a leading role in several high-impact space missions including Tatiana, Vernov, Lomonosov as well as ground-based high-energy experiments such as Tunka and TAIGA that led to several important discoveries.

Professor Mikhail Igorevich Panasyuk was also a very active member of the international scientific community, and his services as an expert, coordinator, promotor of science on different levels, and teaching of the next generation of scientists is the greatest legacy that he leaves behind. In particular, he was serving member of the IUPAP Commission C4 on Astroparticle Physics for the past six years, Vice-President of COSPAR, Chair of "Cosmic Ray" division of the Board of Russian Academy of Sciences, and many others. He devoted his entire scientific career to the same institution – Skobeltsyn Institute of Nuclear Physics (Moscow State University) which he headed as the Director since 1992 and where he remained active and productive right up to the end. But more importantly, his impact on international science will outlive him through the work of his students, his scientific discoveries, as well as the scientific experiments he designed, co-ordinated and supervised. His absence will be felt by all of his colleagues and especially by those of us in C4. Prof. Panasyuk contracted COVID-19 a few weeks before he passed away. Prof. Panasyuk was 75.

IUPAP statement on virtual conferences and worldwide accessibility

IUPAP strongly supports the following statement:

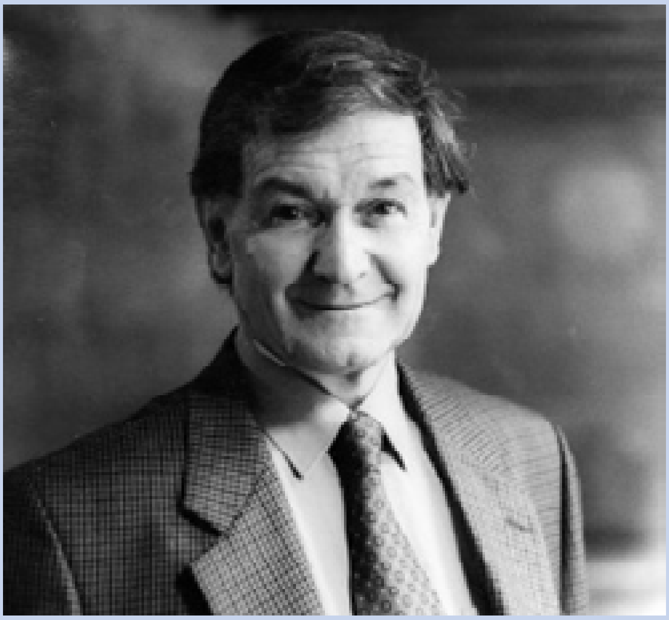
The International Union of Pure and Applied Physics (IUPAP), composed of members representing identified physics communities in 60 different countries, has promoted the international collaboration of physicists since its creation almost 100 years ago. The IUPAP has taken actions to facilitate this collaboration on the understanding that diversity and inclusiveness are key for the advancement of physics and science for the benefit of humanity. To this end, the IUPAP has always worked to ensure that the interaction between scientists can proceed even when relations between their countries are strained. Fostering the free circulation of physicists is one of the IUPAP's primary goals, and unhindered contact and communications is an important part of this ideal.

The Covid-19 pandemic and the lockdowns that have been enforced in various countries have changed the scientific landscape limiting the possibility of traveling and of having conferences or large gatherings of scientists. In 2020, many conferences were transformed into virtual activities. In this regard, having universal access to internet-based meeting platforms over which scientific conferences and meetings take place is critically important to ensure the advancement of the goals of the IUPAP. It has been noted that access to certain internet-based meeting platforms is restricted in some countries due to different regulations. These restrictions not only affect international scientific collaborations but will increase inequality which hinders the advancement of science across all communities.

In view of the above, the IUPAP calls on the organizers of scientific meetings and conferences to take accessibility restrictions into consideration and either choose platforms with global worldwide access or include more than one way to participate in the activities they organize. Virtual conferences will very likely continue after the pandemic is over, particularly, as a way to reduce the carbon footprint of scientific activities. It is therefore very important that this aspect be considered now for a more effective and widespread sharing of scientific knowledge.

Award of Nobel Prize to Roger Penrose - an appreciation of his contributions to general relativity

Nils Andersson (Chair, AC2)



This year's Nobel Prize in Physics was awarded to Roger Penrose "for the discovery that black hole formation is a robust prediction of the general theory of relativity" and Reinhard Genzel and Andrea Ghez "for the discovery of a supermassive compact object at the centre of our galaxy". The press release goes on to refer to Penrose's 1965 paper Gravitational Collapse and Space-Time Singularities as (a paper) "still regarded as the most important contribution to the general theory of relativity since Einstein". Indeed, despite known examples of singular solutions to the field equations, Einstein rejected their physical reality, writing that "singularities of the field are to be excluded". Until the 1960s, it was the prevailing opinion of most researchers that the known singular solutions were an artefact of the high degree of symmetry or were unphysical in some way. For this reason, the Penrose singularity theorem has been described as the first genuine post-Einsteinian result in general relativity.

As noted above, it was widely believed that singularities were not generic features of general relativity. This perception was backed by the work of Lifshitz and Kalatnikov who used a function counting argument which suggested that singular solutions contained fewer arbitrary functions than the general solution to the field equations and could therefore be regarded as of measure zero. All this changed when in 1965, Penrose published the first of the modern singularity theorems which considered gravitational collapse without assuming any symmetry assumptions. Despite its short length, only 3 pages, the paper introduced many of the concepts that continue to play a key role in our analysis and understanding of the structure of spacetime. Most importantly, he introduced the fundamental notion of a trapped surface. He then showed that if a spacetime possesses both a closed trapped surface and a non-compact Cauchy surface, then as long as the local energy density is always positive, so that via Einstein's equations the Ricci tensor satisfies the null convergence condition, the spacetime cannot be future null complete. The paper thus established the idea of using geodesic incompleteness to characterise a singular spacetime and showed for the first time that the gravitational singularity found in the Schwarzschild solution was not a result of the high degree of symmetry. So as long as the gravitational collapse qualitatively resembles the spherically symmetric case, in the sense that a closed trapped surface is formed, then deviations from spherical symmetry cannot prevent the formation of a gravitational singularity. The 1965 paper had immediate impact and inspired a series of papers by Hawking, Penrose, Ellis, Geroch and others which led to the development of modern singularity theorems. Of particular note are the Adam's prize essay of Penrose "An analysis of the structure of space-time", the corresponding essay by Hawking entitled "Singularities and the geometry of space-time" and the 1970 Hawking-Penrose singularity theorem which in the words of the abstract "implies that space-time singularities are to be expected if either the universe is spatially closed or there is an 'object' undergoing relativistic gravitational collapse (existence of a trapped surface) or there is a point whose p past null cone encounters sufficient matter that the divergence of the null rays through p changes sign somewhere to the past". The impact of the 1965 paper was not just in the result that singularities were a stable feature of space-time but just as importantly, in the new methods used to establish the result as demonstrated by the title of his 1972 monograph "Techniques of Differential Topology in General Relativity". In particular, the notion of closed trapped surface has had an enormous influence and continues to play a key role not only in understanding the physics of black holes, but also in numerical relativity and cosmology.

Since Einstein's equations break down at a singularity, it is not clear how the physics involved with the formation of a singularity will causally influence the future. In the case of the Schwarzschild solution, the singularity is hidden from the exterior region so this is not an issue outside the black hole. In his 1969 paper on gravitational collapse (which also introduced the "Penrose process" for extracting energy from a rotating black hole), Penrose suggested that this might be the general situation and asked "does there exist a cosmic censor who forbids the appearance of naked singularities, clothing each one in an absolute event horizon?" This is now called the weak cosmic censorship conjecture which states in essence that all singularities of gravitational collapse are hidden within black holes. However, without adding further conditions there exist counterexamples so the task in proving the conjecture is really one of finding a suitable formulation for which it is true. In 1979, Penrose introduced a second version of the conjecture, now called the strong cosmic censorship conjecture that simply put says that evolving a spacetime from generic initial data does not produce a singularity visible from infinity. Again, the main issue here is giving a suitable formulation for which it is true or for which there are counterexamples.

Apart from his contributions to our understanding of gravitational singularities, Penrose has made numerous other seminal contributions to the study of general relativity. Because of lack of space, I can only talk about these in general terms. One thread running through his work is the role of null geodesics and conformal geometry and in particular, how this manifests itself in understanding both the asymptotic structure and causal structure of spacetime. His first publication in this area was on the spinor approach to general relativity. This led to a number of publications with Ted Newman which introduced the NP formalism and applied this to the study of gravitational radiation. He then combined these ideas with the notion of conformal compactification to give a new description of null infinity. This enabled him to reformulate the expressions for the flux of gravitational radiation and the Bondi expression for mass-loss as well as obtain new conservation laws. The conformal description of infinity and the so-called Penrose diagrams illustrating the causal structure of the (compactified) spacetime are now a standard research tool. On a related note, his papers with Kronheimer and Geroch abstracted the causal structure of spacetime in terms of an event set with a partial order and used this to construct a description in terms of ideal points with both singularities and infinity as boundary points. This was part of a programme to not just prove the existence of singularities but also to understand their nature.

In 1967, Penrose devised twistor theory which attempts to unite ideas from space-time with the principles of quantum mechanics. Twistor space is a 3-dimensional complex projective space which, in a certain sense, is built from the spinor representation of a null line in Minkowski space. The basic idea is to encode information about massless fields defined on Minkowski space into complex analytic objects on twistor space via the Penrose transform. Thus, information about fields satisfying partial differential equations is encoded in the geometry of twistor space. The transform involves computing contour integrals of holomorphic functions (representing the free data) on regions in twistor space. In 1976, the correspondence was generalised to give a solution of (anti-)self-dual solutions Einstein's equations in terms of data on curved twistor space. However, one would really like to have a single description that allows for both self-dual and anti-self-dual solutions which can then be combined to give the general solution but, despite considerable effort, limited progress has been made in achieving this. However, the mathematics generated by twistor theory is very rich and has had many fruitful applications in physics. These include the definition of quasi-local mass in general relativity, the ADMH construction of Yang–Mills–Higgs monopoles and the very active area of twistor string theory which has been used to compute scattering amplitudes in gauge theories.

The limited space available prevents mentioning the full range of Penrose's research. In particular, I have not mentioned quasi-periodic tiling, the Weyl curvature hypothesis and his work on cyclic cosmology nor his thoughts about the role of gravity and the reduction of states in quantum mechanics. He has also written extensively about computing and consciousness, ideas which developed from his book "The Emperor's new Mind". However, I would like to end by saying something about how I first got to know about the work of Roger Penrose. It was long before I knew anything about general relativity and was not on the topic of mathematical physics at all. It came from looking at the "Ascending and Descending" staircase lithograph by M C Escher that was based on the impossible triangle of Penrose which he devised in 1958 and was published in the British Journal of Psychology. Penrose's love of geometry clearly extended beyond mathematical formulae and a distinctive feature of many of his papers and talks are the wonderful diagrams that enable him to describe four-dimensional geometry using two-dimensional drawings.

The Nobel Prize for Black Hole Physics

Prajval Shastri (Member, WG5)

https://en.wikipedia.org/wiki/Creative_Commons

Reinhard Genzel

https://en.wikipedia.org/wiki/Creative_Commons

Andrea Ghez

For the third time in five years, the Nobel Prize in Physics has landed in the astrophysics arena, to Roger Penrose for the most important follow-up discovery to the Theory of General Relativity (see preceding article), and to Reinhard Genzel and Andrea Ghez for the first direct evidence for black holes.

Evidence that Black Holes are Real

Enormous dense stars with escape velocity equal to the speed of light, and therefore "dark", were imagined in the 18th century. The implied sizes were in fact formally consistent with the Schwarzschild "singularity" solution to the General Relativity field equations. Subsequently, Oppenheimer and Snyder correctly interpreted the Schwarzschild "singularity" as the "horizon" of no return of a gravitationally collapsed object, from which no information could emerge.

Such objects were perceived as mere mathematical constructs, however, until the discovery of cosmic objects called quasars in the early 1960s. Quasars shone star-like, but were very far away, and therefore with luminosities a hundred times that from all the stars in a typical galaxy – tough to produce from stellar processes alone. Even more bewildering, this luminosity varied on time-scales of weeks or even days. From the light-travel-time argument it followed that the luminosity must originate from a region of about 1000 Astronomical Units or less. Only a mass of about a million solar masses could counter the resulting radiation pressure. Edwin Salpeter, and independently, Yakov Zel'dovich and Igor Novikov then suggested, that the release of the rest-mass energy of matter swirling into the horizon of such an object could explain the enormous luminosity.

This possible reality of "Schwarzschild throats" spurred physicists to re-examine gravitational collapse into a singularity and indeed impelled Roger Penrose's Nobel-winning discovery. Concomitantly, extensive investigations of these super-powerful and compact light beacons led to the conclusion that they actually inhabited galaxies – some of them had originally appeared star-like only because they outshone the stellar light from their host galaxies. While there was a fairly dominant perception that these galaxies with "active" central black holes were pathological, Lynden-Bell propounded that supermassive black holes occurred in the centres of all galaxies including the Milky Way. The evidence remained circumstantial, however.

The challenges in obtaining direct, i.e., dynamical evidence for black holes, such as a mass estimate from Keplerian orbits of stars, were several. Firstly, purported supermassive black holes outside the Milky Way are simply too distant to discern individual stars. Secondly, the centre of the Milky Way is shrouded by dust. Thirdly, even the sharpest images fell short for the centre of the Milky Way which is 26000 light-years away, because the refractive index fluctuations in the turbulent atmosphere make the photons from the cosmos dance around in the detector (a.k.a. twinkling of stars), blurring the image.

Infrared radiation could penetrate the dust shroud, however, and evidence for rapidly moving stars began to accumulate via IR spectroscopy. Reinhard Genzel and collaborators measured the Doppler shift of the 2.11μm HeI emission line, implying high velocities of stars in the line-of-sight. Something dark and dense at the centre was clearly implied, but confirmation required the three-dimensional velocity vector for the stars, and therefore speeds from precise position shifts of the stars in the sky with time – needing sharpness of images of about 50 milliarcseconds – like reading a newspaper from 15 km away.

The breakthrough was the ability to image the stars faster than the atmospheric turbulence shifted them around (i.e. exposures of a fraction of a second). The 10m Keck Telescope atop Mauna Kea in Hawaii that Andrea Ghez and her team used, could instantaneously collect a lot of photons which was key to this technique of 'speckle imaging' – which Genzel and team also used with the telescopes in La Silla, Chile. Over 40 stars tracked by Eckart and Genzel and 90 stars by Ghez and her team showed stellar speeds upto 1400 km s-1, which was definitive dynamical evidence for the driving central object being a black hole of over 2 million solar masses.

A decade on, another breakthrough enabled correcting for the distortions created by atmospheric turbulence in real time by compensatory deformation of the telescope mirror – i.e., 'adaptive optics'. More and fainter stars could be therefore measured. Spectroscopy of the Br-γ absorption line gave line-of-sight stellar speeds as well, and therefore velocity vectors for the Keplerian orbits. The case for a real supermassive black hole there was thus confirmed beyond doubt.

The Gendered Nobel Prize

Andrea Ghez is only the fourth woman to win the Nobel Prize in physics, which has attracted much comment, starting with journalists right at the prize announcement. In a discipline that prides itself on being the "most objective", and in a practice that claims to acknowledge seekers of truth purely based on the merits of their argument, why is a practitioner's gender relevant at all, and making media headlines? Clearly, as the data show, the meritocracy is flawed. Indeed, the gender-fraction statistic is even more disturbing if the time-gaps are considered: While the first woman physicist (indeed the first woman to win any Nobel at all) was Maria Sklodovska Curie, as early as in 1903, the next had to wait six decades (Maria Goeppert-Mayer, 1963) and the third, another 55 years (Donna Strickland, 2018). Andrea Ghez embarked on the quest for the giant central black hole in the Milky Way, armed with the technique of speckle interferometry that she mastered during her PhD. She has said "I grew up hearing the word 'No' all the time. You are a girl, you can't do it. You are a girl, there is no way you can get into MIT…into CalTech." Her experience is only an example (though a stark one, now that she is a laureate!) of what girls and women experience all the time worldwide, persistently and across cultures. Little wonder that Ghez dedicated her PhD dissertation to "…all the women scientists I have known." Compared to Curie's or even Goeppert-Mayer's time, there is considerable debate and discussion on barriers to gender equity within our profession today, which doubtlessly is a step in the right direction, and indeed the IUPAP WG5 is at the vanguard of these efforts. It is crucial, however, to acknowledge that the barriers within physics are every physicist's s problem. The data make evident that the gender-bias barrier rises highest in selection processes to leadership positions and honours lists at the cost of disregarding scientific merit. But worse is the tendency in the profession, to perceive considerations of the gender-diversity in selection processes as a "pressure" (by both men and women). It is high time there is a shift – to viewing positions on selection and nomination committees as an opportunity and a privilege, to correct historical injustices that only have had negative impact on our profession for centuries now.

Conclusion

The prize-winning research continues to go a notch up further in precision with the use of the interferometry. The measurements have now gone well beyond Keplerian orbits, have confirmed deviations from Newtonian predictions and are testing General Relativistic predictions. The centre of the Milky Way is thus an extraordinary laboratory for General Relativity and also the physics of star formation and evolution in a strong-gravity environment, which is poised to radically widen our horizons.

Prajval Shastri is an astrophysicist (retired from the Indian Institute of Astrophysics), a member of the Women in Physics Working Group of IUPAP and Chair of the Gender in Physics Working Group of the Indian Physics Association.

Exploiting the power of variational principles for magnetic fusion

Joaquim Loizu (2020 – C16 YSP winner) Ecole Polytechnique Fédérale de Lausanne, Switzerland

In magnetic fusion, stellarators are the leading alternative to the tokamak in the quest for generating controlled fusion energy [1]. Stellarators offer two clear advantages: they naturally operate in steady-state and they are much less prone to violent current-driven instabilities, both due to the reduced plasma current.

The calculation of macroscopic, magnetohydrodynamic (MHD) equilibria in 2D configurations such as tokamaks is relatively simple since magnetic surfaces are guaranteed to exist. However, their existence is not guaranteed in 3D. While stellarators can be designed to possess magnetic surfaces in vacuum with exceptional accuracy [2], the necessary existence of plasma currents that maintain force-balance at finite plasma pressure engenders the potential destruction of these surfaces. Moreover, pressure-driven neoclassical (bootstrap) currents, even if small, can also perturb the magnetic topology of the equilibrium. 3D MHD equilibria thus generally consist of an intricate combination of magnetic surfaces, magnetic islands, and magnetic field-line chaos. Their accurate computation is a fantastic, outstanding challenge that is of paramount importance for the understanding of stellarator particle and energy confinement, macroscopic stability, as well as for the correct interpretation of experimental measurements. The Stepped-Pressure Equilibrium Code (SPEC) code has been developed as one possible approach to fulfill this highly non-trivial task [3]. SPEC is based on a variational principle that finds equilibria as minimum energy states, $\delta W = 0$, of a plasma potential energy, W, subject to constraints on, e.g., the pressure and current profiles. During minimization, the plasma is allowed to undergo magnetic reconnection and therefore the resulting equilibrium can present magnetic islands as well as regions of magnetic field-line chaos. The variational formulation of the problem allows using fast numerical methods (e.g. Newton methods) to quickly find energy minima. Furthermore, variational principles directly provide information about the stability of equilibria via the sign of $\delta^2 W$ [4].

A key question is what sets the maximum achievable pressure in the plasma – the so-called δ-limit, where δ is the ratio of plasma pressure to magnetic pressure and this ratio is usually highest in the core (at the magnetic axis). In tokamaks, the δ-limit is set by stability, in the sense that above a critical value of δ violent MHD instabilities arise and preclude the maintenance of a confined hot and dense plasma volume. In stellarators, however, it is often the case that the δ-limit is set by the MHD equilibrium itself, in the sense that above a critical δ the magnetic surfaces degrade (into regions of islands and subsequently large seas of magnetic chaos) and preclude the maintenance of a confined hot and dense plasma volume.

In view of understanding the basic mechanisms and parameter dependencies of the equilibrium δ-limit in stellarators, the SPEC code was used to study a sequence of classical stellarator MHD equilibria at increasingly high δ. Classical stellarators are essentially ellipses that rotate poloidally as one moves toroidally, with a discrete symmetry given by the number of field periods Np (Figure 1).

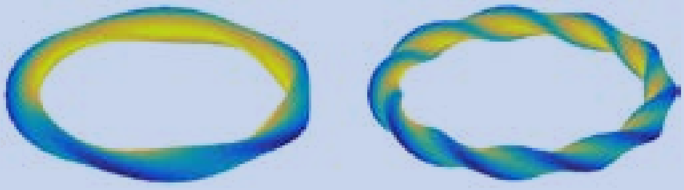


Figure 1. A magnetic surface in a classical stellarator with Np = 5 (left) and Np = 10 (left). Colour indicates the amplitude of B on the surface. [7]

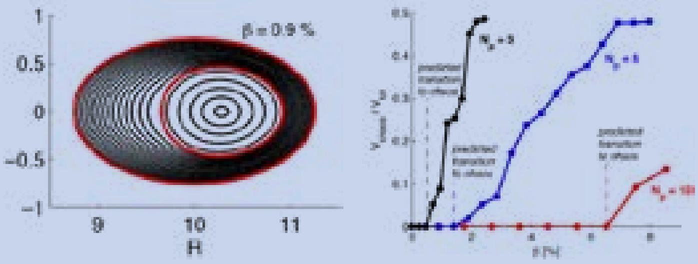


Figure 2. Volume of magnetic chaos as a function of ß. On the right, Poincaré maps of the field-lines for ß below and above the ß-limit (Np=5). [7]

At each value of ß, an MHD equilibrium was obtained with SPEC and the volume of chaos measured (Figure 2). This can be done by calculating the fractal dimension D_{frac} of field-lines, which suddenly becomes larger than 1 when the field-line becomes chaotic and does not foliate a toroidal surface anymore. Results showed that there is a critical ß above which chaos emerges [5]. Analytical theory was also developed and was able to predict the value of ß at which the transition to chaos is observed. These results open the way to characterizing the equilibrium ß-limits in present and future stellarator experiments.

[1] P. Helander et al., Plasma Physics and Controlled Fusion 54, 124009 (2012)
[2] T. Sunn Pedersen, Nature Communications 7, 13493 (2016)
[3] S. R. Hudson et al., Physics of Plasmas 19, 112502 (2012)
[4] J. Loizu et al., Physics of Plasmas 27, 070701 (2020)
[5] J. Loizu et al., Journal of Plasma Physics 83, 715830601 (2017)

YOUNG SCIENTIST PRIZE WINNER 2021

The Commission on Structure and Dynamics of Condensed Matter (C10)

Andrew Potter

"For Fundamental Contributions to the Theory of Many-Body-Localization and Non-Equilibrium States of Quantum Matter"

Dr. Andrew Potter, is an Assistant Professor of Physics at The University of Texas at Austin. His research explores the intersection of quantum- materials, dynamics, information and computing, focusing on emergent phenomena, topology, and quantum criticality both in- and far from- thermal equilibrium. Following undergraduate studies at Brown University, he obtained a PhD in theoretical condensed matter physics from MIT in 2013, and previously worked as a Gordan and Betty Moore Foundation Postdoctoral Fellow at UC Berkeley, and as a research scientist at Honeywell - Quantum Solutions.

YOUNG SCIENTIST PRIZE WINNERS 2020

Commission on Atomic, Molecular and Optical Physics (C15)

Philipp Hauke

"For his outstanding contributions to the development of quantum technologies based on Atomic, Molecular and Optical systems, ranging from quantum annealing, over quantum metrology, to quantum simulations of strongly-correlated condensed-matter systems and lattice gauge theories."

Philipp Hauke received his PhD in 2013 from ICFO – The Institute of Photonic Sciences, Castelldefels, Barcelona. Afterwards, he held positions as University Assistant at the University of Innsbruck and as group leader at Heidelberg University. In fall 2019, he became Associate Professor at the INO-CNR BEC Center and the Physics Department of the University of Trento. His research focuses on developing the theoretical basis for novel quantum technologies. The vision is to harness the pristine control available in synthetic quantum systems such as cold atoms, trapped ions, superconducting qubits, or photonic devices for solving outstanding problems of practical relevance. Philipp Hauke's group develops methods to characterize and measure entanglement as a quantum resource, derives algorithms to solve hard NP-complete problems through quantum annealing, and designs quantum simulations of strongly-correlated systems.

Commission on Plasma Physics (C16)

Joaquim Loizu

"In recognition of his seminal work in the fundamental understanding of three-dimensional magneto-hydrodynamic equilibria and of the interaction of a plasma with a solid wall."

Joaquim Loizu is a researcher and lecturer at the Swiss Plasma Center (SPC) of the École Polytechnique Fédérale de Lausanne (EPFL). He graduated in Physics from EPFL in 2009, carrying out his master thesis project at the Center for Bio-Inspired Technology, Imperial College London, on the theoretical and numerical study of the biophysics of light-sensitive neurons. He then joined the SPC for his doctoral studies on "The role of the sheath in magnetized plasma turbulence and flows" and obtained his PhD in 2013. After that, he spent one year at the Princeton Plasma Physics Laboratory and one year at the Max-Planck-Institute for Plasma Physics (IPP) in Greifswald. During this time, he worked on 3D MHD, studying the formation of singular currents and magnetic islands at rational surfaces. In 2016, he obtained an EUROfusion Postdoctoral Fellowship to carry out research at IPP-Greifswald, focusing on the computation of 3D MHD equilibria in stellarators. In 2018, he joined the SPC as a Scientist. He is also one of the leaders of the Simons Collaboration on Hidden Symmetries and Fusion Energy. His current research interests include MHD equilibrium and stability, magnetic reconnection, self-organization, non-neutral plasmas, plasma sheaths, and plasma transport in chaotic magnetic fields.

International Commission on Medical Physics (AC4)

Jaydev Dave

"For his pioneering work in utilizing subharmonic signals from ultrasound contrast agents (encapsulated microbubbles) for non-invasive real-time in vivo cardiac pressure estimation."

Jaydev Dave was born in Mumbai, India. He earned his BE degree in Biomedical Engineering from Mumbai University, India, in 2006, and his MSc and PhD degrees in Biomedical Engineering from Drexel University, Philadelphia, PA, in 2008 and 2012, respectively. He is currently an Associate Professor of Radiology at the Thomas Jefferson University in Philadelphia, PA. Jaydev is actively involved in ultrasound and applied physics research.

Dr. Dave's extensive research portfolio spans different areas of medical physics. The primary focus of his research has been in a non-traditional application that he has engineered – using subharmonic ultrasound technology with microbubble contrast agents to perform non-invasive real-time pressure estimation, as a means for replacing manometer-tipped catheters, especially for cardiac applications. As a principal investigator, he has led and completed two national clinical trials investigating the use of subharmonic signals for cardiac pressure estimation. For his research, Dr. Dave has received funding and support from the National Institutes of Health, the American Heart Association and industry partners. Additionally, his scientific research is also related to his clinical imaging physicist role, majorly looking at the interplay between radiation dose and image quality. To date, his research has cumulated to several conference abstracts (100+), published conference proceedings (18), and peer-reviewed publications (35).

In addition to his research, Dr. Dave has been active in mentoring and teaching, with national and international teaching appointments/ visiting professorships. He serves as a scientific reviewer for 17 scientific journals, and has also been called upon to act as an expert reviewer for national and international foundation grants, inter-society consensus documents, and draft standards. He has received numerous awards including the award for "Research excellence in recognition of outstanding dedication and achievement in heart disease and stroke research" from the American Heart Association (2015), "Dean's award for excellence in education at Sidney Kimmel Medical College" from the Thomas Jefferson University (2017), and "Young Alumni – Emerging Leader Award" from the Drexel University (2020).

He is currently a member of the American Association of Physicists in Medicine, the American College of Radiology, the American Heart Association, the American Institute of Ultrasound in Medicine, the IEEE and IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society, the International Contrast Ultrasound Society and the Society of Photo-Optical Instrumentation Engineers. In his free time, he enjoys open-water long-distance swimming!

XXXIV International Conference on Phenomena in Ionized Gases and 10th International Conference on Reactive Plasmas, held in Sapporo, Hokkaido, Japan from 14/07/2019 - 19/07/2019, discussed the new trend of plasma material processing such as plasma-assisted inkjet printing and etching profile optimization using machine leaning. Novel applications such as plasma metamaterials were impressive topics. Another recent trend of low-temperature plasma science and technology is atmospheric-pressure plasmas. A lot of studies on precise diagnostics and applications of atmospheric-pressure plasmas were displayed at the conference. Furthermore, it highlighted the progress in interaction between atmospheric-pressure plasmas and liquids.

Quantum Theory and Symmetry, held in Montreal, Canada from 05/07/2019 - 09/07/2019 was well attended. It brought together the physicists and mathematicians working on the topics of symmetry, including the geometrical methods (classical and non-commutative), group theory, Lie and nonlinear algebras, in the framework of their possible applications in modern quantum physics.

CONFERENCE REPORTS – 2020

Large Hadron Collider Physics (LHCP), held virtually from 25/05/2020 - 30/05/2020, was a platform where several new and important results were presented for the first time at the conference. These included, among others, the first observation of the combined production of three massive vector bosons by CMS and evidence of four-top-quark production reported by ATLAS. These results and additional highlights are summarized in an article in the CERN Courier: https://cerncourier.com/a/lhc-physics-shines-amid-covid-19-crisis/. The LHCP2020 was originally scheduled to be held in Paris but has now been postponed to 2021. The IUPAP funds received for LHCP 2020 have been retained and will be used for LHCP2021. Since the conference this year was held virtually, no real "host" country exists, but since the virtual conference was held under the aegis of CERN, Switzerland is assumed to be the host country when counting the number of participants from outside.

XXIX International Conference on Neutrino Physics and Astrophysics (Neutrino 2020), held virtually from 22/06/2020 - 02/07/2020 showcased observations of CNO solar neutrinos, new limits of neutrino-less double beta decay and sterile neutrinos and new data on neutrino oscillations. https://cerncourier.com/a/neutrino-2020-zooms-into-virtual-reality/. Since the conference was virtual, no registration fee was collected. All funds from Conference sponsors (including IUPAP) was refunded.

UPCOMING SUPPORTED CONFERENCES 2021

C2: Commission on Symbols, Units, Nomenclature, Atomic Masses & Fundamental Constants

- International Conference on Precision Physics and Fundamental Physical Constants (FFK – 2021)
  24 – 28 May 2021, Stara Lesna, Slovakia
- The International Conference on Precision Physics of Simple Atomic Systems (PSAS 2020) – **Deferred from 2020**
  10 – 15 May 2021, Wuhan, China
-

C3: Commission on Statistical Physics

- The 6th International Soft Matter Conference, (ISMC2021)
  12 – 17 December 2021, Osaka, Japan

C4: Commission on Astroparticle Physics

- 9th Very Large Volume neutrino Telescopes (VLVnT) – **Deferred from 2020**
  20 – 25 April 2021, Valencia, Spain
- 21st International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI 2020) – **Deferred from 2020**
  Date to be confirmed, Ooty, TN, India
- 16th Patras Workshop on Axions, WIMPs and WISPs
  14 – 18 June 2021, Trieste, Italy
- 37th International Cosmic Ray Conference (ICRC – 2021)
  15 – 22 July 2021, Berlin, Germany
- 17th International Conference on Topics in Astroparticle and Underground Physics (TAUP – 2021)
  30 August – 03 September 2021, Valencia, Spain

C5: Commission on Low Temperature Physics

- International Symposium on Quantum Fluids and Solids (QFS – 2021)
  9 – 14 August 2021, Hokkaido, Japan

C8: Commission on Semiconductors

- International Conference on the Defects of Semiconductors 2020 (ICDS 2021)
  26 – 30 July 2021, Oslo, Norway

C9: Commission on Magnetism

- International Conference on Trends in Magnetism (ICTM 2020) – **Deferred from 2020**
  6 – 10 September 2021, Cefalù, Italy

C10: Commission on Structure and Dynamics of Condensed Matter

- 12th International Conference on Magnetic and Superconducting Materials (ICMSM – 2021)
  1 – 5 August 2021, Duisburg-Essen, Germany
- Joint 28th AIRAPT and 59th International Conference on High Pressure Science and Technology (AIRAPT & EHPRG – 2021)
  25 – 30 July 2021, Edinburgh, UK

C11: Commission on Particles and Fields

- International Conference on Computing in High Energy and Nuclear Physics (ICCHENP – 2021)
  17 – 23 May 2021, Norfolk, USA
- LHC Physics Conference (LHCP) – **Deferred from 2020**
  Date to be confirmed, Paris, France
- 30th International Symposium on Lepton Photon Interactions at High Energies (ISLPIHE - 2021)
  9 - 14 August 2021, Manchester, UK

C12: Commission on Nuclear Physics

- 14th International Conference on Nucleus-Nucleus Collisions (NN21)
  18 – 23 July 2021, Whistler, Canada
- Advances in Radioactive Isotope Science (ARIS 2020) – **Deferred from 2020**
  5 – 10 September 2021, Avignon, France

C13: Commission on Physics for Development

- African Physical Society International Conference (AfPS – 2021)
  15 – 20 November 2021,Kigali, Rwanda
- The 6th Biennial African School of Fundamental Physics and Applications – **Deferred from 2020**
  Date to be confirmed, Marrakesh, Morroco
- 6th African School on Electronic Structure Methods and Applications (ASESMA-2020) – **Deferred from 2020**
  31 May – 11 June 2021, Kigali, Rwanda
- Third African Synchrotron Light Source Conference (AfLS3) – **Deferred from 2020**
  Date to be confirmed, Kigali, Rwanda

C14: Commission on Physics Education

- 3rd World Conference on Physics Education 2020: Innovating physics education: From teacher education to school practices (WCPE 2020) – **Deferred from 2020**
  Date to be confirmed, Hanoi, Vietnam

C15: Commission on Atomic, Molecular, and Optical Physics

- 32nd International Conference on Photonic Electronic and Atomic Collisions (ICPEAC – 2021)
  20 – 27 July 2021, Ottawa, Canada

C16: Commission on Plasma Physics

- International Conference on Phenomena in Ionized Gases (ICPIG -2021)
  11 – 16 July 2021, Egmond aan Zee, Netherlands
- International Conference on Plasma Physics (ICPP) – **Deferred from 2020**
  27 June – 2 July 2021, Gyeongju, Korea

C18: Commission on Mathematical Physics

- 16th International Conference on Integral Methods in Science and Engineering (IMSE 2020) – **Deferred from 2020**
  Date to be confirmed, St. Petersburg, Russia

C19: Commission on Astrophysics

- 31st TEXAS Symposium on Relativistic Astrophysics (TEXAS – 2021)
  13 – 17 December 2021, Prague, Czech Republic

C20: Commission on Computational Physics

- 32nd International Conference on Computational Physics (CCP-2021, previously CCP-2020) – **Deferred from 2020**
  Date to be confirmed, Coventry, United Kingdom

AC.1: International Commission on Optics

- 25th Congress of the International Commission for Optics (ICO) – **Deferred from 2020**
  13 – 17 September 2021, Dresden, Germany

AC.2: International Society on General Relativity and Gravitation (ISGRG)

- 14th Edoardo Amaldi Conference on Gravitational Waves (Edoardo Amaldi – 2021)
  18 – 23 July 2021, Melbourne, Australia

AC3: International Commission for Acoustics, ICA

- International Congress on Acoustics (ICA – 2021)
  6 – 10 December 2021, Sydney, Australia

AC4: International Commission on Medical Physics

- 18th Asian Oceanian Congress of Radiobiology (AOCR) – **Deferred from 2020**
  1 – 4 July 2021, Kuala Lumpur, Malaysia

Upcoming Endorsed Commission Conferences

C9: Commission on Magnetism

- 2021 IEEE International Conference on Nanomaterials: Applications & Properties (NAP 2020)
  5 – 9 November 2021, Odessa, Ukraine

C10: Commission on Structure and Dynamics of Condensed Matter

- Nanowire Week 2021
  12 – 16 April 2021, Chamonix, France

C11: Commission on Particles and Fields

- 28th International Workshop on Weak Interactions and Neutrinos (IWWIN)
  6 – 12 July 2021, Minneapolis Minnesota USA