International Union of Pure and Applied Physics

IUPAP Newsletter

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DECEMBER 2016

C&CC Meeting in Taipei

Group photo of the IUPAP C&CC and the PSROC members at the banquet in Taipei.

Message from the President

The 2017 IUPAP General Assembly

The international Council of Science is the "mother organisation" of IUPAP. The decision to create IUPAP was made at the 1922 meeting of the International Research Council. The IRC underwent various name and structural changes and is now the International Council of Science, or ICSU (it changed its name from the International Council of Scientific Unions but retained the previous acronym). At a Special General Assembly (GA) in Oslo on 24 October 2016, ICSU considered a recommendation to merge ICSU and the International Social Sciences Council (ISSC) and agreed — in principle — to pursue this. [See the ICSU website at http://www.icsu.org/news-centre/news/top-news/world2019s-top-bodies-representing-the-social-and-natural-sciences-vote-to-pursue-a-merger-forming-a-single-organization-representing-all-social-and-natural-sciences-by-2018]

The final decision to merge will be made at the 2017 ICSU GA, in Taipei on 24 to 27 October, 2017. To quote the letter about the merger process "In October 2017, and based on a thorough review and discussion of the Transition Plans and Strategy to be developed by the above-mentioned Transition Task Force, members will be asked to vote for or against a merger. It is important to note that a positive decision, taken in October 2016, to pursue a merger, will not commit any member to agree to a merger in October 2017." ICSU is now pursuing another transformation, one which is significant to all of its members, and especially to IUPAP.

The IUPAP Council and Commission Chairs (C&CC) at its meeting in Taipei in October have decided to move the IUPAP GA to occur before the ICSU GA, enabling the IUPAP vote at the ICSU GA to be based on a resolution of its own GA. **The IUPAP GA will be held in São Paulo, Brazil from 11 to 13 October 2017.** It will be preceded by a meeting of the Council, Commission Chairs and Chairs of Working Groups on 9th and 10th October, and a reception for delegates to both meetings will be held on the night of 10th October.

Formal notice for the General Assembly will be provided to IUPAP members, Commissions, Affiliated Commissions, and Working Groups on **11th March 2017**, but because of this important question to be discussed, I wanted to give advanced notice to all of the date, so that potential delegates can mark the dates in their diaries.

The C&CC approved a recommendation from the Working Group on Women in Physics (WG5), that all commissions in the 2018-2020 triennium should have at least 4 women members. So in this newsletter we are also giving advance notice to Liaison Committees and Commissions of this requirement.

Our 2017 General Assembly will be an important one. Start making the arrangements for your participation or input now.

Bruce McKellar

Nobel Prizes for Physics

Yuval Gefen (Weizmann Institute of Science)

Sometimes Nobel prizes are awarded fairly soon after a piece of research is accomplished. In the case of David J. Thouless (University of Washington, Seattle), F. Duncan M. Haldane (Princeton University), and J. Michael Kosterlitz (Brown University, Providence), it took the Royal Swedish Academy of Sciences nearly three and a half decades (and for one of the works cited, nearly four and a half) to recognize the importance of their research. Not that their works lacked recognition by the community. At the time of writing, the 1973 Kosterlitz-Thouless paper had as many as 8912 citations, and the other works mentioned in the decision have been no less influential. The decision that was so long in the making, is perhaps a sign of changing perspectives, which provides us with an intriguing and rewarding opportunity to witness the history of science in the making. The 2016 Nobel Prize had been awarded to the three scientists "for theoretical discoveries of topological phase transitions and topological phases of matter". But when the 1990 Wolf Prize was given to David Thouless (who shared it with Pierre Gilles de Gennes), an article in *Physics Today* noted his pioneering achievements — yet the word "topology" was hardly mentioned.

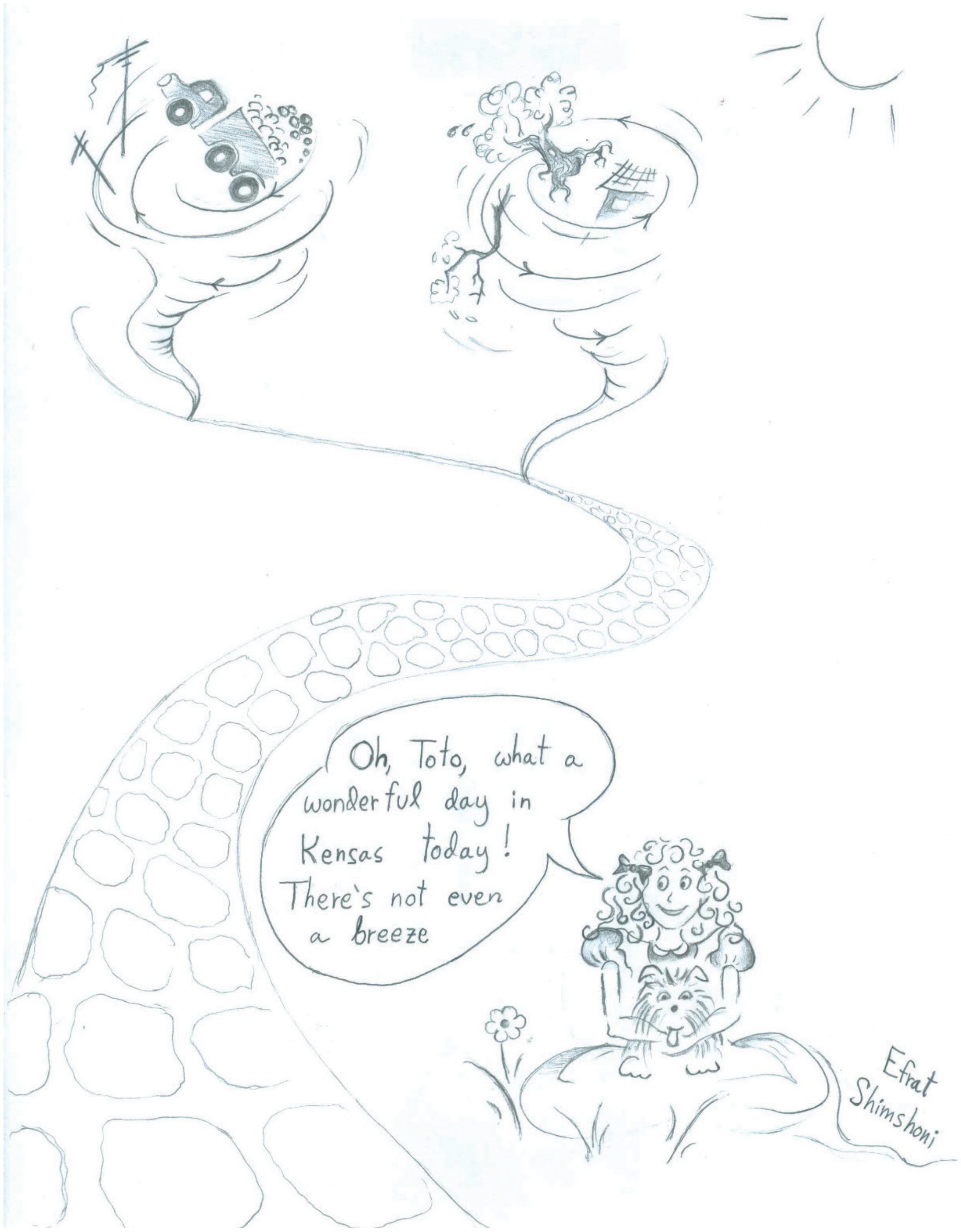
The discoveries of Thouless, Haldane and Kosterlitz have brought together topology, an abstract area of mathematics, and the down-to-earth field of material science. These researchers have used advanced mathematical tools to describe exotic states of matter, such as superconductors, superfluids, magnetic arrays, and quantum conductors, that arise when the constituents of these materials are restricted to "claustrophobic spaces": a flatland defined on the surface of a three-dimensional object (a two-dimensional space), or even a thread (a chain) that forms a one-dimensional space. The phases of matter predicted by the three scientists defied earlier common wisdom concerning such low-dimensional systems. Thanks to their use of topology, they were able to demonstrate that important properties of these exotic materials can only change discontinuously, in jumps.

The earliest work cited by the Royal Swedish Academy is that of Kosterlitz and Thouless. Long before they had conducted this research, microscopic entities, such as atoms, electrons, and spins, that constitute matter, were recognized to obey quantum mechanics. It was also known that interactions among these degrees of freedom may lead to collectively correlated behavior. Landau had shown that non-analytic (abrupt) change in such a collective behavior may be associated with a change of the underlying symmetry of the system, and manifest itself as a (second or higher order) phase transition. The Mermin-Wagner theorem had stated under certain broad conditions that in 1 or 2 spatial dimensions, when the underlying symmetry is continuous (e.g. a system that is invariant under rotation), this symmetry cannot be spontaneously broken. Intuitively, this observation is the result of temperature-induced fluctuations that destroy long-range order. Common belief was that if no ordering were possible, no phase transition could take place. Not so, asserted Kosterlitz and Thouless in a series of papers published between 1972 and 1974. They considered a 2-dimensional array of XY vector spins (oriented in the XY plane, and possessing a circular symmetry around the z-axis; the spins "talk" with each other through short-range interactions). Vortices in such 2-dimensional "XY models" are topologically stable. The "vorticity" (e.g., clockwise arrangement) of the vector spin field can be detected far away from the vortex, in the same way that hurricane gales are felt far from its center. This is a manifestation of the topological nature of a vortex. If our flatland is teeming with vortices, some clockwise and others anticlockwise, it is hard to tell in what direction the spin at a given point is oriented (which way the hurricane wind is blowing), and how these orientations are correlated at a distance: there is no long-range order. Below a certain critical temperature, Kosterlitz and Thouless predicted, vortices of opposite vorticity pair off. Such an object is local — the two opposite vortices "cancel" each other, and their presence is not felt at a distance. The destructive role of vortices undermining order is then mitigated. In accordance with the Mermin-Wagner theorem there is no long-range order at finite temperatures. The KT transition is then between a low-temperature quasi-ordered phase, with correlations decreasing with the distance as a (temperature dependent) power low, and a high-temperature phase where correlations decrease exponentially with the distance. The KT physics is ubiquitous in flatland correlated systems, as well as in many one-dimensional quantum systems (where one is then talking about zero temperature quantum phase transitions). The KT transition has presented an entirely novel understanding of a large class of phase transitions which, unlike the Landau paradigm, are termed "topological transitions".

The second work of Thouless cited in the Nobel Prize decision followed the 1980 discovery of the (integer) quantum Hall effect. That discovery revised our understanding of electrical conductance in solids. Klaus von Klitzing and his colleagues studied a system made of semi-conducting materials, where electrons were cooled to a low temperature — a few degrees above the absolute zero — and were confined to move in two-dimensional flatland, subjected to a strong perpendicular magnetic field. The amazing finding was that the electrical conductance measured in such systems assumed an extremely accurate value (presently the accuracy is at least one part in 10^9), rendering such systems the basis for resistance standard. This value of conductance is robust to modulations in the shape of the sample, impurity content, and some variations in electron density and magnetic field strength, and can be changed only in discrete steps (twice the conductance, triple the conductance etc.). A microscopic quantum picture accounting for these values was developed soon after the experimental discovery. Yet, a mathematically unifying general picture was missing; it was provided in the 1982 paper of Thouless, Kohmoto, Nightingale, and Den Nijs. The topological nature of the quantum Hall effect, the mother of topological states, was explained. In a later work Haldane showed that topology-governed two-dimensional electronic fluids can emerge even without an applied magnetic field — forming the basis of intensive present research.

Quantum one-dimensional spin chains had been studied long before Haldane's work. The anti-ferromagnetic Heisenberg chain is a paradigmatic model. It had been found that when the microscopic building blocks of the chain have spin-1/2, the energy spectrum is gapless. The working assumption was that the same should hold for chains whose components are made of spins of higher values. In 1983, Haldane derived an action describing spin chains. He showed that in addition to a standard O(3) non-linear sigma model part, the action also contains terms that incorporate the effects of topology in a crucial way. Based on this, he predicted that the spectrum of chains with integer spins is gapped, underlying their topological nature. In contrast, half-integer spin chains give rise to gapless spectra, and are non-topological. The Haldane phase is paradigmatic of symmetry-protected topological states. This totally unexpected picture was later confirmed by numerical work and experiments.

Thouless, Kosterlitz and Haldane are true "gentlemen of theoretical physics" – both in their collegial scientific style and in the intellectual nature of their pursuits. But the importance of their pioneering works should be assessed not only through the fundamental revision of our understanding of the principles that govern solid state physics. They are prophets of the new field of Topological Matter, addressing new classes of materials such as topological insulators, topological superconductors, topological metals and more — all under the same umbrella. This coherent field of research that has emerged over the last decade promises to be the basis for a new generation of electronics, and perhaps paves the way to the design of solid state-based quantum computers. It certainly constitutes a triumph of curiosity-driven research, and possibly a path to future Nobel prizes.



Further away from two counter-rotating vortices their effect is diminishing rapidly.

The David J. Thouless I knew

*__Kok Khoo Phua__ (Secretary General, International Union of Pure and Applied Physics)

Recently, the 2016 Nobel Prize in Physics was announced. Three British physicists were joint recipients of the prize: David J. Thouless, Duncan M. Haldane and J. Michael Kosterlitz. They were awarded "for theoretical discoveries of topological phase transitions and topological phases of matter". Among the trio, David J. Thouless was awarded one half of the prize.

What was regrettable was the prize came a little too late for David J. Thouless, who has a mild form of Alzheimer's disease. When Charles Kuen Kao, the "Father of Fiber Optics", received the Nobel Prize seven years ago, he also had Alzheimer's disease. This was a matter of some regret.

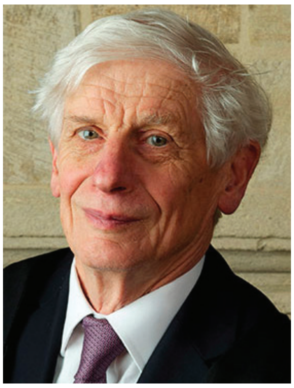
David J. Thouless received his doctorate degree from Cornell University, under the supervision of Hans Bethe. He was also greatly influenced by Rudolf Peierls, who served as the Head of the Mathematical Physics Department at the University of Birmingham for many years. David Thouless served as a professor of mathematical physics at the University of Birmingham from 1965 to 1978. His most important work, including the research that garnered him the Nobel Prize, was done during the period when he was in Birmingham. David Thouless was both my teacher as well as a good friend. We had close interaction and he is a modest and diligent gentleman. From our interaction during that period as well as subsequent communication, I have noted several characteristics which are worthy of attention and which are similar to those of CN Yang's.

Firstly, like fellow physicist CN Yang, he placed great value on mathematics and had a solid foundation in mathematics. CN Yang came from a family of scholars and his father, Yang Wu-Chih, was a famous mathematician. In addition, CN Yang maintained a close friendship with mathematics master Shiing-Shen Chern. These were all "supports" for his subsequent development.

David Thouless has great talent in mathematics, which proved very useful for the subsequent research he did in mathematical physics. Topology is the study of geometrical properties and spatial relations unaffected by the continuous change of shape or size of figures. It was originally an important branch of modern mathematics, but gradually penetrated the field of quantum physics and became an important mathematical method for the study and analysis of states of continuity and connectivity of materials. I believe if David Thouless had lacked a solid foundation in mathematics, he would not have achieved such success.

Secondly, he did not follow trends nor the crowd when it came to research. His capacity for independent thinking was something I found to be very important.

Thirdly, he placed great emphasis on experimental results, another characteristic he shared with CN Yang. All theory is inseparable from experiments. CN Yang was once a follower of American physicist Enrico Fermi. He had intended to engage in experimental physics with Fermi, but at that time, Fermi's laboratory was in Argonne and was a top secret lab to which CN Yang was not granted entry. Hence, Fermi recommended that CN Yang carry out theoretical work with Edward Teller. Although CN Yang had little to do with experimental physics later in his career, he still placed great importance on experiments. David Thouless was much the same.



Prof. David J. Thouless,
Nobel Laureate in Physics 2016

Fourthly, David Thouless was extremely inquisitive and full of interest in new matters and knowledge. He was always eager to sit in on conferences which had nothing to do with his specialisation because he wanted to understand the latest developments in other fields of science. Naturally, he was not God but a human who could not possibly understand everything. There were times when he honestly told me that he "did not understand". These three words were of great inspiration to me in my own intellectual journey, as many things progressed from "unknown" to "known".

Fifthly, when I was at the University of Birmingham, I discovered that David Thouless was an extraordinarily diligent person who was often the last to leave the office. He was a typical gentleman, modest, slow of speech but quick in action. While he was not a fantastic lecturer, he was willing to chat privately. As a result, "afternoon tea" became the best time for our exchanges and I learnt a lot from him during those tea sessions.

CN Yang was one of David Thouless' idols. Between 31 October and 3 November 2007, David Thouless attended an academic conference in celebration of CN Yang's 85th birthday, which was held in Singapore. At the conference, David Thouless delivered a speech titled "Topological Quantum Numbers and Phase Transitions", which was well received. In addition, David Thouless has also personally written, edited and contributed to two high level academic volumes: Topological Quantum Numbers in Nonrelativistic Physics and 40 Years of Berezinskii-Kosterlitz-Thouless Theory; both published by World Scientific Publishing Company, Singapore, a company I founded.

He spent much effort on both books which have become important classics in scientific literature. Now that he has been awarded the Nobel Prize, the prestige and authority of both volumes have consequently increased.

Most youth currently receive a very examination-oriented education. Our youth should carefully consider and strive to learn from the unique manner and spirit with which David Thouless dealt with knowledge and scientific research.

*(The author is the Director of the Institute of Advanced Studies, Nanyang Technological University and chairman and editor-in-chief of World Scientific Publishing.)

Units, constants, and stamps

W.D. Phillips and **V. S. Bagnato** (Vice-president and President of C2 - commission)

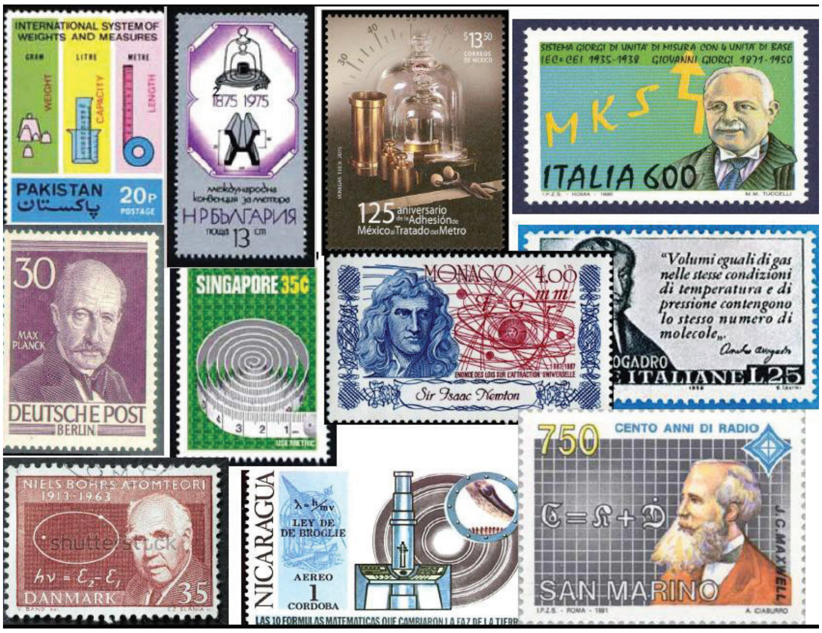
Every civilized society requires a consistent and reliable system of measurement units for needs ranging from commerce to construction to science. Ancient texts, like the Hebrew bible, mandate an honest and accurate set of weights and measures for tradesmen, and the length-measuring practices of ancient Egyptians produced pyramids as tombs for their pharaohs whose dimensions were quite accurate. Today, our modern global community relies on an ever-evolving and improving International System of Units (SystèmeInternationaled'Unités—the SI) to facilitate global trade and to express the results of scientific measurement (See ref.1).

Today, the SI is on the verge of a revolution that is as significant as any revolution in measurement since the French Revolution brought us the beginnings of the metric system of metres, kilograms and seconds. This revolution will extend the use of fundamental constants of nature to replace artifacts as the basis for defining units of measure. For example, in 1875, an international treaty (the Convention du Metre) agreed that the metre was the distance between two scratches on a bar of platinum- iridium. Today, the metre is the distance that light travels in a certain time, effectively defining the fundamental constant c, the velocity of light. The "new SI" will extend this use of fundamental constants to define units.

Due to the importance of units in people's daily lives as seen in activities like the purchasing of food by weight and volume, or the making of clothing using lengths of fabrics or the tiling of floors by area, units have long been celebrated in one of life's most common and tangible articles. Furthermore, the fundamental constants of nature, along with the fundamental equations of physics, which have played such a central role in the advancement of science and technology over time, have been similarly celebrated. Even as electronic communication has made postage stamps less ubiquitous in daily life, the legacy of stamps in areas like official mail and philately maintain the recognition and the importance of units, constants, and the physics that underlies them. (See ref. 2 for a similar discussion of stamps in the realm of chemistry.)

IUPAP, as the most important and extensive international physics organization, has played and continues to play a central role in the advancement of units and constants. For example, IUPAP's encouragement and support was key to the adoption of the current SI, which was finalized by the international metrology community in 1960. Today, commission C2 of IUPAP is sponsoring a working group to measure G, the Newtonian gravitational constant, a constant whose value has been highly volatile and rather poorly known.

The stamps pictured here illustrate some of the romance associated with units and constants. For example, stamp (2) celebrates the 100th anniversary of the Convention du Metre, immortalizing the establishment of the international character of the metric system. Stamp (6) from Singapore (the present home of IUPAP headquarters) illustrates one of the most common ways that the unit of length is used in human life. Monaco's stamp (7) features Isaac Newton and his law of universal gravitation focuses our attention on G, the subject of intensive current research. Equivalently the Danish stamp (9) commemorates Niel's Bohr's use of Planck's constant (Stamp 10) to relate the energy levels of atoms to the frequency of light that connects them. Nicaragua's celebration of De Broglie's astounding application of Planck's constant to the basis of matter-wave quantum mechanics illustrates one of the most powerful examples of the unity of physics. Other stamps in this small sampling emphasize the international character of appreciation for units, constants, and the laws of physics by this simple yet profound recognition.



Order sited in the text: from left to right and from top to bottom

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1. Le Systém International d'unité - 8th Édition - Bureau International des poids et measures (2006).
2. D. Rabinovich - A Philatelic Tribute to the SI - Chem. Internat. November 2010

Rita Levi-Montalcini Prize

Prof. Procaccia (center) receiving the first Rita Levi-Montalcini Prize from the Minster of Foreign Affairs Mr. Paolo Gentiloni (left) and the Minister of Education Ms. Stefania Giannini (right).

The first “Rita Levi-Montalcini Prize for scientific cooperation between Italy and Israel” was awarded to Prof. Itamar Procaccia of the Weizmann Institute of Science at a ceremony held on 2nd November 2016 at the Italian Ministry of Foreign Affairs in Rome. The prize was presented by the Italian Minister of Foreign Affairs and International Cooperation (MAECI), Paolo Gentiloni and the Minister of Education, University and Research (MIUR), Stefania Giannini.

The government of the Republic of Italy announced the new prize in memory of Nobel Laureate (Physiology or Medicine, 1986) Prof. Rita Levi-Montalcini, who passed away in 2012 at the age of 103. The prize is planned as an annual conferment, and is meant to promote international collaboration in basic scientific research of the highest quality. This bi-national prize is promoted by the MAECI and the Fondazione CRUI for Italian Universities in partnership with the MUIR.

Prof Itamar Procaccia of the Weizmann Institute of Science (Rehovot, Israel) was the first recipient of this prestigious prize. He received the prize for his collaboration with the eminent Italian physicist Prof. Giorgio Parisi of the University of Rome “La Sapienza”. Their work, ‘Mechanical and magnetic properties of amorphous advanced materials’ explores the physics of amorphous solids, focusing on their formation via the glass transition and on their mechanical and magnetic properties, including their modes of failure. It was presented by the University La Sapienza of Rome, Department of Physics under the supervision of Prof Giorgio Parisi in partnership with Prof Procaccia. Prof Procaccia’s project was selected from more than 170 ongoing collaborative research projects between the two countries.

On receipt of this prize, Prof Procaccia will spend four months at the La Sapienza University of Rome investigating and teaching to further the study toward the scientific research project led by Prof Parisi.

Among other honors Prof. Procaccia is the recipient of the Israel Prize in Physics (2009) and is currently serving as the Chair of the IUPAP Commission for Statistical Physics (C3).

APPROVED CONFERENCES 2017

SPONSORED COMMISSION CONFERENCES 2017

C3: Commission on Statistical Physics

8–11 January 2017 Lausanne, Switzerland
Recent Advances on the Glass and Jamming Transitions (RAJT)

5–8 June 2017 Mallorca, Spain
Conference on Crossroads in Complex Systems (CCCS 2017)

4–8 December 2017 Viña del mar/Valparaiso, Chile
XVI International Workshop on Instabilities and Nonequilibrium Structures (IWINS 2017)

C4: Commission on Astroparticle Physics

12–20 July 2017 Busan, South Korea
International Cosmic Ray Conference (ICRC)

25–29 July 2017 Sudbury, Canada
XV International Conference on Topics in Astroparticle and Underground Physics (TAUP 2017)

C5: Commission on Low Temperature Physics

9–16 August 2017 Gothenburg, Sweden
The 28th International Conference on Low Temperature Physics (LT28)

17–21 August 2017 Heidelberg, Germany
ULT2017: Frontiers in Low Temperature Physics (ULT2017)

C6: Commission on Biological Physics

5–9 June 2017 Rio de Janeiro, Brazil
International Conference on Biological Physics (ICBP2017)

24–28 June 2017 The Abdus Salam International Centre for Theoretical Physics (ICTP), Italy
Frontiers in Olfaction (FIO 2017)

C8: Commission on Semiconductors

31 July–4 August 2017 Pennsylvania State University, USA
Joint Conference EP2DS22-MSS18: 22nd International Conference on Electronic Properties of Two Dimensional Systems and 18th International Conference on Modulated Semiconductor Structures (EP2DS22-MSS18)

24–29 September 2017 San Juan, USA
18th International Conference on II-VI Compounds and Related Materials (IC-II-VI-RM 2017)

C10: Commission on the Structure and Dynamics of Condensed Matter

3–8 September 2017 San Antonio Texas, USA
14th International Meeting on Ferroelectricity (IMF)

C11: Commission on Particles and Fields

14–19 May 2017 Copenhagen, Denmark
International Particle Accelerator Conference 2017 (IPAC 17)

5–12 July 2017 Lido di Venezia, Venice, Italy
EPS-HEP 2017 (EPS-HEP 2017)

7–12 August 2017 Guangzhou, China
International Symposium on Lepton Photon Interactions at High Energies (ISLPIHE)

C12: Commission on Nuclear Physics

5–11 February 2017 Chicago, USA
Quark Matter 2017 (QM 2017)

28 May–2 June 2017 Park City, Utah, USA
Advances in Radioactive Isotope Science (ARIS 2017)

23–27 October 2017 La Habana, Cuba
XII Latin American Symposium on Nuclear Physics and Applications and the Workshop on Nuclear Physics and Nuclear Related Techniques (XII – LASNPA + WONP-NURT)

C13: Commission on Physics for Development

31 July–4 August 2017 Tlaxcala, Mexico
XLVII International Symposium on Multiparticle Dynamics (ISMD2017)

21–28 August 2017 Hyderabad, India
24th IUCr Congress and General Assembly (IUCr C&GA)

9–20 October 2017 University of Ziguinchor, Senegal
Laboratory and Synchrotron X-Ray Crystallography: Applications to Emerging Countries (LSXC:AEC)

C14: Commission on Physics Education

3–7 July 2017 Dublin, Ireland
GIREP-ICPE-EPEC 2017 (GIREP 2017)

C15: Commission on Atomic, Molecular, and Optical Physics

26 July–1 August 2017 Cairns, Australia
XXX International Conference on Photonic, Electronic and Atomic Collisions (ICPEAC)

C16: Commission on Plasma Physics

3–7 April 2017 Vina Del Mar, Chile
8th International Conference on the Frontiers of Plasma Physics and Technology (ICFPPT 8)

21–26 May 2017 Prague, Czech Republic
8th International Conference on the Physics of Dusty Plasmas (ICPDP 8)

9–14 July 2017 Lisbon, Portugal
International Conference on Phenomena in Ionized Gases (ICPIG)

11–15 September 2017 Saint Malo, France
International Conference on Inertial Fusion and Science Applications (IFSA)

C19: Commission on Astro Physics

12–16 June 2017 Nanjing, China
The 3rd PANDA Symposium on Multi-wavelength Time Domain Astronomy (3rd PANDA)

3–8 December 2017 Cape Town, South Africa
29th Texas Symposium on Relativistic Astrophysics (29-TEXAS)

C20: Commission on Computational Physics

9–13 July 2017 Paris, France
Conference on Computational Physics (CCP 2017)

AC.2: International Commission on General Relativity and Gravitation

3–7 April 2017 La Falda, Córdoba, Argentina
Grav17 (GRAV17)

9–14 July 2017 Pasadena, CA, USA
Edoardo Amaldi Conference on Gravitational Waves (AMALDI)

ENDORSED COMMISSION CONFERENCES 2017

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

15–19 May 2017 University of Warsaw, Poland
International Conference on Precision Physics and Fundamental Constants (FFK 2017)

C8: Commission on Semiconductors

16–21 July 2017 University of Buffalo, NY, USA
EDISON'20: The 20th International Conference on Electron Dynamics in Semiconductors, Optoelectronics and Nanostructures (EDISON 20)

29 July–3 August 2018 Montpellier, France
34'th International Conference on the Physics of Semiconductors (ICPS2018)

8–14 August 2020 Sydney, Australia
35th International Conference on the Physics of Semiconductors (ICPS2020)

C19: Commission on Astro Physics

12–16 June 2017 Nanjing, China
The 3rd PANDA Symposium on Multi-wavelength Time Domain Astronomy (3rd PANDA)

C20: Commission on Computational Physics

16–20 January 2017 University of Macau, Macau
The 10th International Conference on Computational Physics (ICCP 10)