

# Faces & Places

## CONFERENCES

# TAUP 2015 gives updated overview on astroparticle and underground physics



Participants gather for a group photograph at the TAUP 2015 conference, held in Torino (Italy). (Image credit: TAUP 2015.)

Around 500 physicists, astrophysicists and cosmologists from 38 countries convened in Torino to discuss current developments in astroparticle physics and particle cosmology. The 14th edition of the International Conference on Topics in Astroparticle and Underground Physics (TAUP 2015) was held in Torino from 7 to 11 September, and was organised by the University of Torino, the National Institute for Nuclear Physics (INFN), the National Institute for Astrophysics (INAF), the Italian Space Agency (ASI), the Gran Sasso National Laboratory (LNGS), the Torino Science Academy and the Inter-university Centre for Space Physics (CIFS).

The scientific focus of the TAUP conference is theoretical and experimental progress on dark matter, neutrino physics, high-energy astrophysics and cosmic rays, cosmology and gravitational waves. The biennial TAUP conference series started in 1989 in L'Aquila. Since then, it has grown to be the major event in astroparticle and underground physics. This latest edition saw unprecedented participation, and full days of lively discussions and exchanges on all current key subjects of particle astrophysics and cosmology. As is traditional for TAUP, the conference was organised as plenary review talks in the mornings, and workshop sessions held in parallel in the afternoons. A dedicated poster session completed the programme.

The plenary programme – 32 talks in total – opened with three reviews on the current status of cosmological observations and its connections to particle physics. It then moved to cover high-energy astrophysics, with reports on  $\gamma$  rays and cosmic-ray observations, both from Earth and space. High-energy neutrinos have been a hot topic: a comprehensive theoretical exploration of high-energy messengers and their sources placed the observational results in context.

### Major players

Dark matter was discussed, both in the high- and low-energy mass windows, from axions to WIMPs, with reports on the current theoretical understanding and experimental searches for new physics. After a detailed and informative overview of dark-matter distribution on small scales, a critical element for particle dark-matter astrophysical signals, the whole spectrum of indirect- and direct-detection strategies was covered extensively. Highlights included new avenues like directionality in direct detection, and anisotropies and cross-correlations in indirect-detection searches.

Neutrino physics was another major player: the theoretical landscape of neutrino physics, including sterile neutrinos, was the background for reports on the whole experimental programme in the field: measurement of the absolute neutrino masses, reactor neutrinos, short- and

long-baseline experiments, neutrinoless double-beta decay, low-energy neutrinos, solar, geo and supernova neutrinos.

The gravitational-wave session reported on the kick-off of the second phase of advanced interferometers, happening this year, such as the start of the LISA pathfinder mission. A talk on multimessenger astronomy provided a link to the high-energy and neutrino sessions.

The plenary programme was further enriched by the well-attended workshop sessions, six each afternoon, and the poster session, where the topics covered in the plenary sessions were explored in greater depth with more focussed presentations. With more than 340 contributions, the sessions offered a complete and exhaustive overview of the experimental results and their theoretical and phenomenological interpretations.

TAUP 2015 also paid special attention to outreach and science communication. The conference programme included a dedicated parallel session, which was well-attended both by specialists and scientists. Three outreach events, aimed at the general public, were organised in the city. One of these was a fulldome planetarium show on dark matter and particle physics, set up in collaboration with the CERN Media Lab and LBNL, and held at the Torino Planetarium. The event was very much appreciated by the general public.

● For further details, visit [taup2015.to.infn.it](http://taup2015.to.infn.it).

## Faces & Places

# Dallas welcomes the DIS2015 International Workshop

This spring, the 23rd International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2015) took place at the Southern Methodist University (SMU) in Dallas, Texas. The workshop was held from 27 April to 1 May, and included some 250 participants representing 30 countries, presenting more than 200 talks on a multitude of subjects. The programme reported on current developments in DIS and QCD, as well as updates on the latest results from the LHC, HERA, Tevatron, Jefferson Lab, RHIC and fixed-target experiments. It also covered related theoretical topics and future experimental opportunities.

The workshop began with a full day of plenary reports on recent progress from both the experiment and theory frontiers; these excellent overview presentations stimulated extensive discussion and generated interest for the upcoming parallel talks. This was followed by two and a half days of parallel talks, organised around seven themes: structure functions and parton densities; small- $x$ , diffraction and vector mesons; electroweak physics and beyond the Standard Model; QCD and hadronic final states; heavy flavours; spin physics; and future experiments.

Work on the structure of the proton has seen tremendous advances recently. The final HERAPDF2.0 results were presented, as well as updates from the individual groups working on parton-distribution functions (PDFs). These discussions were timely because the PDF improvements will help with analysis of the LHC Run 2.

There were also extensive updates from the LHC on the properties of the Higgs boson, as well as prospects for searching for new Higgs-like objects including SUSY, extra gauge bosons ( $W'$ ,  $Z'$ ) and other exotica. Precision measurements from both RHIC and LHC experiments can also place constraints on new physics signatures such as “dark photons”.

On the heavy-flavours frontier, new improvements on theoretical calculations matched with new experimental measurements from RHIC and the LHC were seen. Heavy-flavour production is an incisive tool, which can probe many features of QCD;



*Conference participants on the steps of SMU (top), and enjoying the social events (above left), which included the conference banquet at the Perot Museum of Nature and Science (above right). (Image credits: DIS2015.)*

however, the heavy-quark mass introduces an additional scale, which complicates the theoretical calculations. Nevertheless, new techniques, clever ideas and hard work have enabled progress to be made in this area.

The spin-physics session had extensive discussions on HERMES and COMPASS data, as well as measurements from RHIC and Jefferson Lab experiments. This was complemented on the theoretical side by advances in generalized PDFs, which can reconstruct the proton structure in 3D.

### The future of DIS

In the areas of small- $x$ , diffraction and vector mesons, a wide range of interesting topics were presented, including parton saturation and shadowing, non-linear evolution, tests of factorisation, and rapidity-gap physics for both protons and nuclei.

The future landscape of DIS was also discussed, including the JLab 12 GeV upgrade, the Deep Underground Neutrino Experiment (DUNE) at the Long-Baseline Neutrino Facility (LBNF), the Electron-Ion Collider (EIC) and the LHeC. In combination, these projects will vastly extend the reach of DIS to study matter from the lowest to highest energies and densities.

The workshop programme made room for several social and outreach events, including a public lecture entitled “If the universe is the answer, what is the question?” This event featured four physicists from the workshop discussing critically important unanswered physics questions that upcoming

experiments might help to resolve. The presentations were stimulating and thought provoking, and gave the local audience a non-technical glimpse into issues discussed at the workshop.

The social highlight of the meeting was the “Night at the Science Museum” conference banquet, which was held at Dallas’s new Perot Museum of Nature and Science. The museum blends art, technology and science with renowned interactive and hands-on scientific exhibits, which flow across multiple levels in a building that is a creative, ecologically “green” architectural design, situated in the heart of downtown Dallas. Conference members enjoyed a “strolling” catered dinner, which progressed from the upper exhibits through to the entry-level atrium, where dinner culminated with dessert, coffee and discussion.

The workshop was generously supported by Brookhaven National Laboratory (BNL), CERN, DESY, Fermilab, Jefferson Lab, the National Science Foundation (NSF), the US Department of Energy (DOE) and the SMU.

The workshop demonstrated how “DIS and related subjects” permeates a broad range of physics topics, from hadron colliders to spin physics, neutrino physics and more. There is still much work to be done and information to be extracted from the latest experiments. The good news is that the DIS workshop series will continue next year, with DESY hosting DIS2016 in Hamburg, Germany, from 11 to 15 April 2016.

● For more details, see [www.dis2015.org](http://www.dis2015.org).

## Explorers of 'strange world' get together in Sendai for HYP2015

HYP2015, the 12th International Conference on Hypernuclear and Strange Particle Physics, took place from 7 to 12 September in Sendai, Japan, where around 200 participants from 20 countries gathered at Tohoku University.

Since 1982, the HYP conferences have been held every three years to discuss nuclear and hadron physics with strangeness. The main subjects are the production and structure of hypernuclei and strange hadrons, as well as baryon–baryon and meson–baryon interactions with strangeness. The subjects have been extended to low-energy aspects of QCD, dense and cold matter, and implications for neutron stars, and hadronic and nuclear systems with heavier flavours.

Experimental results and plans at J-PARC, JLab, GSI/FAIR, MAMI, DAΦNE, Spring-8, RHIC and the LHC were presented. A highlight was new data from MAMI and J-PARC, which confirmed the strange phenomenon that a  $\Lambda$  hyperon largely breaks the charge symmetry in a nucleus. Concerning the  $K^-pp$  bound system, a new positive signal from J-PARC was presented, while other experiments at GSI, Spring-8 and J-PARC have not caught any clear signal yet. Theoretical progress was reported in approaches including *ab-initio* calculations (starting from basic nuclear forces) of hypernuclei and lattice QCD calculations of baryon–baryon interactions.

Besides plenary and parallel sessions, topical sessions on “Hypertriton lifetime”, “YN scattering experiments” and “Hyperon puzzle in neutron stars” were organised. Recently, heavy-ion collision experiments at RHIC, the LHC and GSI reported the lightest hypernucleus,  $^3_\Lambda\text{H}$  (hypertriton), has a lifetime much shorter than theoretically expected. It is agreed that the discrepancy should be solved by further experimental and theoretical work. The lack of low-energy hyperon–nucleon (YN) scattering data has long been a problem in this field, and ongoing plans and prospects of scattering experiments were discussed in detail. “Hyperon puzzle” is a hot topic in strangeness nuclear physics. Hyperons are predicted to appear in high-density nuclear matter in neutron stars, based on our knowledge of YN and YY interactions, but this results in a softening of the nuclear-matter equation of state, and cannot support recently observed heavy neutron stars with twice the solar mass. To solve this serious discrepancy, several theoretical approaches were proposed and intensive discussions took place. The proceedings will be published in the *JPS Conference Proceedings*.

• Visit [lambda.phys.tohoku.ac.jp/hyp2015/](http://lambda.phys.tohoku.ac.jp/hyp2015/).



Conference participants in Sendai (Japan). (Image credit: HYP2015.)

## PT2026 NMR Precision Teslameter Reach new heights in magnetic field measurement

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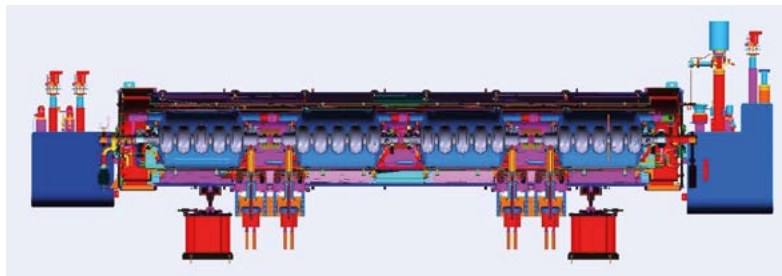
### WORKSHOPS

# Workshop on future electron–hadron colliders at CERN

In June, CERN hosted the annual workshop on upgrading the LHC with a powerful electron accelerator to enable electron–proton (and –ion) collisions in one interaction region. The Large Hadron electron Collider (LHeC) would use an energy recovery linac (ERL) to achieve 1000 times the luminosity in electron–proton scattering, compared with HERA, with a centre-of-mass energy above 1 TeV. The ERL principle is also considered for the configuration of a 3.5 TeV electron–proton collider that would use the 50 TeV proton beam of the Future Circular Collider (FCC–eh).

A scientific colloquium opened the workshop and introduced LHeC (FCC–eh)-related developments on the accelerator, detector and physics issues to the audience. The LHeC is being designed for concurrent operation with the LHC. This leads to significant cost reductions in possibly realising a far-reaching electron–hadron (proton and ion) physics programme. Moreover, this may transform the LHC into a precision Higgs facility, i.e. with increased precision and new opportunities using electron–proton collisions, and much reduced theory uncertainties for proton–proton Higgs physics.

Guido Altarelli spoke about the “Importance of deep inelastic scattering in the 21st century”. His talk was followed by an impressive list of “Novel ideas” presented by Stan Brodsky, the other prominent theorist and member of the International Advisory Committee (IAC) chaired by Director-General emeritus of CERN, Herwig Schopper. Exciting prospects were presented on precision



*Sketch of the cryo-module housing four 802 MHz cavities. Each cavity contains five cells. This configuration is currently being designed by a collaboration of CERN and Thomas Jefferson Laboratory for the LHeC. In its current default configuration, the electron-beam energy in the LHeC achieves 60 GeV in three steps. The beam is accelerated by two linear accelerators, each comprising 140 such modules housed in a tunnel one third of the LHC in circumference. (Image credit: JLab.)*

measurements in the top and Higgs sectors leading beyond the Standard Model, including a striking Higgs self-coupling sensitivity at the FCC–eh.

Further physics highlights concerned nuclear structure, important for heavy-ion physics and the understanding of physics at high parton densities; the latter is also required for ultra-high-energy neutrino physics exploring the far universe. Software challenges in detector development were also reviewed in detail. Due consideration was also given to the installation of the LHeC detector within a regular LHC shutdown, its synchronous operation during the HL-LHC phase, and a first design was presented of FCC–eh apparatus.

Much attention was given to ERL-related technology progress, especially on super-conducting radio frequency (SCRF)

cavities (see figure), high-current electron sources and the recovery of beam power. As an intermediate step, an ERL facility delivering about 1 GeV energy electrons at high currents of tens of mA was considered. Such a facility would have a number of first-class potential physics applications related to photonuclear reactions and low-energy electromagnetic, as well as weak electron–proton interactions. However, the IAC recommended focusing on technical developments in international collaboration, with the aim to verify and optimise the principal accelerator design choices. The LHeC will be further developed in a three-year R&D programme, with the objective to maintain the option for moving forward when the European context is clearer and the Run 2 LHC results become available.

● For more details, see [lhec.web.cern.ch](http://lhec.web.cern.ch).

## EMMI workshop kicks off at CERN

The first workshop on antimatter, hypermatter and exotica production at the LHC was held at CERN on 20–22 July. The workshop was supported by the ExtreMe Matter Institute (EMMI) at GSI in Darmstadt (Germany). EMMI aims to foster research topics such as the properties of quark–gluon plasma and the phase structure of strongly interacting matter, the structure and dynamics of neutron matter,



*Group photograph of the EMMI workshop participants. (Image credit: EMMI.)*

electromagnetic plasmas of high-energy density, ultra-cold quantum gases and extreme states in atomic physics.

The LHC is an ideal factory for anti- and hypermatter because heavy ions colliding at ultra-relativistic energies produce a huge

number of quarks and antiquarks in equal amounts. An interesting feature of the ion collisions at the LHC is that  $s$  and  $\bar{s}$  quarks are as abundant as  $u$  and  $d$  quarks.

The aim of the workshop was to discuss in depth the wealth of results on antimatter,

hypermatter and exotic bound states (including pentaquarks, hexaquarks and dibaryons) obtained so far at the LHC using the data collected with pp, Pb–Pb and p–Pb collisions. Results obtained at other accelerators were also examined, together with a broad overview of the different theoretical approaches.

More than 50 scientists from around the world contributed to stimulating discussions in which the interplay between experimental results and their theoretical interpretation was essential. Out of the 27 invited talks, 10 were delivered by young scientists, providing them with an excellent opportunity to present

their work in an informal and challenging environment.

A major outcome of the workshop was a complete overview and improved understanding of the data collected during LHC Run 1, as well as data from non-LHC experiments at lower energies. A heavily debated topic was the production of light antinuclei (from deuterons to  $^4\text{He}$ ) in heavy-ion collisions, and their interpretation through two competing models: the thermal production mechanism and production through coalescence. Furthermore, the production of  $\Lambda$  hypernuclei (nuclei in which one nucleon is replaced by a  $\Lambda$  hyperon)

at different energies and with different production reactions was presented. These data were discussed in view of the open puzzle of hypernuclear physics, namely the unexpected low value of the hypertriton ( $^3_\Lambda\text{H}$ ) lifetime measured in heavy-ion collisions. Finally, the state-of-the-art of the search for possible exotic bound states, such as the H-dibaryon, was presented. Possible measurements to look further for the discovery of these states were elaborated in a fruitful exchange between theorists and experimentalists.

● For more information, see <https://indico.csi.de/conferenceDisplay.py?confId=3767>.

## NEW PUBLICATIONS

# iSGTW relaunches as The Science Node

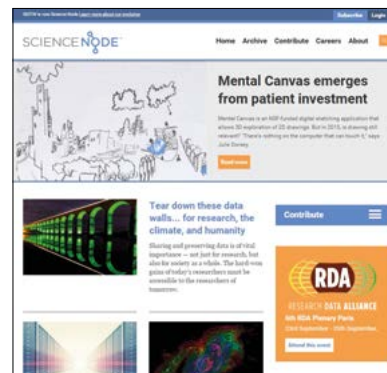
Earlier this year, the online magazine *International Science Grid This Week* (iSGTW) celebrated its 10th anniversary. Now, this free publication, which is run jointly by CERN in Europe and Indiana University in the US, has relaunched as *The Science Node*.

With its more memorable name, *The Science Node* will continue to report on research made possible by distributed and

high-performance computing technologies. The publication will also feature the latest news and in-depth analysis related to networking, big data, volunteer computing, “the internet of things”, citizen science and much more.

Find out more at [www.sciencenode.org](http://www.sciencenode.org). If you're interested in contributing to *The Science Node*, please contact the editorial team at [info@sciencenode.org](mailto:info@sciencenode.org).

The Science Node was launched in September. (Image credit: The Science Node.)



On 15 September, Helsinki Institute of Physics and Tampere University of Technology announced the launch of a new Business Incubation Centre (BIC) of CERN technologies. The Finnish BIC joins a network of six other such centres already established across Europe. Similarly to the others, it will connect science with industry and support the formation of new businesses from scientific research. CERN's technologies are already available through a variety of schemes, ranging from R&D partnerships to licences and consultancy. With the BIC scheme, CERN supports new companies and small businesses in the development and exploitation of innovative ideas in fields related to the laboratory's activities. In particular, CERN contributes with the transfer of knowledge and know-how through technical visits to the organisation, support for the BIC and preferential-rate licensing of CERN intellectual property. The new Finnish Business Incubation Centre will work in collaboration with CERN's Knowledge Transfer Group to encourage entrepreneurs to turn technology developed at CERN into useful, marketable ideas. The partnership agreement was signed at CERN. From left, head of CERN's Knowledge Transfer Group, Giovanni Anelli, CERN's Director-General, Rolf Heuer, the Finnish ambassador to Switzerland, Päivi Kairamo, HIP's director, Juha Äystö, TUT's president, Markku Kivikoski, and professor, director of HIP's Technology Programme, Saku Mäkinen. (Image credit: CERN.)

## Faces & Places

### OBITUARIES

# Jacob Bekenstein 1947–2015

Jacob (Yacov) Bekenstein, a faculty member of the Racah Institute of Physics of the Hebrew University, Jerusalem, Israel, passed away on 16 August 2015 while visiting the Department of Physics in Helsinki.

Jacob made seminal contributions to the understanding of the properties of black holes and information storage in quantum field theory and general relativity. His powerful tool was *Gedankenexperiments*. This approach (in English, “thought experiments”) has played a very important role in the developments of new ideas in physics: Galileo envisaged falling bodies, Maxwell had demons, Einstein chased light rays and studied elevators and Schrödinger mulled over the fate of cats. Jacob Bekenstein took these experiments to a whole new level.

He revolutionised the understanding of black holes after performing a *Gedankenexperiment* upon the suggestion of his adviser at Princeton University, John Wheeler. In the experiment, the content of a teacup was poured into a black hole. Jacob was able to transform the implied threat of the reduction of entropy in this very esoteric process (in apparent violation of the second law of thermodynamics) into the totally unexpected realisation that black holes have thermodynamical properties. It was a triumph of the human spirit. Not only did he ascribe to black holes properties such as entropy, which reflects the number of degrees of freedom, but he also brought about a revolution in the deep understanding of thermodynamics and the structure of space as seen at high-enough energies, where black holes and their like emerge and play a role.

### Pioneering study

For well over a century, textbooks have been teaching us that thermodynamical properties such as entropy are extensive, namely that they are proportional to the volume of the system under study. However, for reasons of consistency, Jacob decreed that black holes are objects whose thermodynamical properties must be proportional only to the area of the system. The body of work in which these ideas were developed and argued dates from 1972. As the years pass, and even though the full implications of this deep insight are yet to be understood, appreciation of this pioneering study is only increasing.

Since the beginning of his work, Jacob pointed out the crucial role played by



Jacob Bekenstein. (Image credit: Bekenstein family.)

the properties of processing information in unlocking the secrets of black-hole and quantum gravity. His research led him to suggest bounds on the amount of information that can be stored in a given volume of space–time. This bound is called the “Bekenstein bound”, and has direct implications on theories in which gravity seems to play no role. Jacob’s work, based again on *Gedankenexperiments*, raised a great deal of interest as well as controversy. He published it in 1981, and it has since passed several refinements and generalisations.

The very special nature of black holes uncovered by Jacob increased the realisation that information, in certain interesting circumstances at the very least, is stored on the boundary of those systems. This general feature was named “holography” – a concept borrowed from quantum optics. In particular, in one set of cases, that information is encoded in the form of a quantum-field theory where gravity is not even present. This goes under the name of AdS/CFT correspondence. Issues related to AdS/CFT correspondence are still the subject of active research in 2015, more than 40 years after Bekenstein’s seminal paper appeared.

Physics may be about uncovering the objective secrets of nature, but it is done by humans, and most humans appreciate due recognition and credit. Jacob’s ideas in the 1970s encountered both significant resistance and attempts to diminish his role. Not least from Stephen Hawking, who briefly mentions

Bekenstein’s role in his bestselling book *A Brief History of Time*. He writes: “I was motivated partly by irritation with Bekenstein, who I felt misused my discovery.” And then: “However, it turned out in the end that he [Bekenstein] was basically correct, though in a manner he had certainly not anticipated.”

This reflects the enormous pressure that the 25 year-old Jacob had to withstand, essentially all alone. Jacob who, while being rather shy was very opinionated, answers Hawking’s remarks in his book *Of Gravity, Black Holes and Information*, where he writes: “I cannot, of course, do anything about another’s anger but... Nobody can be held to blame for giving in a published result a novel interpretation of his own.” He also mentions that “I almost lost confidence then.” One can only imagine the strength he needed to stick to his intuition. The main argument against him at the time was the conventional wisdom that black holes should have zero temperature and thus supposedly no entropy. So much for conventional wisdom. Out of this cocktail of emotions that Bekenstein and Hawking brewed, one following the other, breakthroughs came in the understanding of the physical properties of black holes.

### A dedicated teacher

As mentioned previously, Jacob was highly opinionated. In his book, one can find critical remarks on aspects of string theory, as well as a line such as “aspiring students, beware” with regards to string theory and “beware of cheap interdisciplinary fads”. I venture to say that in my opinion, some of this was self-critique, because both string theory and Jacob’s breakthroughs relied on the consistency of physical structures and seem painfully far from any near-future experimental verifications. In recent years, Jacob actually searched for some experimental evidence for quantum aspects of gravity itself. He was an excellent and dedicated teacher, and as such he also encouraged students to study advanced mathematics and improve their mastery of the English language.

At the Racah Institute of Physics, the high-energy theorists sit on the higher floor; nevertheless, Jacob seemed to have a quite guarded respect for the field. He was very interested in the results coming (and not coming) out of the LHC.

Part of Jacob’s personality was that he practised religion in a private manner. He was named after Jacob in the bible, about

whom it is said that he struggled with a formidable stranger (an angel, according to some), and did not lose. Very few faced the formidable challenges of presenting a theory of gravity with as much success as Jacob Bekenstein. One is also told about the biblical Yacov that he dreamed about: a ladder grounded on Earth and reaching heaven on which there was motion upwards and downwards. Jacob always made every research effort to be grounded on the Earth, but he did not shy away from climbing the ladder and bringing back his insights.

He will be dearly missed.

Jacob (Yacov) David Bekenstein was born in Mexico City on 1 May 1947. His father, Joseph Bekenstein, worked as a carpenter, and his mother, Esther (Nee) Vladaslavitsky, was a homemaker. They were Jewish immigrants from Poland to Mexico. He went on to graduate from Princeton University, obtaining a PhD in 1972 under John Wheeler. After time as a postdoctoral fellow at the University of Texas in Austin, he moved to the Ben-Gurion University of the Negev in Beersheba, where he eventually became chairman of the astrophysics department. In 1990, he joined the faculty of

the Hebrew University of Jerusalem.

His awards include the Rothschild, Israel, Wolf and Einstein prizes in Physics. He was a member of the Israeli Academy of sciences and humanities.

Jacob is survived by his wife Bilha, his daughter Rivka (a PhD student in physics at the Technion) and his sons Yehonadav (a condensed-matter physicist, now a postdoctoral fellow at UC Berkeley) and Uriya (a PhD student in biology at the Hebrew University), as well as by his six grandchildren.

● *Eliezer Rabinovici.*

## Bernard D'Espagnat 1921–2015

Bernard D'Espagnat, physicist and philosopher, passed away on 1 August 2015.

His father was a famous post-impressionist; one of his paintings can be seen in Musée d'Orsay. Bernard D'Espagnat entered the Ecole Polytechnique in Paris, but his studies were interrupted when he was sent to Vienna during the German occupation period for forced labour. After the war, he came back to France and finished his studies, starting his PhD in the Leprince Ringuet laboratory at the Ecole Polytechnique. After a year spent in Chicago he went to CERN, which was in its infancy in 1954. Indeed, D'Espagnat was the first member of the CERN Theory Group in Geneva (at that time there was another group of theorists affiliated to CERN but based in Copenhagen).

A year later, in 1955, he convinced Jacques Prentki, whom he had met at Ecole Polytechnique, to join him at CERN. As we know, Prentki played a very important role for the organization until his death in 2009, while D'Espagnat left CERN and became professor in Orsay (France) in 1961. The early work of D'Espagnat was mostly in collaboration with Prentki, mainly searching for symmetries of hadrons and their decays. In 20 publications, they had developed their own theoretical model, and later worked with Abdus Salam (1979 Nobel prizewinner) on the “global-symmetry” theory. Their exploratory work was very useful, despite the fact that, in 1961, Gell-Mann and Ne’eman independently (and, in parallel, Speiser and Thirring-Wess) developed the “good model” – the octet model in SU3. Indeed, looking for order in the jungle of hadrons is like playing the archeologist: you dig in different directions and different places and finally someone finds the truth.

In 1961, D'Espagnat published a paper, which I consider to be a turning point in



*Bernard D'Espagnat. (Image credit: Templeton Prize/Laurence Godart.)*

his career. Two years earlier, the American physicists Day, Snow and Sucher had proposed a mechanism in which a negatively charged particle captured by a proton could cascade down to an S quantum state. In his paper, D'Espagnat pointed out that if a proton and an antiproton in an S state annihilate into a pair of neutral  $K^0$  mesons, it will unavoidably be a  $K_1^0$  and a  $K_2^0$  meson (this was before CP violation was discovered in 1964; today, these states are called  $K_S^0$  and  $K_L^0$ ). D'Espagnat's theory was confirmed in an experiment carried out at CERN in 1962.

### Instant knowledge

The theory implies that, as seen in the annihilation of a proton–antiproton, if a  $K_2^0$  is detected, one knows instantly that the other decay product is a  $K_1^0$ . The information seems to propagate at a velocity greater than the speed of light. John Bell later called this mechanism the “Bertlmann effect”.

The name comes from Reinhold Anton Bertlmann, a physicist living in Vienna who had the habit of wearing one blue sock and one red sock. If he put his socks in two envelopes and sent one to Moscow and the other to Geneva, the person who received the sock in Geneva would know instantly the colour of the sock received in Moscow. This is classically acceptable, but in quantum mechanics there is a subtle effect called entanglement, for instance seen in the decay of a  $\pi_0$  into two photons that show correlations in their polarizations. In fact, this is only an example of the many things that are difficult to swallow in the so-called “Copenhagen interpretation” of quantum mechanics. Even Einstein, who initiated quantum mechanics with his theory of the photoelectric effect, did not believe in it. He even said: “God does not play dice,” criticizing the probabilistic aspect of the theory. However, John Bell proposed tests of quantum mechanics, which were experimentally checked by the French physicist Alain Aspect. In fact, in the ordinary life of physicists, quantum mechanics is tested every day. For instance, the energy levels of atoms are predicted with incredible accuracy by quantum mechanics.

In this complex situation, D'Espagnat tried to find a way out. His views, almost mystical, are certainly respectable. They imply a veiled reality. He has written several books in a marvellous style about this, in particular *Conceptual Foundations of Quantum Mechanics*. Others, like Roland Omnès, have different points of view. D'Espagnat was rewarded by the prestigious Templeton prize in 2009, and was a member of the Académie française des Sciences Morales et Politiques. He was full of charm. We will sorely miss him.

● *André Martin.*

## Faces &amp; Places

# Raymond Stora 1930–2015

A great figure of theoretical physics, Raymond Stora passed away on 20 July. He leaves behind an impressive body of work in the difficult domain of quantum field theory, as well as a vast empty space in the community of theoretical physicists.

Taking an equal interest in the use of quantum field theory in particle physics as in its mathematical structures, Raymond Stora significantly participated for more than half a century in important developments such as the relativistic invariance in quantum field theory or the instanton theory. In the 1970s, his work with C Becchi and A Rouet in the framework of the renormalisation of non-Abelian gauge theories – a basis for the unification of electromagnetic and weak interactions – led to the famous “BRS transformation”, named after its authors, and which cannot be ignored by any student of theoretical physics.

Raymond Stora defended his thesis at MIT, then became a member of the Department of Theoretical Physics at the CEA in Saclay, from 1957 to 1970. He then joined the CNRS and became director of the Laboratory of Theoretical Physics in Marseilles. At the beginning of the 1980s, after several long-term visits to CERN, his career led him to Annecy, where he played a fundamental and vital role in the development of the group that was to become the LAPTh, Laboratory of Annecy-le-Vieux of Theoretical Physics.



Raymond Stora. (Image credit: Stora family.)

In the last few years, Raymond Stora was emeritus director of research at the CNRS, as well as emeritus researcher at the Theory Division of CERN.

## International reach

Raymond Stora occupied several positions of responsibility at various national and international levels, in particular as president of the Theoretical Physics Commission of the CNRS and as director of the School of Physics at Les Houches. He was also awarded several national and

international scientific prizes: the Joannidès Prize of the French Academy of Sciences, the Ricard Prize of the French Society of Physics, the Max-Planck Medal, and the Dannie Heineman Prize of Mathematical Physics. He was a corresponding member of the French Academy of Sciences as well as a Chevalier de la Légion d'Honneur.

A brilliant mathematical physicist and a particularly gifted particle physicist, Raymond Stora was a man of immense culture beyond the sciences. He loved arts and books, especially those of the 16th century, because they were the first printed texts to be published. But his main concern was in helping his fellow human beings to realise their full potential. He was a gentle, kind and fair man, exceptionally generous with the most precious thing: his time. With his eclectic knowledge, he spared no effort in guiding, correcting and advising people, encouraging without ever judging others, particularly young physicists. A man of conviction, he was driven by an incredible intellectual vivacity and extraordinary foresight. He was both demanding and tolerant, in his work as well as in his personal life: demanding towards himself, demanding for the truth, tolerant of different scientific ideas and tolerant of others.

Raymond was a master, a respected and beloved man. Some scientists deserve the term of humanist, and Raymond Stora was definitely one of them.

● *His friends and colleagues.*

## PRIZE

### IUPAP Young Scientist Prize In Nuclear Physics

This prize was established by IUPAP in 2005 at the time of the General Assembly in Cape Town, South Africa.

The purpose of this prize, which consists of €1000, a medal, and a certificate citing the recipient's contributions, is “To recognise and encourage very promising experimental or theoretical research in nuclear physics, including the advancement of a method, a procedure, a technique, or a device that contributes in a significant way to nuclear-physics research. Candidates for the prize must have a maximum of eight years of research experience (excluding

career interruptions) following the PhD (or equivalent) degree.”

Nominations by one or two nominators (and distinct from the nominee) are open to all experimental and theoretical nuclear physicists. The nomination package should contain, in addition to the nomination letter, at least two further letters of support, and the curriculum vitae of the nominee, which also contains the list of publications. Three prizes will ordinarily be awarded at the time of the tri-annual International Nuclear Physics Conference.

The deadline for nominations is 1 December 2015. The additional letters supporting the nomination should detail the expected significance of the contributions of the nominee to nuclear physics. To underline this, additional material such as published articles can be added to the nomination package. In particular, information that allows the selection

committee to evaluate the nominee's contribution to, and its direct impact, on the field.

Nominations for prizes to be awarded at the next International Nuclear Physics Conference, to be held on 11 to 16 September 2016, in Adelaide, Australia, should be e-mailed, by 1 December 2015, to the chair of the IUPAP Commission of Nuclear Physics (C12), Professor Alinka Lépine-Szily, to [alinka@if.usp.br](mailto:alinka@if.usp.br), with the subject line “IUPAP prize nomination”.

## CORRECTION

An unfortunate error crept in to the figure published on page 9 of the September issue. The units used in the ordinate of the graph in figure 5 had (pp) instead of (pb), which stands for “picobarn”. The error has been corrected in the online and archived version of the journal.

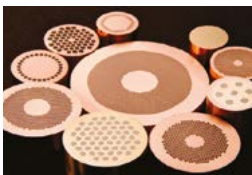
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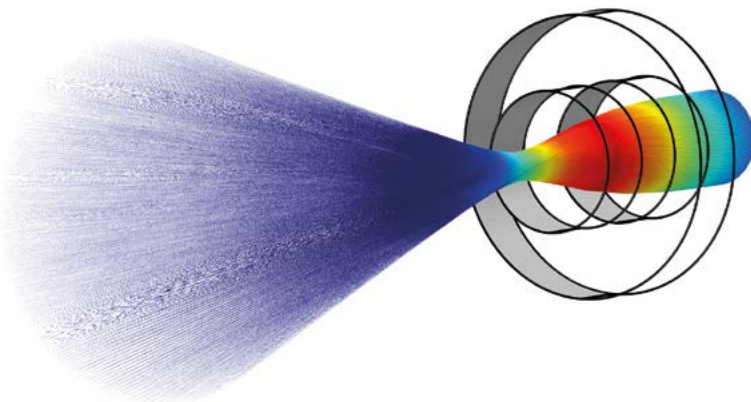
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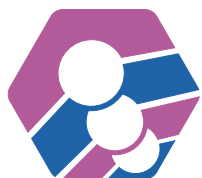
The Particle Tracing Module extends the functionality of the COMSOL Multiphysics modelling environment to allow the computation of the trajectories of particles in fluids and charged particles in electromagnetic fields. The particles can be subjected to a wide variety of forces, such as electrical, drag and thermophoretic, as well as particle-particle and fluid-particle interactions. This webinar introduces particle tracing for applications such as erosion, etching, mixing, filtration, mass spectrometry, ion optics and beam physics. The webinar includes a demonstration and ends with a Q&A session.



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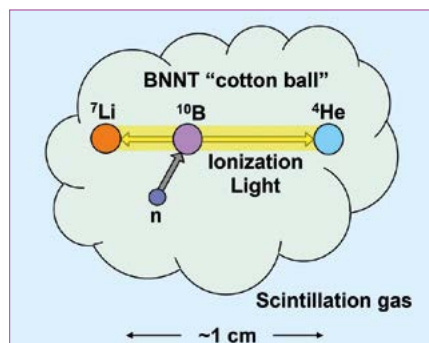
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