IUPAP International Union of Pure and Applied Physics

Newsletter

DECEMBER
2020

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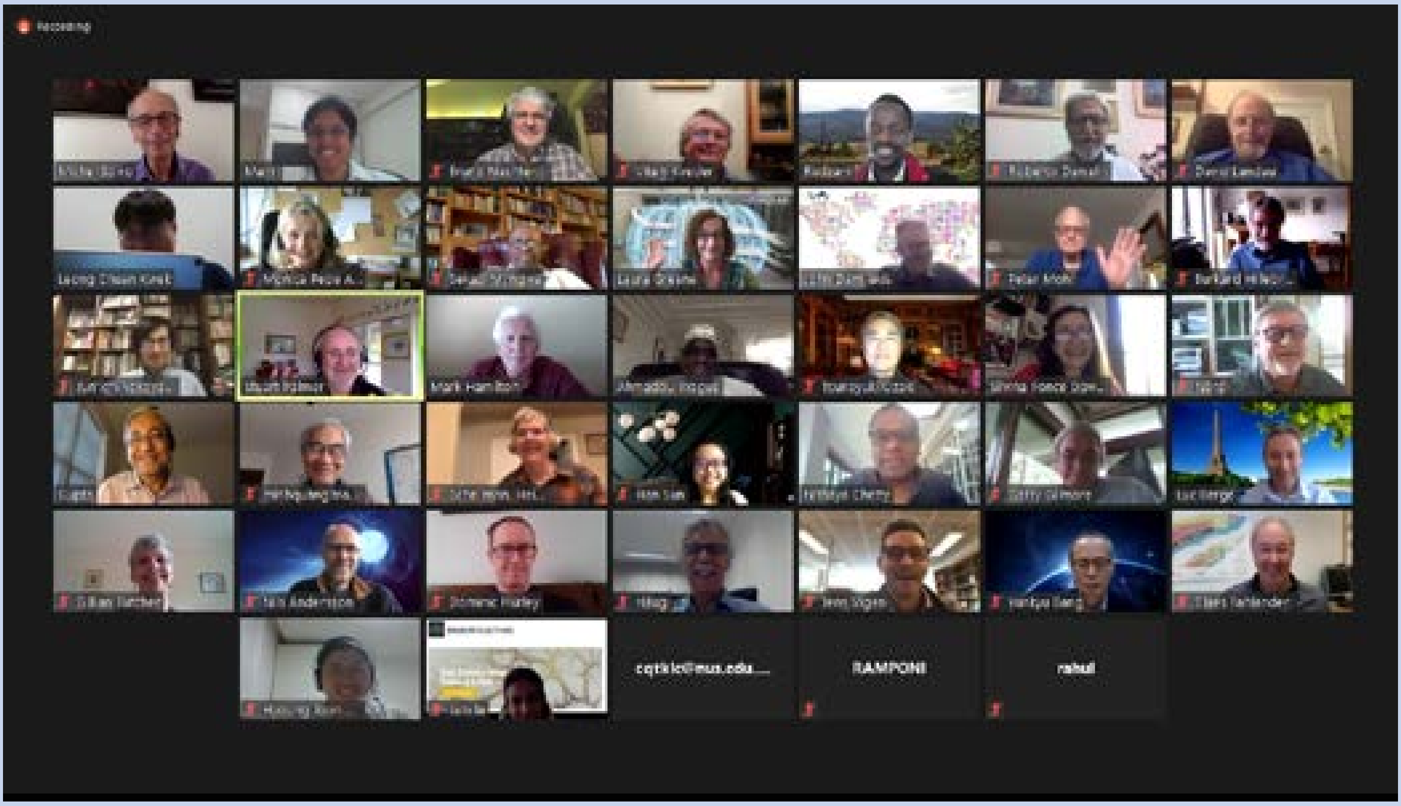
PRESIDENTS' NOTE



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

IUPAP statement on virtual conferences and worldwide accessibility

IUPAP strongly supports the following statement:

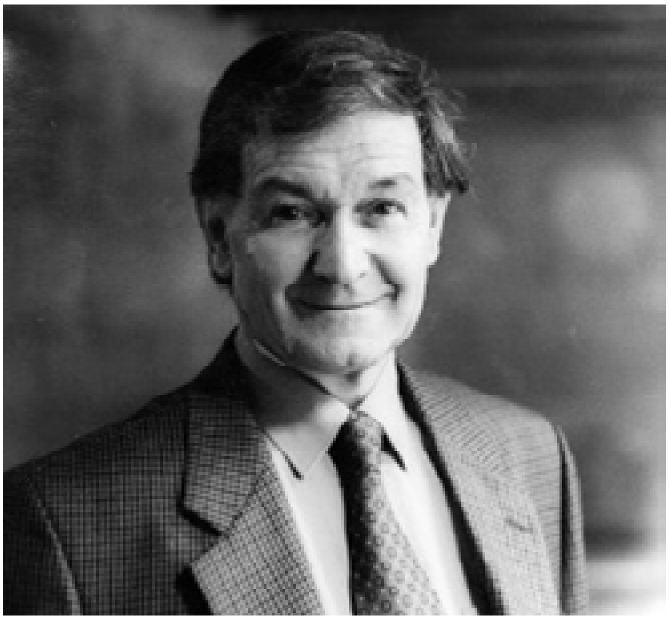
The International Union of Pure and Applied Physics (IUPAP), composed of members representing identified physics communities in 60 different countries, has promoted the international collaboration of physicists since its creation almost 100 years ago. The IUPAP has taken actions to facilitate this collaboration 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).

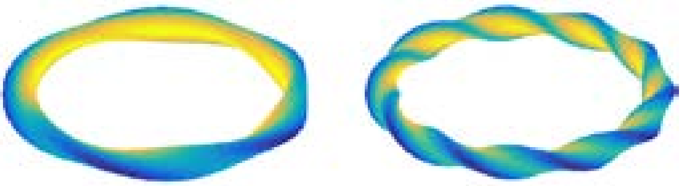


Figure 1. A magnetic surface in a classical stellarator with Np = 5 (left) and Np = 10 (left). Colour indicates the amplitude of B on the surface. [7]

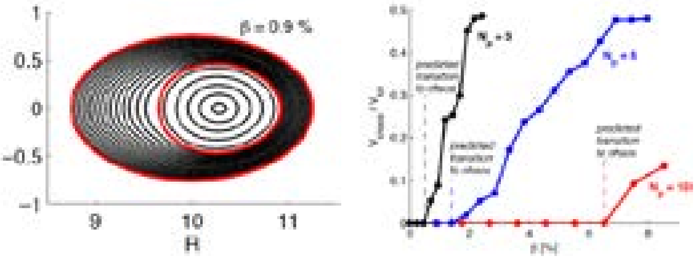


Figure 2. Volume of magnetic chaos as a function of ß. On the right, Poincaré maps of the field-lines for ß below and above the ß-limit (Np=5). [7]

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!

CONFERENCE REPORTS – 2019

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
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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, Edinburg, 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