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Covering current developments in high-energy physics and related fields worldwide

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The start of a long journey p8

Parlez-vous français p26

A welcome return to school p39

Cover: A US Air Force C-5 Galaxy stands on the tarmac at Geneva International Airport in preparation for taking off for Florida with the AMS experiment on board (p5).

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NEWS

ASTROPARTICLES

AMS takes off for Kennedy Space Center

The Alpha Magnetic Spectrometer (AMS), an experiment that will search for antimatter and dark matter in space, left Geneva on 26 August on the penultimate leg of its journey to the International Space Station (ISS). Following work to reconfigure the AMS detector at CERN, it was flown to the Kennedy Space Center in Florida on board a US Air Force Galaxy transport aircraft.

The AMS experiment will examine fundamental issues about matter and the origin and structure of the universe directly from space. Its main scientific target is the search for dark matter and antimatter, in a programme that is complementary to that of CERN's LHC.

Last February the AMS detector travelled from CERN to the European Space Research and Technology Centre (ESTEC) in Noordwijk for testing to certify its readiness for travel into space (*CERN Courier* April 2010 p5). Following the completion of the testing, the AMS collaboration decided to return the detector to CERN for final modifications. In particular, the detector's superconducting magnet was replaced by the permanent magnet from the AMS-01 prototype, which had already flown in space in 1998. The reason for the decision was that the operational lifetime of the superconducting magnet would have been limited to three years because there is no way of refilling the magnet with liquid helium – which is necessary to maintain the magnet's superconductivity – on board the space station. The permanent magnet, on the other hand, will now allow the experiment to remain operational for the entire lifetime of the ISS.

Following its return to CERN, the AMS detector was reconfigured with the permanent magnet before being tested with particle beams. The tests were used to validate and calibrate the new configuration before the detector leaves Europe for the last time.

The AMS detector under preparation at CERN in July 2010.

On arrival at the Kennedy Space Center, AMS will be installed in a clean room for further tests. A few weeks later, the detector will be moved to the space shuttle. NASA is planning the last flight of the space-shuttle programme, which will carry AMS into space, for the end of February 2011.

Once docked to the ISS, AMS will search for antimatter and dark matter by measuring cosmic rays. Data collected in space by AMS will be transmitted to Houston and on to CERN's Prévessin site, where the detector control centre will be located, as well as to a number of regional physics-analysis centres set up by the collaborating institutes.

● The AMS experiment stems from a large international collaboration, which links the efforts of major European funding agencies with those in the US and China. The detector components were produced by an international team, with substantial contributions from CERN member states (Germany, France, Italy, Spain, Portugal and Switzerland), and from China (Taipei) and the US. The detector was assembled at CERN, with the assistance of the laboratory's technical services.

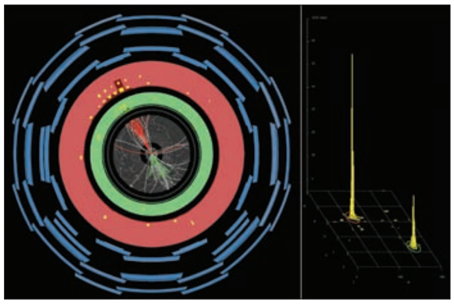
Sommaire

LHC PHYSICS

ATLAS puts limits on excited quarks

The ATLAS experiment at the LHC has set the world's best known limits for the mass of a hypothetical excited quark, q*. The analysis, accepted for publication by *Physics Review Letters*, represents ATLAS's first exclusion of physics outside the Standard Model and extends the scientific reach of previous experiments. The existence of such a state would indicate that a quark is a composite particle as opposed to an elementary one as the Standard Model assumes.

The search was based on a sample of 315 nb^{-1} of proton–proton collision data collected at 7 TeV in the centre-of-mass. Looking at the mass distribution of measured dijets – events with two jets – the analysis used six different model-independent statistical tests to hunt for narrow resonances that could indicated the production of new heavy particles. The lack of evidence for such resonances allows the collaboration to set limits on the existence of the hypothesized q*, in particular, because predictions indicated a chance that it could be observed in the first samples of data at the LHC.



A high-mass event detected by ATLAS at 7 TeV in the centre-of-mass system: the invariant mass of the two jets is 2.55 TeV.

The results exclude at the 95% confidence level the existence of a q* with a mass in the range 0.40–1.26 TeV. With further data ATLAS will continue its searches to exclude or discover hypothesized particles such as the q* over greater ranges in mass.

Further reading

ATLAS collaboration 2010 arXiv:1008.2461v1.

LHC NEWS

The LHC gets set for more luminosity

Recent work by the operations team at the LHC has focused on pushing the machine's performance towards higher luminosity and into new territory in terms of stored beam power.

Moving to 25 bunches per beam with almost nominal bunch intensities at the beginning of August implied operation with a stored energy in each beam of more than 1 MJ (*CERN Courier* September 2010 p8). This corresponds to the current record for stored beam energy in existing hadron accelerators and marks an energy regime where a sudden loss of beam or operational errors can result in serious damage to equipment: an energy of 1 MJ is sufficient to melt 2 kg of copper. Extreme care and a thorough optimization of all operational procedures are therefore required in making this important transition in the machine's performance. The work during August has included optimizing the operational procedures and the machine protection systems, with the aim of gaining experience with the reliability and reproducibility of the operation of the machine at such a high stored beam energy.

Early August also saw record results for the LHC performance in terms of delivered luminosity. For the first time the peak luminosity surpassed 4×10^{30} cm^{-2} s^{-1} and the total integrated luminosity delivered to the experiments passed the milestone of 1 inverse picobarn (1 pb^{-1} or 1000 nb^{-1}) over the weekend of 7–8 August. Another step towards higher luminosity occurred on 19 August, when the number of bunches in each beam was increased from 25 to 49. By the end of August the total integrated luminosity passed the threshold of 3 pb^{-1}, about half being delivered in just one week of running with the higher number of bunches.

In parallel, the operations team has been conducting several tests for improving the LHC performance still further. The ramp speed of the magnets (the rate at which the electrical current can be changed in the LHC main dipoles) has been increased from 2 A/s to 10 A/s for the pre-cycle (without beam) of the magnet system. The ramp speed of 10 A/s has also been successfully tested for acceleration with beam, but the final implementation must wait until the LHC starts operation with bunch "trains", in which the bunches of protons are grouped closely together, in contrast to the present operation with widely separated bunches. The faster ramp speed reduces significantly the minimum required time between two physics fills and therefore increases the overall machine performance in terms of integrated luminosity,

Operating the machine with bunch trains will open the door for increasing the total number of bunches in successive steps, so improving the LHC's luminosity over the coming months by another factor of 10 to 100. For this the operations team is working with bunch trains with 150 ns spacing between bunches (the current minimum spacing is 1000 ns). This involves making the necessary changes throughout the injector chain, as well as in the LHC itself. In the LHC, bunch trains imply working with a defined crossing angle between the beams throughout the machine cycle, in order to avoid unwanted parasitic collisions. This means that the whole process of injection, ramp and squeeze has to be re-commissioned.

The task also includes re-commissioning all of the protection systems, both at injection and elsewhere in the cycle. This is particularly important now that the energy stored in each beam is about 3 MJ and is set to increase further in the coming weeks. Alongside these operations, the LHC teams will bring the higher-speed energy ramp (10A/s) into operation, which will reduce the time needed to fill the machine. The initial aim of this re-commissioning phase is to bring a few high-intensity bunches in trains into collision for physics and later move from 50 up to 96 bunches injected in each direction. Once again, this should result in a significant increase in the luminosity delivered to the experiments.

● For news on the LHC, follow the *Bulletin* at http://cdsweb.cern.ch/journal/CERNBulletin/.

DESY

FLASH is in full swing again

On 2 September, user operation resumed at the FLASH free-electron laser (FEL) at DESY in Hamburg after a major upgrade that boosted its energy to 1.2 GeV and its wavelength to 4.45 nm. The third user run will last a year and comprise more than 350 twelve-hour shifts. It is already overbooked by a factor of three.

FLASH, the world's first soft X-ray FEL, has been available to photon-science users for experiments since 2005. Last winter, the facility underwent an extensive five-month upgrade. The photo-injector was replaced with a new electron source that generates considerably less dark current and features a low transverse emittance. A further superconducting accelerator module – a prototype for the European XFEL hard X-ray laser – was added to the six that are already installed, increasing the beam energy from 1 to 1.2 GeV. This enabled the FLASH team to set a new record for the facility, pushing the wavelength from 6.5 nm to 4.45 nm in June.

Another key element is a new module with four superconducting cavities operating at 3.9 GHz rather than the 1.3 GHz customary at FLASH. This third-harmonic RF system – built at Fermilab in collaboration with DESY – flattens the energy distribution of the electrons in the bunch, leading to a linearization of the longitudinal phase space. The system is now routinely in operation, allowing a considerable increase in the energy of a single photon pulse to a couple of hundred microjoules and more flexibility in adjusting the duration of the photon pulse. This also constitutes an important test for the European XFEL, which is to be equipped with similar modules.

In addition, the FLASH team installed a seeding experiment (sFLASH) in which light amplification will be triggered using an optical laser – as opposed to the current self-amplified spontaneous emission (SASE) process in which amplification is started by the stochastic radiation that the electron bunches emit along the undulator. The optical laser provides the seed radiation with a wavelength of 38 nm by generating higher harmonics of the optical wavelength in a gas cell. The seeding will make it possible to reduce significantly the intensity fluctuations between individual pulses and enhance further the laser properties of the radiation. The radiation produced this way will be made available at a separate beamline, without interfering with the rest of the FLASH operations.

FLASH thus continues to offer new and unique experimental possibilities. The shortest wavelengths may even allow for first experiments on carbon in organic molecules, while magneto-dynamics experiments, with the third-harmonic wavelength, will benefit from the substantially increased intensities.

Installation of the 3.9 GHz module into the FLASH injector. (Courtesy Courtesy Kay Jensch/DESY.)

PETRA III begins research operations

DESY's new X-ray source, PETRA III, has begun operating for the international scientific community, with the first external users welcomed at the third-generation synchrotron source. The first user period, which will last until Christmas, is already overbooked, indicating the user community's enormous interest in the new facility.

In this period, 32 scientific workgroups will carry out experiments at the first three measuring stations at PETRA III. They were selected from a total of 54 applications for beam time, through an international peer-review process. The experiments cover a variety of science, from high-temperature superconductivity and magnetism to the mapping of biological nanostructures. In parallel with the start of research activities, the remaining measuring stations in the PETRA III experimental hall are being equipped and put into operation. Light will reach 14 beam lines by the end of the year. PETRA III, with a circumference of 2.3 km, is the third reincarnation of the PETRA storage ring, which began life as a leading electron–positron collider in the 1980s (*CERN Courier* September 2008 p19). In the newly erected 300-m long experimental hall, it will ultimately be possible to carry out up to 16 experiments simultaneously at 30 measuring stations.

The first PETRA III user group is welcomed by Helmut Dosch, chair of DESY's Board of Directors. The team, from the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, will investigate changes in the atomic structure of zirconium dioxide that are generated by heavy-ion radiation. Left to right: Bruno Merk, Tim Seidl, Beatrice Schuster, Florian Pforr, Helmut Dosch and Hermann Franz. (Courtesy DESY.)

COLLABORATION

WMO and WIPO sign co-operation agreements with CERN

The World Meteorological Organization (WMO) and the World Intellectual Property Organization (WIPO), both based in Geneva, have signed co-operation agreements with CERN. This follows the signing of an agreement with the International Telecommunication Union in May (*CERN Courier* June 2010 p26). A common thread in the three agreements is the stimulation of technological innovation.

The director-general of WIPO, Francis Gurry, and CERN's director-general, Rolf Heuer, signed an agreement on 20 August to strengthen collaboration between the two organizations. The co-operation agreement, which is to be ratified by the WIPO Co-ordination Committee, focuses on four main areas: capacity building, awareness raising and knowledge sharing; transfer of technology and know-how; co-operation in the area of technological, scientific and patent information and options for alternative dispute resolution for IP-related matters.

Michel Jarraud (left), secretary-general of WMO, with CERN's director-general Rolf Heuer.

Rolf Heuer (left) with WIPO's director-general, Francis Gurry. (Courtesy WIPO.)

The co-operation agreement with WMO is to promote the sharing of information and knowledge in information technologies, in line with WMO's policy to foster global scientific and technical collaboration. It was signed by WMO secretary-general Michel Jarraud and CERN's director-general, Rolf Heuer, on 26 August. Areas of potential collaboration include: high-bandwidth-capacity networks for exchange of observations and information; collaborative on-line software tools for data and information analysis; management of mass data and storage systems; and capacity building and e-education tools, especially in developing nations.

JINR and CERN begin a new phase of collaboration

Equipment destined for a new project at JINR, Dubna, has been shipped from CERN. A tracking detector manufactured by the NA48 collaboration at CERN will be used in the Multipurpose Detector (MPD) in the Nuclotron-based Ion Collider Facility (NICA), which is aimed at studying maximally high baryonic densities (*CERN Courier* January/February 2010 p13).

The shipment marks the beginning of a renewed partnership between the two international physics centres within the context of a new co-operation agreement, which was signed in January (*CERN Courier* April 2010 p8). The previous co-operation agreement, which had been in force since 1992, defined the participation of JINR's scientists and specialists in the research programme carried out at CERN. The new agreement introduces more symmetry into the relationship, with mutual participation in the research programmes of both laboratories. In particular, it foresees the help of experts from CERN in the realization of JINR's research programme.

JINR has contributed for almost two decades to the construction of the accelerator and detectors for the LHC project, which is now successfully completed, with data-taking and data analysis underway. In the meantime JINR has developed its own exciting research programme. This programme will renew JINR's experimental base, and CERN will help with its expertise in accelerator and detector technology.

The chambers are prepared for shipment before setting off on the journey from CERN to Dubna.

Left to right: Vladimir Karjavin, representative of JINR at CERN; Mikhail Itkis, acting JINR director; Rolf Heuer, CERN's director-general; Tadeusz Kurtyka, CERN adviser for relations with non-member states; Ferdinand Hahn, technical co-ordinator of NA62; and Viacheslav Golovatyuk, technical co-ordinator of the MPD project, JINR.

The NICA/MPD project was initiated by former director of JINR, Alexei Sissakian, who sadly passed away on 1 May (*CERN Courier* June 2010 p32). The studies of hot and dense baryonic matter at the facility, together with the search for the quark-hadron mixed phase, could make Dubna one of the most attractive centres in this domain, together with GSI and Brookhaven.

The equipment transported to Dubna in July consists of a tracking detector, which includes four drift chambers with a diameter of 2.6 m – optimal for use as end-cap tracking systems in the MPD as well as for the future Spin Physics Detector. It was shipped together with data read-out electronics.

CLIC/CTF3 goes truly global

The Australian Collaboration for Accelerator Science (ACAS) - a new Australian institute for accelerator science launched in July - has become the latest participant in the CLIC/CTF3 collaboration, working on the Compact Linear Collider (CLIC) study for a future linear electron-positron collider and the CLIC Test Facility 3 (CTF3) at CERN. ACAS is a collaboration between the Australian National University, the Australian Nuclear Science and Technology Organization, the Australian Synchrotron and the University of Melbourne. This brings not only a new country – Australia – to the collaboration, but equally a new continent and even a new hemisphere.

Roger Rassool, right, director of ACAS, shakes hands with Rolf Heuer, after signing the new agreement.

The agreement, which is an addendum to the standard CLIC/CTF3 memorandum of understanding, specifies the contribution of ACAS to the CLIC/CTF3 Collaboration. This focuses on studies for the damping rings and for the accelerating RF test modules. The agreement was signed on 26 August by the ACAS director, Roger Rassool from the University of Melbourne, and witnessed by CERN's director-general, Rolf Heuer.

COSMIC RAYS

Cosmic accelerators may be at work in the Milky Way

Measurements by the Pierre Auger Observatory may provide evidence of natural nuclear accelerators at work in the local galaxy, the Milky Way. Alexander Kusenko of the University of California, Los Angeles, his student Antoine Calvez, and Shigehiro Nagataki, from Kyoto University, have found that possible sources such as gamma-ray bursts (GRBs) or rare types of supernova explosions could produce the observed energy-dependent composition of ultrahigh-energy cosmic rays.

An edge-on view of our Milky Way galaxy in infrared light . (Courtesy NASA/GSFC.)

Earlier this year, the Pierre Auger Collaboration published an analysis of cosmic rays with energies above 10^{18} eV (1 EeV), which indicated a gradual increase in the average mass of the cosmic rays with energy, up to about 59 EeV (Abraham *et al.* 2010). In other words, these ultrahigh-energy cosmic rays appear to be heavier nuclei, rather than protons. Previous results, such as the lack of anisotropy in their arrival direction have indicated an extragalactic origin for the highest-energy cosmic rays. However, it seemed surprising that nuclei would travel such long journeys without disintegrating into protons. Moreover, it is unlikely that a cosmic accelerator could accelerate nuclei better than protons at these high energies.

Kusenko and colleagues have now proposed an explanation in which the nuclei originate from sources within the Galaxy (Calvez, Kusenko and Nagataki 2010). Stellar explosions, such as GRBs, can accelerate protons and nuclei but, while the protons leave the Galaxy promptly, the heavier and less mobile nuclei become trapped in the turbulent magnetic field of the source, lingering longer than protons. As a result, the local density of nuclei is increased, so they bombard Earth in greater numbers, as seen by the Pierre Auger Observatory. The nuclei detected will have been trapped by Galactic magnetic fields for millions of years, so their arrival directions have been completely randomized. However, protons escaping from other galaxies should still be seen at the highest energies, and should point back to their sources.

Further reading

J Abraham *et al.* 2010 *Phys. Rev. Letts.* **104** 091101.
A Calvez, A Kusenko and S Nagataki 2010 *Phys. Rev. Letts.* **105** 091101.

SCIENCEWATCH

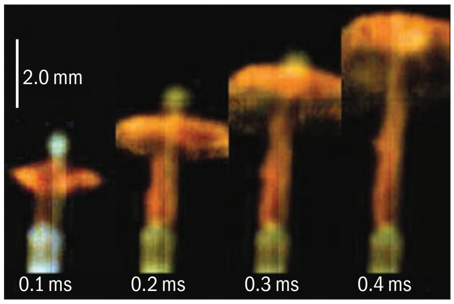
Compiled by John Swain, Northeastern University

Sphagnum moss shoots out high-speed rings of spores

It is well known that animals, including squid and jellyfish, can generate vortex rings of water during propulsion, and that dolphins can blow air rings in water apparently just for amusement. Now, researchers have discovered for the first time that plants can also perform the same kind of feat – and at remarkably high speeds.

Dwight Whitaker, a physicist at Pomona College in California, and Joan Edwards, a biologist at Williams College in Massachusetts, teamed up to film *Sphagnum* moss as it shoots its spores. It does this in the form of vortex rings, which are ejected with amazing accelerations in excess of 36 000 *g*. The value for the low-lying moss of this explosive expulsion is that it sends the spores to heights at which they can be caught by winds, ensuring dispersal over a wide area.

Sphagnum moss covers about 1% of the Earth's surface, but nobody ever seems to have bothered taking a close look at such short (submillisecond) time-scales before. This neglect is perhaps odd when *Sphagnum* moss, also known as peat moss, plays a key role in the flavour of many whiskies. It also has antiseptic properties, which played an important role in wound dressings in war time.



Sequential video frames of an exploding capsule recorded at 10 000 frames per second with 20-μs exposure. (Courtesy Whitaker and Edwards.)

Further reading

D L Whitaker and J Edwards 2010 *Science* **239** 406.

For a video of the moss in action, see www.sciencefriday.com/videos/watch/10318.

Tiny transistors get inside cells

The standard electrical device for looking inside a biological cell is the clunky passive patch-clamp probe that has been used since the 1970s, but nanoscale field-effect transistors (FETs) appear to be poised to make revolutionary changes. Charles Lieber and colleagues at Harvard University in Boston have put a small FET into an acute-angle bend of a tiny silicon wire with an electrical connection on each arm of the bend.

Coating the apex of the bend with phospholipids to mimic a cell membrane, they put the FET into the membrane of a single cultured cell of an embryonic chicken heart so that the voltage pulses from the individual beating cell could be recorded. The FET is only 50 nm wide so the research clearly opens a window for monitoring individual living cells.

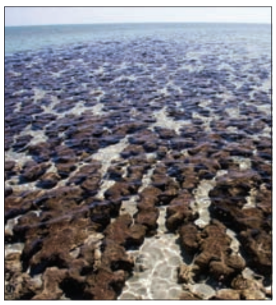
Further reading

B Tian *et al.* 2010 *Science* **329** 830.

Stromatolites harbour a new kind of chlorophyll

For the past 60 years researchers believed that they had found all of the varieties of chlorophyll appearing in nature: basically four chemically distinct types, labelled a, b, c and d (where the c type comes in two subtypes, c1 and c2). Each form is a little different chemically and has a different absorption spectrum. In work that has come as a complete surprise to botanists and biochemists, Min Chen of the University of Sydney and colleagues have found a fifth form of the photosynthetic molecule, which they designate "chlorophyll f".

Found in cyanobacteria (blue-green algae) that the team collected in stromatolite formations in Western Australia, the new form of chlorophyll absorbs further into the infrared than the other chlorophylls. This gives the organisms that use it some advantage in accessing the longer and more penetrating wavelengths of light, for example, within the stromatolites, the rock-like structures that are built by cyanobacteria. In addition to its intrinsic interest, the discovery could also help in the production of energy from photosynthetic processes.



Stromatolites in Western Australia where Chen and colleagues found the new kind of chlorophyll. (Courtesy Jarrodboord/ Dreamstime.com.)

Further reading

M Chen *et al.* 2010 *Science* published online. Science. DOI: 10.1126/science.1191127.

Ferroelectric ferromagnetics

Multiferroics – materials that are both ferroelectric and ferromagnetic – are rare. They are also interesting because they can directly couple electric and magnetic fields and could lead to novel devices that combine the speed and low power consumption of field-effect devices with the permanence of ferromagnetism. June Hyuk Lee of Cornell and Pennsylvania State universities and colleagues have shown a promising route to such devices with materials that start with neither property, but acquire it under strain.

The team significantly changed the properties of thin films of materials such as europium titanate by applying strain at levels that would crack the material in bulk. The mechanism is fundamentally one that involves the couplings of spins to the lattice. The multiferroics made so far work only at low temperatures, but the research clearly points the way to higher temperature analogues.

Further reading

J H Lee *et al.* 2010 *Nature* **466** p954.

Compiled by Marc Türler, ISDC and Observatory of the University of Geneva

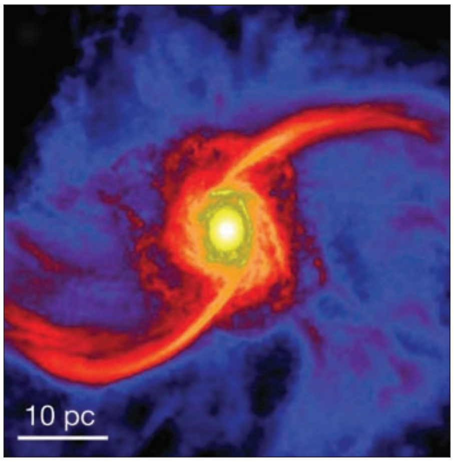
Colliding galaxies formed giant black holes

Like Ben Johnson's explosive jump out of the starting blocks for 100 m, the growth of supermassive black holes had a "jump start" in the early universe. What triggered this fast build-up has long been a mystery, but now a detailed numerical simulation shows that a major collision between two galaxies rapidly drives huge amounts of gas towards the centre, where it collapses into a supermassive black hole.

How is it possible that fully mature quasars are already observed at a redshift, z, of around 6, corresponding to a time when the universe was only about 1000 million years old? How could their central engine – a supermassive black hole of about 1000 million times the mass of the Sun – have grown so quickly? This rapid spurt has puzzled theorists for many years (*CERN Courier* July/August 2005 p10).

Whether the starting point is a black hole of about 100 solar masses, which could be the remnants from the first generation of stars, or a larger one of 100 000 solar masses resulting from the gas that can accumulate and collapse in the centre of an isolated protogalaxy, the problem is basically the same. The black hole must be continuously fed at – or close – to its maximum rate, which is controlled by the balance between gravitational attraction and radiation pressure. The surrounding matter is either of too low density or undergoes strong stellar formation, both of which prevent the black hole from effectively capturing the gas.

Numerical simulations have shown that the collision and merging of two galaxies can



A simulated surface density map of the inner gas disc that results from the merger of two galaxies, some 9000 years later. The strong spiral arms drive the matter towards the centre, where it will ultimately collapse into a supermassive black hole (L Mayer et al. *2010).*

rapidly drive most of their gas content within about 100 light-years from the centre, but it remained unclear whether this gas could be channelled towards the very centre of the galaxy and collapse into a black hole. This issue has now been addressed by Lucio Mayer from the University of Zurich and colleagues. The trick they use to go to smaller spatial scales with current supercomputer facilities is to split the fluid particles describing the gas into eight lighter particles. They do this in a limited volume, only slightly before the final merger of the two galaxies. This allows them to study the infall of the gas on scales 100 times smaller than previously achieved.

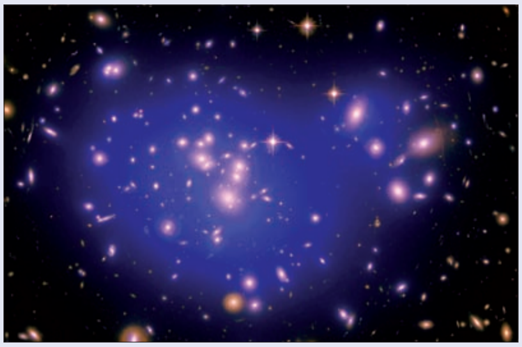
The new simulation, published in *Nature*, starts with two identical, and relatively large, disc galaxies. The results reveal the formation of a central disc of turbulent gas with a strong spiral pattern that further channels the matter towards the central light-year. The dense, central gas cloud with a mass of about 260 million solar masses suddenly becomes unstable towards gravitational collapse and forms a supermassive black hole in only about 100 000 years after the completion of the merger. Additional simulations show that this direct-collapse scenario would also work for mergers of galaxies with a 10 times lower mass, but for still lighter ones the central gas cloud remains stable, which could explain the absence of supermassive black holes in most dwarf galaxies.

The study has several cosmological implications. The common idea that galaxies grow in parallel with their supermassive black hole needs to be revised. The simulations suggest that the heaviest black holes form first and that galaxy growth is modulated by the size of the black hole, rather than the opposite. Furthermore, the rapid growth of big galaxies seems to be in contradiction with hierarchical structure formation (*CERN Courier* September 2007 p11). Stelios Kazantzidis, a co-author of the study, solves the paradox by explaining that only dark matter builds up slowly from smaller to larger structures, whereas ordinary, baryonic matter collapses more efficiently.

Further reading

L Mayer *et al.* 2010 *Nature* **466** 1082.

Picture of the month



This image of the galaxy cluster Abell 1689 combines visible light from the Hubble Space Telescope with a map of the dark-matter distribution shown in blue. The latter was derived from the distortion of background galaxies induced by the presence of this invisible matter of unknown origin. The matter content of the galaxy cluster deforms space–time locally and thus bends the light path of remote galaxies, which then appear distorted and brighter (*CERN Courier* April 2008 p11). This strong gravitational lensing effect is also influenced by the effect of dark energy on the geometry of the universe. This property has now been exploited in Abell 1689 to derive an additional, independent constraint on the equation of state of dark energy (Jullo E *et al. Science* 329 924). (Courtesy NASA, ESA, E Jullo (JPL/LAM), P Natarajan (Yale) and J-P Kneib (LAM).

CERN COURIER ARCHIVE: 1967

A look back to *CERN Courier* vol. 7, October 1967, compiled by Peggie Rimmer

ACCELERATORS

The big machines at the Cambridge Accelerator Conference

The 6th International Conference on High Energy Accelerators, held at Cambridge, Massachusetts, USA, from 11 to 15 September, brought together 276 accelerator physicists from throughout the world, including 24 from CERN.

At the time of the conference, commissioning of the 70 GeV proton synchrotron was underway at Serpukhov and V A Titov was able to report that an 8 mA beam had been accelerated to the injector energy of 100 MeV for the first time in July.

Perhaps the most eagerly awaited talk of the conference was that by R R Wilson, Director of the National Accelerator Laboratory [later renamed the Fermi National Accelerator Laboratory, Fermilab for short]. He presented the design study for the American 200 GeV machine – though perhaps it should be written 200–400 GeV machine.

Design work started at Oak Brook on 15 June, with the team under pressure to produce fairly detailed plans and a budget breakdown by October in order to request full authorization for fiscal year July 1968/ June 1969. If this authorization comes through, Wilson estimates the completion date of the machine as mid-1972.

Authorization is being requested initially for a 200 GeV machine but it is obvious that with a ring packed with magnets so that a field of only 9 kG is needed to reach 200 GeV, the step to higher energies will be an easy and economical one. The magnet designers are confident that good field will be retained up to 18 kG, equivalent to 400 GeV, and probably beyond that.

Left to right, A Merrison, G Pickavance, E Amaldi, three of the leading figures from the European accelerator world, pacing the sands during a conference excursion. (Courtesy Cambridge Electron Accelerator, R J Levy.)

300 GeV

An invited paper on "The 300 GeV accelerator in the European programme for high-energy physics" was given by E Amaldi. It was mainly concerned with the work of the European Committee for Future Accelerators ECFA, reported in *CERN Courier* June 1967 pp103–105 [see *CERN Courier* June 2010 p11].

As a sobering conclusion to the sessions on the big machines, here is a quote from a recent interview given to *The Christian Science Monitor* by the Brookhaven physicist S L Lindenbaum. "I'm beginning to think that 200 GeV or even 1000 GeV is not even 'high-energy' physics. It looks as though we may have to go to something like 20 000 GeV before we could expect to be in a region where things settle down, where even higher energies will not get us into a new realm of phenomena".

CERN comment and reactions

The Americans have evolved, in a very short time, a new design for their accelerator, with mid-1972 as the target date for completion. The proposed programme for the construction of the European 300 GeV machine means that it will follow in 1976.

At the 35th Session of CERN Council, on 21 and 22 September, concern was expressed at the fact that accelerator physicists from Europe are being drawn to the American project, and ways of setting up the basis of the European construction team in advance of full authorization are now being examined. Experimental physicists are also likely to be attracted away during the several years before the 300 GeV machine could come into operation.

If Europe is to build the big accelerator then the sooner the decision can be taken the better – not an easy one for individual European governments. Three governments, Austria, Belgium and France, have now indicated their willingness to participate and others are likely to present their position on the project in December.

● Compiled from texts on pp198–200, 203

COMPILER'S NOTE

Although beam energy is not everything, higher is usually better.

The Serpukhov synchrotron operated at full energy for the first time on the night of 13–14 October 1967, when protons were taken to 76 GeV, making it the highest-energy accelerator in operation in the world at the time.

The machine at what became Fermilab was authorized in April 1968 and reached the design energy of 200 GeV in March 1972, taking over as the world's highest-energy accelerator.

The European machine – the Super Proton Synchrotron (SPS) – was approved in 1971, to be sited at CERN. It was commissioned in June 1976 and exceeded its design energy by reaching 400 GeV. However, a month earlier, Fermilab had accelerated protons to 500 GeV, an energy reached by the SPS at the end of 1978.

The Fermilab Energy Doubler – the Tevatron – project reached fruition in 1983 with the first acceleration of a proton beam to 512 GeV; a record of 900 GeV was reached in 1984. Operating in proton–antiproton collider mode, the Tevatron has been delivering beams at 980 GeV since 2001.

Today, pole position is occupied by the LHC, where proton–proton collisions at a record 3.5 TeV per beam were achieved in March 2010. After the 2012 shutdown, the LHC will be taken to its design energy of 7 TeV per beam – high indeed but still in an energy region well below the one in which Lindenbaum thought things might settle down.

Searching beyond the frontiers in Cape Town

The latest conference in the BEYOND series presented an exciting overview across the current frontiers of research in particle physics, astrophysics and cosmology.

The Fifth International Conference on Beyond the Standard Models of Particle Physics, Cosmology and Astrophysics (BEYOND 2010) took place earlier this year in Cape Town. With 87 participants from all over the world and 73 presentations, it gave a broad view of the status and future of particle physics beyond the Standard Model. Although the meeting took place just before the LHC entered a new energy region at 7 TeV in the centre of mass, it allowed the presentation of some first results from 2009 and a look at what lies in store. Other highlights centred on areas beyond the Standard Model that are already under investigation, either theoretically or experimentally. This report, however, can mention only part of the broad range of topics and a few of the excellent speakers.

With the prospect of a few 100 pb^{-1} integrated luminosity to be delivered by the LHC during 2010, Claude Guyot of Saclay discussed the discovery potential of the ATLAS experiment. Silvia Costantini of CERN and the CMS experiment pointed out the challenges of the search for a fourth generation of quarks and for exotic partners of the top quark. An additional quark generation could account for the asymmetry between matter and antimatter; and natural, nonsupersymmetric solutions of the hierarchy problem generally require fermionic partners of the top quark with masses that are not much heavier than about 500 GeV. The LHC also has exciting potential in the areas of B physics and CP violation, particularly with the LHCb detector, as Jacopo Nardulli of the Rutherford Appleton Laboratory outlined. On the theoretical side, Thomas Appelquist of Yale reviewed recent work on the role of approximate conformal symmetry in strongly coupled theories, on which the LHC will begin to shed light. Flavour physics in warped extra dimensions is another topic on this level, with hidden sectors and hidden extra dimensions discussed by CERN's Ignatios Antoniadis. More down to Earth, the Minimal Supersymmetric Standard Model allows estimates of the possible production rates at the LHC of long-lived superparticles.

Participants pose in the sunshine at the BEYOND 2010 conference, Cape Town. (Photos courtesy H V Klapdor-Kleingrothaus.)

From neutrinos to Q balls

Neutrinos have already provided the first hints of new physics through their non-zero mass, which leads to neutrino oscillations. The study of their elusive properties continues in experiments on double-beta-decay, tritium-decay and reactor neutrinos, as well at accelerators. Present and near future double-beta-decay experiments, including a variant of the Cryogenic Underground Observatory for Rare Events (CUORE) called LUCIFER, are still far from being able to test the 6.4 σ evidence for neutrinoless double-beta decay observed in the Heidelberg-Moscow experiment, which took data in the Gran Sasso National Laboratory for 13 years. Even the huge KATRIN tritium-decay experiment at Karlsruhe can check for a neutrino mass of 0.2 eV – the lower limit for the electron-neutrino mass from the Heidelberg-Moscow experiment – only at the 1 σ level. The fastest independent measurement of the neutrino mass (and independent confirmation of the Heidelberg-Moscow result) might come from the PLANCK mission and – eventually – the Experimental Probe of Inflationary Cosmology (EPIC), NASA's post-PLANCK mission. EPIC should have a neutrino-mass sensitivity of $\Sigma m_\nu < 0.05$ eV and should test Super-Kamiokande's result of $\Delta m^2 = 2 \times 10^{-3}$ eV^2, from atmospheric-neutrino oscillations.

Reactor-neutrino experiments aim to determine the mixing angle Θ_{13} in the Maki-Nakagawa-Maskawa matrix. The Double Chooz experiment is expected to improve the current limit of $\sin^2 2\Theta_{13} < 0.15$ down to 0.03, and similar limits of 0.02 and 0.01 are expected from the Reactor Experiment for Neutrino Oscillation (RENO) at Younggwang and the Daya Bay experiment, respectively. This would allow, in three years or so from now, a check of the first hints for a non-vanishing Θ_{13}, which were obtained in 2008 in a global fit of all neutrino-oscillation data to a three-flavour scenario. ▷

At accelerators, the long-baseline experiments OPERA and MINOS have not yet yielded results. The T2K experiment, using an intense muon-neutrino beam generated by the new J-PARC facility at Tokai, with the detector 295 km away at Kamioka, aims at measuring Θ_{13} down to $\sin^2 2\Theta_{13} < 0.008$. This ambitious experiment started operation in March. In the more distant future, neutrino factories (producing neutrinos by muon decay) will be important for determining Θ_{13} if the sensitivity of T2K proves to be insufficient, as Osama Yasuda of Tokyo Metropolitan University discussed. Neutrino factories will also tackle topics such as violation of unitarity arising from heavy particles, or schemes with light and sterile neutrinos.

Leptogenesis can provide a solution to the baryon asymmetry of the universe and here, as Marta Losada of Bogota outlined, the focus has moved from understanding the qualitative features to detailed quantitative analysis. Neutrino masses and mixings consistent with recent neutrino data can lead to the correct baryon/photon ratio of 10^{-10}. The special case of electromagnetic leptogenesis considers the electromagnetic dipole-moment coupling between the light and heavy neutrinos, instead of the minimal Yukawa interactions, and again there is a strong connection between light-neutrino parameters and leptogenesis, as Sandy Law of Chung-Yuan University explained.

The decay $\mu \rightarrow e\gamma$, which is under study by the MEG experiment at PSI, is radiatively induced by neutrino mass and mixings, and extensions of the Standard Model enhance the rate through mixing in the high-energy sector of the theory. The result of the 2008 run, presented at the conference, gives the branching ratio for the decay as 3×10^{-11}, with a limit of 5×10^{-12} expected for this year's data. A positive result would yield evidence for physics beyond the Standard Model.

The search for exotic particles continues at accelerators and in cosmic rays. The best limit for penetrating grand-unified theory monopoles in cosmic radiation is still provided by the MACRO detector at Gran Sasso, and is close to the extended Parker bound, except at very high energies, where the best limits come from the AMANDA experiment at the South Pole and the Lake Baikal experiment. At the LHC, the MoEDAL detector – housed in the cavern of the LHCb detector – will search for magnetic monopoles. In the case of nuclearites, MACRO and the SLIM experiment (at a height of 5230 m at Chacaltaya, Bolivia) give the best limits, as Laura Patrizii of INFN Bologna outlined. The best limits for strangelets also come from the SLIM detector, with improvements expected from the Alpha Magnetic Spectrometer (AMS-02) mission, to be launched in February 2011. For charged Q balls, the best limits are from AMS-01, SLIM and MACRO.

Cosmological connections

Dark matter provided a vibrant topic for discussion. Rita Bernabei of Rome presented data taken over 13 years by the DAMA/LIBRA (Large sodium Iodide Bulk for Rare processes) experiment, which show behaviour consistent with an annual modulation signature from dark matter in the galactic halo at a confidence level of 8.8 σ. The Cryogenic Dark Matter Search (CDMS) II ended operations in March 2009. This experiment looked for elastic scatters of weakly interacting massive particles (WIMPs) from germanium nuclei in a detector array of a few kilograms. From the start it was somehow the object of debate for its selection of data. After 612 kg days searching for WIMPs between July 2007 and September 2008 (compared with 317 697 kg days, or 0.87 tonne years collected by DAMA/LIBRA), the final result shows no significant signal for dark matter.

Left to right: Irina Krivosheina, scientific secretary, Raoul Viollier, local chairman, Nevan Bilic, local organizing committee, and Hans Volker Klapdor-Kleingrothaus, chair and founder of the BEYOND series.

A look beyond – in this case beyond the cape at the edge of South Africa.

Imaging atmospheric Cherenkov telescopes (IACTs) can search for annihilations of WIMPs that could occur in high-density regions of our galaxy, such as the galactic centre. They look for high-energy gamma rays produced by effects of constraints on subhalo formation scenarios, such as spikes of dark matter around black holes of intermediate mass. Other theoretical candidates for dark matter, beyond the neutralinos that are a natural explanation in supersymmetry, include Kaluza-Klein particles, which arise in models with extra dimensions. Annihilation of such particles, gravitationally bound to the Sun, would produce neutrinos that could then give rise to muons and antimuons in Earth's matter. The ICECUBE detector, at the South Pole, can put constraints on the parameter space for models with only one of two types of the lightest Kaluza-Klein particles.

Dark energy was another hot topic. QCD provides an exciting approach that avoids the long-known discrepancy of the order of 10^{120} between the usual quantum vacuum-energy predictions of particle theory and the observed cosmological constant. QCD contains a massless dipole (the Veneziano "ghost") that contributes to the vacuum energy and could make it numerically close to what is observed, as Federico Urban of British Columbia described.

Lattice tests could confirm the existence of a Casimir QCD energy. A next step would be to gain a better theoretical understanding of the dynamics of the "ghost" in the expanding universe and to work out the consequences of its magnetic field in more detail. Another approach, presented by Gerard Stephenson of the Los Alamos theory group, investigates a connection between interacting Majorana fermions and cosmic acceleration. A system of fermions interacting through scalar exchange exhibits negative pressure when perturbed to densities less than the equilibrium density. On the basis of an adiabatic approximation, there are parameter ranges compatible with cosmic acceleration; the lightest supersymmetric particle could be a viable candidate fermion. A Majorana neutrino of mass around 0.26 eV would also be a candidate, which may be exciting in view of the neutrinoless double-beta-decay result from the Heidelberg–Moscow experiment.

An interesting, nonmainstream view of understanding dark energy was presented by Chris Clarkson of Cape Town. He argues that the huge Hubble-scale inhomogeneity has not been investigated in detail and could conceivably be the cause of apparent acceleration. If this is indeed the case, then we exist in a highly exceptional corner of the universe. The void models offer the possibility of describing dark energy as a radical inhomogeneity in a dynamically predictable model, rather than as an unknown dynamical degree of freedom in a postulated homogeneous model.

Astroparticle physics

A highlight of the conference was the presentation by NASA's Malcolm Niedner of the potential of the rejuvenated Hubble Space Telescope and some early results. The Hubble Ultra Deep Field Infrared Survey is entering new territory in the redshift region $z=8$–10. Within just a few weeks of operation, the new Cosmic Origin Spectrograph will probe more of the cosmic web than all previous Hubble spectrographs combined.

Back on Earth, at the South Pole the ICECUBE detector will start operation in 2011, following on from AMANDA, which was decommissioned in 2009, to study high-energy neutrino astronomy, atmospheric neutrinos and nonstandard oscillations. The ANTARES experiment, running in the Mediterranean Sea since 2006, has similar goals, focusing on high-energy cosmic neutrinos, the production mechanism of high-energy cosmic rays, high-energy processes in gamma-ray bursts and the study of binary systems and microquasars. ANTARES and ICECUBE cover complementary regions of the sky.

At lower energies, the BOREXINO experiment at Gran Sasso has new results on solar neutrinos. With the first real-time and simultaneous measurement of solar neutrinos from the vacuum-dominated region (^{7}Be-neutrinos) and from the matter-enhanced oscillation regions (^{8}B-neutrinos), the experiment claims to confirm the Mikheyev-Smirnov-Wolfenstein large mixing-angle solution of solar-neutrino oscillations at a 4σ level. It has also improved the best limit on the neutrino magnetic moment. Future plans include a check of the 7% seasonal variation of the neutrino flux so as to confirm its solar origin.

Understanding the origin and composition of ultrahigh-energy cosmic rays (UHECRs) may shed light not only on astrophysical acceleration processes but also on fundamental particle interactions – hence the excitement surrounding the Pierre Auger Observatory in South America. However, the latest results on the energy spectrum of UHECRs beyond the Greisen-Zatsepin-Kuzmin (GZK) cut-off show that there is still no hint of physics beyond the Standard Model. The strategy for the future lies in Auger North, an array that is seven times larger, which is hoped will be sufficient for discovering new physics.

Very high-energy, gamma-ray observation of supernova remnants interacting with molecular clouds seems to be a new way to reveal cosmic-ray accelerators. Thanks to a high sensitivity and good angular resolution, the HESS IACT array in Namibia produces detailed images of galactic sources in the tera-electron-volt energy range. Several supernova remnants show a similar pattern, where an excess of very high-energy photons coincides with a maser (or possibly laser) signal, typical of a shocked molecular cloud, situated on the rim of the supernova remnant.

In the search for gravitational waves the first generation of interferometers is now operating at the design sensitivity. The direct detection of gravitational waves would test general relativity in the strong-field regime and provide essential new information on objects such as neutron stars, black holes and the Big Bang. As Peter Aufmuth of the Max Planck Institute for Gravitational Physics in Hannover explained, while no signal has yet been seen, the detectors should be close to making observations. As for the future, an advanced LIGO/Virgo detector is scheduled for 2014, to be followed in 2025 by the Einstein Gravitational Wave Telescope, with 10 times higher sensitivity, as well as NASA's Laser Interferometer Space Antenna in 2022. All models for the unification of general relativity with quantum-field theory lead to (small) deviations from general relativity, which are least constrained experimentally at small and large scales. The CAsimir FORce and Gravitation (FORCA-G) experiment allows the exploration of gravity at short range using complementary physics to existing experiments, while the Search for Anomalous Gravitation with Atomic Sensors (SAGAS) investigates gravitation at large scales.

Back to Earth

Andrej Popeko of Dubna and Fritz-Peter Hessberger of GSI reported on the formation of superheavy elements at their respective laboratories, with exciting results that extend our understanding of element synthesis in the universe. The naming of the new element copernicium (^{112}Cn) was celebrated at GSI shortly after the conference. The elements 113 to 118 synthesized at Dubna have also been recently independently confirmed at GSI. Physics beyond the Standard Model may become accessible in nuclear physics through measurements of correlation coefficients in neutron decay. Possible topics include the search for right-handed weak currents, for scalar and tensor interactions (leptoquarks, charged Higgs bosons), for supersymmetric particles (via loop corrections in the beta-decay coupling constants), and tests of the unitarity of the Cabibbo-Kobayashi-Maskawa matrix. The new spectrograph aSPECT at the Institut Laue-Langevin will help to exploit this potential.

Ideas for future high-energy accelerators that could access physics beyond the Standard Model include an International Linear Collider (ILC), a muon acceleration facility and 100 TeV boson–boson collisions in the PETAVAC – a project proposed for the tunnel of the aborted Superconducting Super Collider and presented by Peter McIntyre of Texas A&M University. Yosuke Takubo of Sendai ▷

Not penguin diagrams, but real penguins seen during the conference excursion.

pointed out that one of the goals of the ILC would be to measure the parameters of heavy gauge-bosons, "little Higgs" partners of the Standard Model gauge-bosons, one of which is a dark-matter candidate. An intense cooled low-energy muon beam could provide extraordinarily precise lepton-flavour-violating experiments, while the same muons, accelerated and held in a storage ring, could be used for a neutrino factory.

In conclusion, the lively, enthusiastic and highly stimulating atmosphere of BEYOND 2010 raises the expectation of an exciting future for particle physics and cosmology beyond their standard models. The organizers thank all of the speakers and participants who made this meeting an unusually successful one scientifically.

● The conference chairs were Hans Volker Klapdor-Kleingrothaus, Heidelberg, founder of the BEYOND series, and local host Raoul Viollier of the Centre for Theoretical Physics and Astrophysics, University of Cape Town. Irina Krivosheina of Heidelberg and Nishnij Novgorod was scientific secretary.

Further reading

The proceedings are to be published by World Scientific. For the conference website, see www.phy.uct.ac.za/beyond2010/; for the programme and presentations, see www.klapdor-k.de/Conferences/Conferences.htm.

Résumé

Le Cap : au-delà des modèles standard

La dernière conférence dans la série « Au-delà des modèles standards » a été l'occasion d'un tour d'horizon des perspectives de la physique « au-delà » dans les domaines de la physique des particules, de la cosmologie et de l'astrophysique. Les moments forts de la conférence ont été les derniers résultats des expériences recherchant les signatures d'une nouvelle physique, sur la terre, sous la terre, sous l'eau ou la glace, ou encore en orbite autour de la Terre. Les neutrinos, la matière noire et l'énergie sombre ont été à nouveau les sujets les plus présents, mais la nouvelle physique a également été évoquée. D'autres interventions concernaient la théorie, et les attentes pour les expériences actuelles et futures, notamment au LHC.

Hans Volker Klapdor-Kleingrothaus, *Heidelberg.*

RICH pickings in Cassis

The seventh international workshop on ring imaging Cherenkov detectors highlighted many new developments for experiments in particle and astroparticle physics.

RICH2010 drew 115 participants to the port of Cassis. (Courtesy CPPM.)

The ring imaging Cherenkov (RICH) technique is used extensively in nuclear, high-energy and astroparticle physics experiments to identify charged particles via the measurement of their Cherenkov emission angles, over momenta ranging from a few hundred MeV/*c* to several hundred GeV/*c*. The technological feats of the single-photon RICH detection technique – manifested in the most extreme case via the 3D imaging of single photoelectrons that have been created by Cherenkov photons and then been allowed to drift a metre or so through gas at atmospheric pressure – remain unmatched in any other detection technology.

In 1993, Eugenio Nappi of INFN Bari and Tom Ypsilantis of Collège de France launched a series of international workshops as a forum for reviewing new developments and perspectives in this powerful technique (*CERN Courier* May 2005 p33). RICH2010, the latest in the series, took place on 3–7 May in the French Mediterranean port of Cassis. A broad programme of invited and contributed talks, as well as poster presentations, attracted 115 participants from 25 countries, reflecting the expanding application of Cherenkov imaging in accelerator-based particle and nuclear physics, astroparticle physics and neutrino astronomy. In addition to 10 invited talks, the programme included 42 contributed talks, which were selected from some 80 submissions to allow time for extensive discussions; the other 34 contributions were presented in poster sessions.

From the LHC to Lake Baikal

The workshop began appropriately with a comprehensive review of the fundamentals of Cherenkov-light imaging and recent developments by Jurgen Engelfried of the University of San Luis Potosi. The opening session on operating RICH detectors in nuclear- and particle-physics experiments then provided an opportunity to see the first calibration measurements with real LHC data from the ALICE and LHCb experiments.

The High Momentum Particle Identification Detector (HMPID) in ALICE employs a perfluoro-n-hexane (C_6F_{14}) liquid radiator with photon imaging via a reflective caesium iodide (CsI) photocathode operating in a multiwire proportional chamber (MWPC) filled with methane (CH_4) at atmospheric pressure. The detector has already demonstrated the expected π/K separation up to 3 GeV/*c* and proton identification up to 5 GeV/*c*; a future upgrade should extend the momentum range beyond this. LHCb has two RICH systems: RICH1, operating with aerogel and perfluoro-n-butane (C_4F_{10}) radiators; and RICH2, with a carbon tetrafluoride (CF_4) radiator, to provide a combined particle-identification range over 2–100 GeV/*c* (*CERN Courier* July/August 2007 p30). The data already taken clearly demonstrate the identification of hyperons and strange mesons.

Also at CERN, the COMPASS experiment has a RICH detector that has been operating since 2002 in beam rates as high as 10^8 Hz with a C_4F_{10} gas radiator for hadron identification over 3–60 GeV/*c*. The detector was subsequently upgraded with multianode photomultiplier tubes (MAPMTs) replacing the four central CsI MWPCs with pad read-out. This should allow an improvement from the present operation at 40 MHz to deadtimeless operation at 100 MHz in the central region. The NA62 experiment will use a RICH detector with a 17 m neon radiator and a focal plane of 2000 PMTs. Designed for electron–muon separation between 15 and 35 GeV/*c*, it should begin data-taking in 2012.

At Brookhaven, the hadron-blind RICH in the PHENIX experiment has demonstrated extremely high efficiency for photon detection in windowless operation, with CF_4 serving as radiator and for photoelectron detection in a gas-electron multiplier (GEM) device with a CsI photocathode. Ionization from passing hadrons is trapped on electrodes in the GEM, allowing for clean electron identification in gold–gold collisions at the Relativistic Heavy Ion Collider.

Following the success of the BaBar experiment at SLAC, techniques for the detection of internally reflected Cherenkov (DIRC) light produced in quartz bars continue to evolve. The barrel focusing-DIRC for the proposed Super-B facility would be more compact than its BaBar ancestor. It would also have quartz blocks instead of water in the focusing zone and MAPMTs with sub-200 ps time resolution or multianode microchannel plate PMTs to replace conventional tubes and provide time-of-propagation (TOP) measurements that could resolve the colour of individual Cherenkov photons. The more compact forward region would use an aerogel radiator.

SuperKEKB, the upgraded B facility planned at KEK, will operate at beam luminosities of more than 80 times the current value ▷

of 10^{34} cm^{-2}s^{-1}. The Belle II experiment will employ a challenging TOP detector that relies on new multichannel hybrid devices based on avalanche photodiodes (APDs) that are under development at Hamamatsu Photonics. The PANDA experiment at the Facility for Antiproton and Ion Research (FAIR), Darmstadt, will include a barrel DIRC that follows similar principles to barrel designs for Super-B and Belle II, while for the forward directions a DIRC detector with innovative disc geometry is under study.

The expansion in the use of imaging Cherenkov detectors in astroparticle physics, witnessed in earlier RICH workshops, continues to accelerate. Imaging air Cherenkov telescope (IACT) arrays use the Earth's atmosphere as radiator. The High Energy Stereoscopic System (HESS) array in Namibia has discovered numerous high-energy gamma-ray sources and a legacy survey of the galactic plane is almost complete. Sensitivity will be further increased in HESS-II with a fifth and larger (600 m^2) dish added at the centre of the array. The future Cherenkov Telescope Array (CTA), with around 80 dishes of three diameters, is expected to be approved in 2013. The CTA will greatly increase sensitivity to astrophysical gamma-ray sources through the exploitation of ongoing advances in mirror coatings, photon-camera technology and control systems for telescope positioning. Some of these advances are already becoming apparent in the innovative photon cameras of the MAGIC-II IACT and in the First Avalanche-photodiode Camera Test (FACT) project for a novel camera using Geiger-mode APDs (G-APDs), both on La Palma.

The ANTARES neutrino telescope, by contrast, looks downwards, using seawater as the radiator and the Earth to filter out up-going charged cosmic rays. At a depth of 2500 m in the Mediterranean Sea, the telescope was completed in 2008 and results based on an analysis of around 1000 detected neutrinos were presented. The constructional and operational experience gained in ANTARES represents a major step towards the KM3NeT multi-cubic-kilometre neutrino telescope for the deep Mediterranean, which is being pursued by a consortium that includes members of the ANTARES, NEMO and NESTOR neutrino-detector projects.

The Lake Baikal neutrino telescope has been running while increasing in size since 1993. With the deployment of additional optical detectors it will soon reach a target mass of a gigatonne of water. Nearby, the complementary 1 km^2 TUNKA-133 extensive air-shower array is coming into operation. This will be sensitive to primary cosmic rays in the energy range of 10^{15}–10^{18} eV.

Glimpses of the future

The first permanent RICH installation outside the Earth's atmosphere will soon be achieved with the launch of the Alpha Magnetic Spectrometer (AMS-02) in the final NASA space shuttle mission (STS-134) to the International Space Station in February 2011. The RICH subdetector consists of sodium fluoride and aerogel radiators, with a conical mirror and MAPMT photon detection. Tests at CERN last year using cosmic rays and a test beam confirmed the expected performance of the RICH subdetector (*CERN Courier* October 2009 p7).

Rapid, ongoing developments in solid-state, vacuum-based and gaseous photon detectors were reviewed in invited talks by Samo Korpar of Maribor, Toru Iijima of Nagoya and Silvia Dalla Torre of INFN Trieste, respectively. Leszek Ropelewski of CERN completed the picture with a fascinating evening seminar on developments in micropattern gas detectors (MPGDs) within the RD51 collaboration.

The Meditrio ensemble performing at the RICH 2010 concert in the barrel hall of the Domaine Bunan vineyard. Suspended and floor-level detectors used by the Cosmophone are visible. (Courtesy CPPM.)

Solid-state, single-photon detectors continue to mature. Progress on the design of G-APDs has led to commercialized silicon photomultipliers, offering single-photon sensitivity with high detection efficiency, high gain for bias voltages less than 100 V, excellent (tens of picoseconds) timing resolution and operation in high magnetic fields. Current disadvantages include a high (temperature-sensitive) dark count rate, which increases with radiation exposure. Nonetheless, G-APDs have already demonstrated their adaptability in various detectors. They are combined with light-collecting Winston cones in successful prototype IACT cameras in MAGIC and FACT. More than 60 000 G-APD modules are currently installed in the near detector of the Tokai-to-Kamioka long-baseline neutrino experiment; G-APDs have also been successfully tested with an aerogel radiator in studies for the RICH detector for Belle II.

Vacuum-based photon detectors continue to diverge from classical PMT forms to include: new multianode types; versions with photoelectron gain achieved in the pores of a microchannel plate (MCP), affording the time resolution required for future DIRC devices; and hybrid devices that combine a pixellated silicon pin-diode sensor or APD with a photocathode and photoelectron acceleration potential of several kilovolts. LHCb's RICH detectors represent the first implementation of such semiconductor hybrid devices in an operating experiment, while 144-channel hybrid APDs are foreseen as the baseline for Belle II. Quantum efficiencies continue to rise from typical values of 23% for bialkali (BA) photocathodes operating in the visible range to routinely produced "super" and "ultra" BAs, which approach 35% and 45% respectively. Such improvements are important for future water-based neutrino detectors, including MEMPHYS, because they allow for a bigger detector spacing and target volume.

While gaseous photon detectors – today with solid reflecting photocathodes rather than photosensitive vapours – remain the only approach to affordable large surfaces, great efforts have been made to inhibit the positive-ion feedback that limits photocathode lifetime and reduces operating speed. MPGDs based on stacked, perforated electrostatic layers in the GEM configuration have been implemented in several tracking detectors, including the hadron-blind RICH detector in PHENIX. Gaseous photon detectors for visible wavelengths so far remain elusive but many applications await, if they can be made cheaply enough.

Making the most of RICH detectors requires exceptional performance in many challenging technical areas, as highlighted in the invited talk by Clara Matteuzzi of INFN Milano. These include the purity of the solid, liquid or gas media – which the Cherenkov radiator transparency depends upon – as well as the transparency of radiator windows and reflectivity of focusing mirrors, which often operate at ultraviolet wavelengths. Groups in Novosibirsk and Japan have attained new levels of performance from aerogel radiators, in particular in terms of improved transparency and the production of tiles with customized refractive index.

In the tradition of the previous workshops, a session was also devoted to talks on pattern recognition and data analysis, where sophisticated methods and algorithms were presented. Last, in the conference summary, Blair Ratcliff of SLAC selected highlights from the many contributions at RICH2010 and revealed a picture of high "V^2" (variety and vitality) in Cherenkov-light imaging.

The first half of the conference suffered appalling and uncharacteristic weather, but nevertheless the participants enjoyed a social programme that included a (rescheduled) boat visit to the Calanques of Cassis and a banquet in the barrel hall of the Domaine Bunan vineyard, near Bandol. The accompanying concert featured keyboard improvisations by Jacques Diennet of Ubris Studio, Marseille, accompanied by passing cosmic rays, made audible in the "Cosmophone", which was introduced by its inventor, Claude Vallée of the Centre de Physique des Particules de Marseille. The concert continued with contemporary pieces played on vintage Provençial instruments by Jean-Marc Montera (lute and guitar) and the Meditrio ensemble. Fortunately, the weather smiled on the final days of the conference and on the closing ceremony, where the RICH2010 conference flag was presented to Takayuki Sumiyoshi of Tokyo Metropolitan University, in anticipation of RICH2013, which will take place in Japan.

● RICH2010 was sponsored by French and European private companies and institutions including CERN, IN2P3, Commissariat à l'énergie Atomique, Université de la Méditerranée Aix-Marseille II, Conseil General des Bouches du Rhône, Conseil General de la Région Provence – Alpes – Cote d'Azur and the town of Cassis.

Further reading

For all presentations and posters and further information about the sponsors and the Cosmophone, see http://rich2010.in2p3.fr/. The proceedings of the workshop will be published in *Nuc. Inst. Meth. A*.

Résumé

Cassis : une idée RICHe

La technique RICH (imagerie Tchérenkov à focalisation annulaire) est utilisée largement dans les expériences de physique des hautes énergies, de physique astroparticule et de physique nucléaire pour l'identification des particules chargées. RICH2010 était le 7e atelier international consacré à cette technique. De nombreuses communications et présentations d'affiches ont rassemblé 115 participants à Cassis, petit port méditerranéen. Les interventions ont montré le développement récent des techniques d'imagerie Tchérenkov. Il a été question des derniers résultats des expériences vedettes auprès des accélérateurs et des télescopes spécialisés, ainsi que des dernières avancées en matière de détecteurs de photons.

Greg Hallewell, **Dirk Hoffmann**, *Centre de Physique des Particules de Marseille, and* **Eugenio Nappi**, *INFN Sezione di Bari.*

An international future for nuclear-physics research

A working group set up under the auspices of IUPAP is taking a forward look at nuclear physics and the facilities it uses from an international perspective.

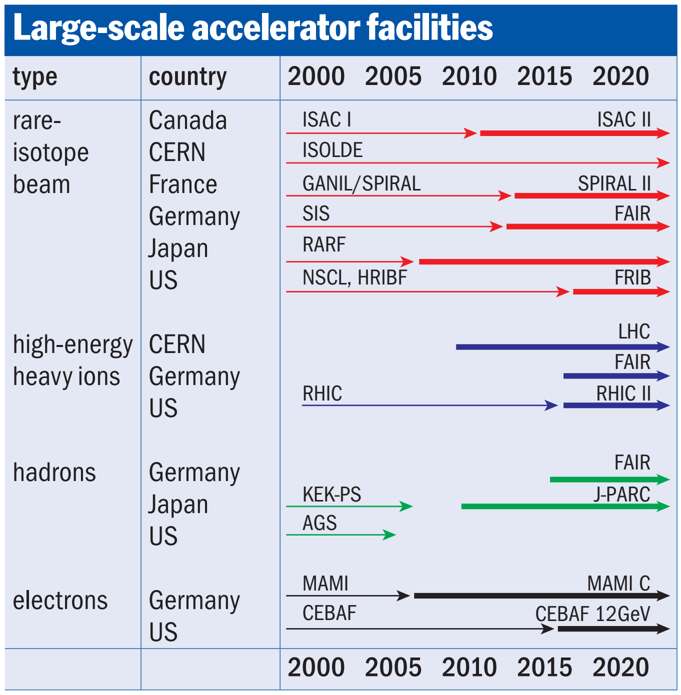
The International Union of Pure and Applied Physics (IUPAP) was established nearly 90 years ago to foster international co-operation in physics. It does this in part through the activities of a number of commissions for different areas of research, including the Commission on Nuclear Physics (C12), set up in 1960. In the mid-1990s, under Erich Vogt as chair, C12 identified the need for a coherent effort to stimulate international co-operation in nuclear physics. While it took some time for this new thrust to gain momentum, by 2003, under Shoji Nagamiya as chair, C12 established a subcommittee on International Co-operation in Nuclear Physics. This body, chaired by Anthony Thomas, then became IUPAP's ninth official working group, WG.9, at the IUPAP General Assembly in Cape Town in October 2005. As many will be aware the first working group, IUPAP WG.1, is the International Committee of Future Accelerators (ICFA), which was formed more than 40 years ago and plays such an important role in particle physics.

The membership of IUPAP WG.9 was chosen to constitute a broad representation of geographical regions and nations, as one would expect for a working group of IUPAP. Its members consist of the working group's chair, past-chair and secretary; the chairs and past-chairs of the Nuclear Physics European Collaboration Committee (NuPECC), the Nuclear Science Advisory Committee (NSAC), the Asia Nuclear Physics Association (ANPhA) and the Latin-American Association for Nuclear Physics (ALAFNA); the chair of IUPAP C12; the directors of the large nuclear-physics facilities (up to four each from Asia, Europe and North America); and one further representative from Latin America. The working group meets every year at the same location as, and on the day prior to, the AGM of IUPAP C12 – whose members are encouraged to attend all meetings of IUPAP WG.9 as observers. Other meetings, such as the two-day Symposium on Nuclear Physics and Nuclear Physics Facilities, are held as required.

The first task of IUPAP WG.9 was to answer three specific questions:

- What constitutes nuclear physics from an international perspective?
- Which are the facilities that are used to investigate nuclear physics phenomena?
- Which are the scientific questions that these facilities are addressing?

The answers to these questions are given in IUPAP Report 41, which



Summary of large-scale accelerator facilities in nuclear physics for countries participating in IUPAP WG.9, including estimated and proposed starts of operation until 2020. (From OECD GFS Report of the Working Group on Nuclear Physics.)

was published in 2007 and is posted on the IUPAP WG.9 website (IUPAP 2007). It contains entries for all nuclear-physics user facilities that agreed to submit data. The 90 entries range from smaller facilities with more restricted regional users to large nuclear-physics accelerator laboratories with a global user group. The report also has a brief review, prepared by the IUPAP WG.9 members, of the major scientific questions facing nuclear physics today, together with a summary of how these questions are being addressed by the current facilities or how they will be addressed by future and planned facilities. There is also a short account of the benefits that society has received, or is receiving, as a result of the discoveries made in nuclear physics.

In late 2005 the Office of Nuclear Physics in the US Department of Energy's Office of Science requested the OECD Global Science Forum (GSF) that it establish a GSF Working Group on Nuclear

Physics. The purpose of this working group was to prepare an international "landscape" for nuclear physics for the next 10 to 15 years. In particular, it was clear that for policy makers in many countries it is essential to understand how proposals for future facilities fit within an international context. IUPAP WG.9 agreed to provide expert advice to the GSF Working Group, and the chair and secretary of WG.9 as well as the chair of IUPAP C12 served as members of the GSF Working Group.

The work of the GSF Working Group was completed in March 2008, with the final version of the report being accepted by the OECD GSF. IUPAP Report 41 provided a great deal of valuable input, with the data and analysis contained within it helping to guide the deliberations of the GSF Working Group. Copies of the final OECD GSF report, which provides a global roadmap for nuclear physics for the next decade, in a format suitable for science administrators, are available from the OECD Secretariat; it also downloadable from the GSF website (OECD GSF 2008).

Central themes

In response to the mandate given to IUPAP WG.9 by the OECD GSF in a missive from its chair, Hermann-Friedrich Wagner, a two-day Symposium on Nuclear Physics and Nuclear Physics Facilities took place at TRIUMF on 2–3 July (*CERN Courier* September 2010 p6). The purpose of the symposium was to provide a forum where the international proponents of nuclear science could be appraised of, and discuss, the present and future plans for nuclear physics research, as well as the upgraded and new research facilities that will be required to realize these plans. This symposium was the first time that proponents of nuclear science, laboratory directors of the large nuclear physics facilities and governmental science administrators have met in an international context. The symposium is expected to be held every three years.

At the 2009 AGM of IUPAP WG.9, which was held at the Forschungszentrum Jülich in August 2009, the decision was taken to update the 90 descriptions of the nuclear-physics facilities and institutions. Following the requests for updated information, 35 replies with updated descriptions were received. These were entered into the online version of IUPAP Report 41 in January 2010. Following the International Symposium on Nuclear Physics and Nuclear Physics Facilities it became apparent that the introduction to the IUPAP Report 41 also needed updating. IUPAP WG.9 is currently reformulating the six main themes of nuclear physics today:

- Can the structure and interactions of hadrons be understood in terms of QCD?
- What is the structure of nuclear matter?
- What are the phases of nuclear matter?
- What is the role of nuclei in shaping the evolution of the universe, with the known forms of matter comprising only a meagre 5%?
- What physics is there beyond the Standard Model?

Members of the IUPAP WG.9 at the AGM in August 2009. (Courtesy FZJ.)

- What are the chief nuclear-physics applications serving society worldwide?

It is anticipated that these new descriptions for the roadmap for nuclear science will be entered in the online version of IUPAP Report 41 in January 2011.

Further reading

For further information on the activities of IUPAP WG.9, see www.triumf.info/hosted/iupap/icnp/index.html.

IUPAP 2007 Report 41, www.triumf.info/hosted/iupap/icnp/Report41.pdf.

OECD GSF 2008 *Report of the Working Group on Nuclear Physics*, www.oecd.org/dataoecd/35/41/40638321.pdf.

Résumé

Un avenir international pour la recherche en physique nucléaire

Un groupe de travail établi sous les auspices de l'Union internationale de physique pure et appliquée (IUPAP) se penche sur l'avenir de la physique nucléaires et les installations que requerra cette discipline, dans une perspective internationale. Ce groupe (IUPAP WG 9), constitué de membres représentant l'Asie, l'Europe, l'Amérique latine et l'Amérique du Nord, a été constitué en 2005. En 2007, il a publié un rapport (IUPAP Report 41), qui donne la liste de toutes les installations dans le monde et passe en revue les grandes questions scientifiques pour la physique nucléaire aujourd'hui. Le groupe a également organisé un colloque dans le but de réunir toutes les parties prenantes, y compris les directeurs de laboratoire et les responsables de politiques scientifiques.

Willem van Oers, *secretary of IUPAP WG.9, and* **Anthony Thomas**, *chair of IUPAP WG.9.*

« Le CERN est un fleuron de la

En novembre, François de Rose, diplomate français et l'un des fondateurs du CERN, aura 100 ans. Dans une interview, il partage ses impressions sur l'Organisation.

François de Rose (à gauche) avec John Adams lors de l'inauguration du Synchrotron à protons du CERN en 1960.

En mission diplomatique aux Etats-Unis, au lendemain de la Seconde guerre mondiale, François de Rose y rencontra de grands noms de la physique qui siégeaient, comme lui, à la Commission pour le contrôle international de l'énergie atomique de la toute jeune Organisation des Nations Unies. Il se lia d'amitié avec Robert Oppenheimer, rencontra Isidor Rabi et les Français Lew Kowarski, Pierre Auger et Francis Perrin, des physiciens convaincus que la reconstruction de l'Europe passait aussi par le développement de ses moyens de recherche. Les Etats-Unis s'étaient dotés de puissants accélérateurs de particules, et l'Union Soviétique suivait. Ces outils de plus en plus sophistiqués et imposants étaient trop onéreux pour un seul Etat européen. C'est ainsi que François de Rose et des scientifiques allèrent plaider auprès des gouvernements européens la création du premier centre de recherche fondamentale à l'échelle du Vieux Continent. On connaît la suite. Le CERN fut fondé en 1954 et François de Rose en fut le Président du Conseil de 1958 à 1960. Durant son mandat, il obtint notamment l'extension du CERN sur le territoire français. Il fut également délégué Français au Conseil du CERN pendant plusieurs années. Près de 60 ans plus tard, le CERN s'est hissé au premier rang mondial de la physique fondamentale, ce qui réjouit François de Rose, son seul fondateur encore en vie.

Au début des années 50, la physique fondamentale était dominée par les Etats-Unis et l'URSS. Aujourd'hui, le CERN est le plus grand Laboratoire de physique des particules du monde. Que vous inspire cette évolution ?

Un de mes premiers souvenirs est celui du sentiment de fierté et d'enthousiasme qui a animé les premiers collaborateurs du CERN. Tout le monde avait le sentiment d'être embarqué dans une aventure sans pareille, depuis un géant de la science tel que Niels Bohr jusqu'au plus humble collaborateur théoricien ou expérimentateur. Je crois que c'est une expérience unique d'une entreprise scientifique qui a suscité des vocations aussi engagées et passionnées.

Quelles étaient les convictions qui animaient les grands scientifiques qui ont participé à cette aventure ?

L'idée essentielle était celle que m'avait exposée Robert Oppenheimer quand il aborda la suggestion qui devait aboutir à la création du CERN, et ce dès 1946 ou 1947 : « Une grande partie des connaissances que nous avons, nous les avons acquises en Europe » disait-il. Les moyens nécessaires à la recherche en physique fondamentale allaient devenir si importants qu'ils dépasseraient les ressources humaines et économiques des états européens pris individuellement ; ces pays devraient donc grouper leurs forces pour rester au niveau des Etats-Unis et de l'Union Soviétique. Cette coopération a nécessité une ferme conviction de la part des scientifiques qui prirent part à la création du CERN et des gouvernements qui acceptèrent d'en payer la réalisation. Tous les fondateurs seraient heureux de voir que leur espoir a été plus que comblé, le CERN abritant, aujourd'hui, le plus puissant instrument de recherche au monde.

Y avait-il des résistances face à ce projet, par exemple des résistances politiques puisqu'il impliquait la collaboration de pays qui venaient de se combattre ?

Je ne me souviens d'aucune difficulté particulière concernant les rapports entre les anciens belligérants. Nous étions sur le plan scientifique et les considérations politiques n'intervinrent jamais. Cela était d'autant plus facile qu'on avait décidé que le CERN ferait uniquement de la recherche fondamentale, qu'aucune application militaire n'y serait étudiée, et qu'aucun secret ne couvrirait ses travaux. Par ailleurs, l'idée de l'Europe était en marche. Il était de l'intérêt européen de mettre sur pied ce centre de recherches.

Les résistances émanaient de scientifiques qui, à la tête de leur propre laboratoire, craignaient que l'attribution de crédits importants au CERN ne tarisse les ressources sur lesquelles ils comptaient. En fait, ce fut le contraire qui se produisit, le CERN jouant le rôle d'une puissante locomotive qui entraînait l'ensemble de la recherche européenne.

Comment les scientifiques vous percevaient-ils alors que vous étiez le seul diplomate ?

Mon enthousiasme pour l'idée de fonder le CERN parla en ma faveur. J'en fus un avocat déterminé auprès des hommes politiques comme des autorités financières. J'aurais mauvaise grâce à donner l'impression que j'étais le seul à nourrir ces sentiments. Les scien-

a construction européenne »

François de Rose, lors de la célébration du cinquantenaire du CERN en 2004.

tifiques Francis Perrin et Pierre Auger en France, John Cockcroft en Angleterre, Eduardo Amaldi en Italie et plusieurs autres dans les pays nordiques ainsi qu'aux Pays-Bas s'en firent aussi les « champions ». Il faut aussi souligner les encouragements de la communauté scientifique américaine.

Ma formation de diplomate m'a servi mais dans des conditions particulières à l'égard du gouvernement français. Il fut clair dès le début que le CERN serait vite à l'étroit sur le site mis à sa disposition par les autorités genevoises. La seule solution était de s'étendre en territoire français. Je constituais donc le dossier d'extension avec les arguments politiques et financiers appuyant les arguments scientifiques. C'est sur ce dossier que le gouvernement français décida de mettre à la disposition du CERN la parcelle qui abrite aujourd'hui, entre autres, les installations du LHC.

Continuez-vous à suivre les actualités liées au CERN ?
Je m'intéresse aux recherches du CERN lorsqu'elles ne sont pas trop complexes à comprendre. J'étais heureux et fier de la mise en marche du LHC. Je suis particulièrement intéressé par les recherches qui portent sur l'évolution de l'Univers et son origine. Il y a là une fenêtre qui s'ouvre sur un monde jusqu'à présent clos : les découvertes ne résoudront certainement pas toutes les énigmes mais nous permettront peut être de réaliser quelques pas dans cet inconnu.

Pourquoi êtes vous attaché au CERN ?
Je suis attaché au CERN parce que c'est une aventure extraordinaire, qui m'a mis en contact avec des gens très intelligents et qui m'a ouvert des perspectives qui font rêver. C'est aussi parce que le CERN est à la fois l'un des plus beaux fleurons de la construction européenne, un foyer d'où rayonne la culture européenne dans ce qu'elle a de plus universel, un centre de paix qui accueille les chercheurs du monde entier. En ma qualité d'ancien diplomate, je me félicite du succès de cette entreprise de coopération internationale.

Justement, en tant que diplomate, quelle est votre opinion sur les liens entre la science fondamentale et l'entente entre les nations?
On peut penser que tout ce qui est du domaine des connaissances partagées est un élément de rapprochement. La science, qui a souvent été l'auxiliaire des œuvres de guerre, est devenue un instrument de rapprochement entre les nations. Archimède et Léonard de Vinci, et tant d'autres, ont travaillé à des œuvres de guerre. Mais, dit on, les Chinois n'avaient trouvé que les feux d'artifice comme application de la poudre. Ma fréquentation régulière des hommes de science m'a permis de constater que ceux-ci sont profondément attachés au développement pacifique de leurs activités.

Quelle est selon vous l'utilité de la science fondamentale dans un monde plutôt porté vers la rentabilité économique à court terme?
La spéculation intellectuelle la plus désintéressée est la plus haute. La science fondamentale n'obéit pas dans son principe à la notion d'utilité. Pourtant, très nombreuses sont les retombées qui ne répondent pas à l'objectif primaire du chercheur, mais en sont les conséquences directes ou indirectes. C'est ainsi que le Web, qui est utilisé dans le monde entier, a son origine dans les travaux du CERN.

Si vous souhaitiez transmettre un message aux scientifiques qui viennent mener leurs recherches au CERN, quel serait-il?
Plusieurs générations de scientifiques et administrateurs ont œuvré au CERN depuis plus d'un demi siècle. Ils ont tous été conquis par l'importance à la fois scientifique et internationale du travail auquel ils étaient associés. Je souhaite que ce double idéal anime toujours les hommes et les femmes qui ont le privilège de travailler au CERN. Je suis d'ailleurs sûr qu'il en sera ainsi.

● Cet article a été en partie publié dans le *Bulletin* du CERN (http://cdsweb.cern.ch/record/1281661?ln=fr).

Summary
CERN, one of the proudest flagships of European co-operation

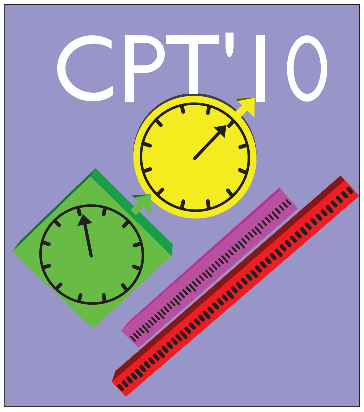
French diplomat François de Rose was one of CERN's founding fathers, a member of the group, mainly of renowned physicists, who advocated to governments the creation of the first fundamental research centre on a truly European scale. Their mission was successful. CERN was founded in 1954 and de Rose was later president of Council (1958–60) and a French delegate to Council for many years. Now in his 100th year, in this interview he shares his impressions of the organization that has grown to host the world's largest laboratory for particle physics. For an abridged version in English, see the CERN Bulletin http://cdsweb.cern.ch/record/1281661?ln=en.

Propos recueillis par **Corinne Pralavorio**.

Lorentz invariance goes under the spotlight

Experimental advances, intriguing developments and new results in the search for Lorentz violation were all under discussion at the CPT '10 meeting in Indiana. **Neil Russell** reports.

Experimental tests of relativity and theoretical developments in relativity violation have flourished over the past few years. This interest has been strengthened by recent results in particle physics that appear to deviate from the predictions of the Standard Model. Two examples are the evidence for anomalous CP violation in the B_s system and the indications that antineutrinos might not have the same properties as neutrinos. These and many other frontier topics were discussed at CPT '10, the fifth Meeting on CPT and Lorentz Symmetry, which was held in Bloomington, Indiana, on 28 June – 2 July. Speakers from four continents presented dozens of new limits on coefficients for Lorentz violation in the Standard-Model Extension (SME). In the opening scientific talk, James Bjorken of SLAC not only delivered an analysis of vacuum structures associated with emergent QED and torsion but also took the opportunity to put the meeting in perspective by looking back at the development of the SME over the past 15 years, as well as referring to the opening presentation at the CPT '01 meeting by Nobel Laureate Yoichiro Nambu.



The CPT '10 logo illustrates the concept that clocks and measuring rods of differing materials will differ in their response to rotations and boosts in a Lorentz-violating universe.

From antimatter to Antarctica

The CERN antimatter collaborations ALPHA, ATRAP, ASACUSA and AEgIS all provided updates on recent progress. Makoto Fujiwara of TRIUMF described how the ALPHA group developed a technique for evaporative cooling of trapped antiprotons down to temperatures of 9 K. The group is designing the apparatus to enable future hyperfine spectroscopy in antihydrogen. The ATRAP collaboration has made a number of advances using trapping techniques. Spokesperson Gerald Gabrielse of Harvard discussed results gained from ATRAP and other projects with single, trapped particles, including an improved measurement of the electron's magnetic moment and a method for cooling single, trapped protons. Masaki Hori of the Max Planck Institute of Quantum Optics discussed techniques developed for performing spectroscopy on a beam of antiprotonic helium by the ASACUSA collaboration. The group has developed a titanium sapphire laser that should reduce spectral-line widths in future experiments.

Antihydrogen will provide new opportunities to study the interaction of neutral antimatter with the gravitational field. Marco Giammarchi of INFN/Milan described how the AEgIS collaboration aims to measure the local gravitational acceleration of antihydrogen to about 1% by detecting the fall of an antihydrogen beam travelling at some 500 m/s over a distance of about 1 m. Alan Kostelecký of Indiana and Jay Tasson of Whitman College have recently completed a study of Lorentz violation involving gravitational couplings to matter and antimatter. They use toy models to demonstrate that Lorentz-violating effects could appear in antihydrogen spectroscopy without observable effects in hydrogen and could cause gravimetric properties of antihydrogen and hydrogen to differ. Gravitational experiments can also place limits on the a-type coefficients in the SME. These are unmeasurable with a single particle species in the Minkowski space–time context and in principle could be large without having been detected to date. Experiments with the potential for interesting results include ones involving free-fall gravimeters, as well as weak equivalence principle tests with free fall and with satellites. In this context, Paul Worden of Stanford described the latest developments from the Gravity Probe B and STEP satellite programmes.

Atom interferometers have the potential to explore untested regions in the matter-gravity sector of the SME coefficient space. The caesium interferometer built by Holger Müller's group at the University of California, Berkeley, is currently the highest-resolution atomic gravimeter. It has generated improved limits on half a dozen pure-gravity SME coefficients during 2009, which Müller described in an overview of the current results and interests within his group.

Atom-based co-magnetometers built by groups at Princeton University, the Harvard-Smithsonian Center for Astrophysics and the University of Mainz have contributed a number of sharp bounds on SME coefficients in the fermion sector. The three groups presented the status of their programmes at CPT '10. Mike Romalis' group at Princeton has commissioned a new apparatus, CPT-II, which is ▷

mounted on a turntable and is more compact than the one presented at the last meeting in the series, CPT '07 (*CERN Courier* January/February 2008 p23). At this year's meeting, Romalis presented results from the device, a K-He co-magnetometer, which was run for 143 days between July 2009 and April 2010, allowing sidereal signals to be separated from diurnal ones. These new data represent the highest energy-resolution to date of any spin-anisotropy experiment. A future improvement of two orders of magnitude is feasible by using neon in the magnetometer, and systematic effects due to the Earth's rotation could be evaded by running the experiment at the Amundsen-Scott South Pole Station in Antarctica.

Participants, posing for the traditional group photo, demonstrated definite symmetry-breaking at CPT '10. (Courtesy Jorge Diaz.)

Mesons, neutrinos and gamma rays

Rick Van Kooten of Indiana gave an overview of the recent evidence from the DØ collaboration at Fermilab for anomalous B-system CP violation differing at the level of 3.2 σ from the prediction of the Standard Model (*CERN Courier* July/August 2010 p6). He and Kostelecký have recently demonstrated that this result also yields the first sensitivity to CPT violation in the B_s system. The analysis interprets the anomaly in terms of CPT violation, placing a first limit on a CPT-breaking SME-coefficient combination at the level of 10^{-12}, a result that could be improved in the LHCb experiment at the LHC at CERN. Top-quark experiments at Fermilab have reached sufficient statistical power to produce first-time bounds on SME coefficients for the third generation of matter, while improved sensitivities may be possible with LHC statistics, as Fermilab's Gaston Gutierrez described in his discussion of prospects for future results.

In Europe, new accelerator-based results have come from the GRAAL beamline at the European Synchrotron Radiation Facility (ESRF). Dominique Rebreyend of the Laboratory for Subatomic Physics and Cosmology, Grenoble, presented recent results published in *Physical Review Letters*, which improve the limits on parity-violating SME coefficients in the photon sector by an order of magnitude. Ralf Lehnert of the National University in Mexico City presented the theoretical underpinnings of this work.

Conventional theory attributes neutrino oscillations to mass and predicts that oscillations are controlled by the baseline-to-beam-energy ratio, L/E. A variety of other dependences arising from Lorentz and CPT violation occur in the SME framework, and these have the potential to model some of the anomalous behaviour seen in recent oscillation experiments. The MINOS collaboration at Fermilab has recently published the results of their search for sidereal variations in neutrino oscillation probabilities using the MINOS near detector. Brian Rebel of Fermilab presented this and the latest related work, in which the collaboration also searched for effects at the far detector located about 700 km away in northern Minnesota. Teppei Katori of Massachusetts Institute of Technology gave an account of preliminary results from an analysis using the SME coefficients for Lorentz violation to reconcile the data from the LSND experiment at Los Alamos and MiniBooNE at Fermilab. Jorge Diaz of Indiana provided a complementary theoretical overview of SME neutrino physics.

Gamma-ray bursts (GRBs) are particularly suited to providing limits on some of the nonminimal SME coefficients in the photon sector, owing to their high energies, long baselines and high variability. Vlasios Vasileiou of the NASA Goddard Space Flight Center presented the first bounds from GRB 090510 on certain SME coefficients of mass dimensions 6 and 8. These results are from data taken with the Large-Area Telescope and the Gamma-Burst Monitor on the Fermi Gamma-Ray Space Telescope. High sensitivity to Lorentz violation in the photon sector has also been achieved in laboratory experiments with resonators. The cavity-oscillator groups of Achim Peters at Humboldt University and Mike Tobar of Western Australia have plans to start a new international collaboration based in Germany. Recent years have seen the development of a full theory of higher-order SME operators for Lorentz violation in the photon sector. This work, by Kostelecký and Matt Mewes of Swarthmore College, systematically enumerates and classifies Lorentz-violating operators of arbitrary dimension in electrodynamics. More formal developments were described by Luis Urrutia of the National Autonomous University of Mexico, who discussed spontaneous Lorentz breaking in models of nonlinear electrodynamics that maintain gauge invariance.

Experimental advances in the neutron sector, reports on the steady progress of antihydrogen technology, intriguing developments in the meson and neutrino sectors, experimental results in the nonminimal photon sector and new work in the theory of Lorentz-breaking matter-gravity couplings are some of the highlights from this meeting. While there is still no compelling sign of Lorentz violation, hints of effects have appeared in several sectors. The lively exchange of ideas and information at CPT '10 shows that the resolve of physicists in this field to dig more deeply into fundamental symmetries is stronger than ever.

Résumé

L'invariance de Lorentz à l'honneur

Les avancées expérimentales dans le secteur des neutrons, des communications sur les progrès de la technologie de l'antihydrogène, des découvertes intéressantes concernant les neutrinos et les mésons B, des résultats expérimentaux concernant les photons, et de nouveaux travaux sur les couplages matière-gravité avec violation de l'invariance de Lorentz, tel était le menu de la réunion CPT '10 qui s'est tenue en Indiana. Les résultats présentés lors de la réunion couvraient un ensemble de domaines d'expérimentation : particules élémentaires, atomes, sursauts gamma célestes. Il n'y a pas encore de données probantes concernant la violation de l'invariance de Lorentz, mais les communications présentées suggéraient différents effets intéressants dans plusieurs domaines.

Neil Russell, *Northern Michigan University.*

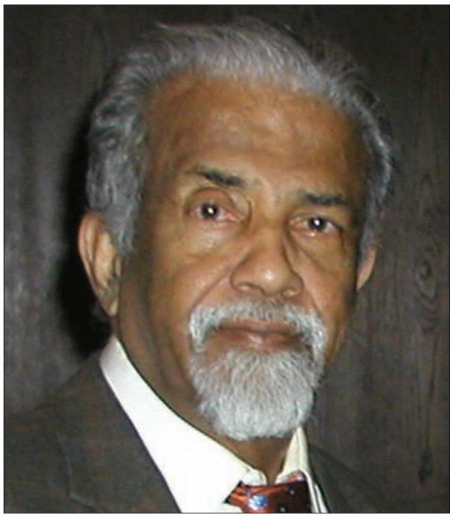
AWARDS

Dirac Medals for work on weak interaction

Italian physicist Nicola Cabibbo of the University La Sapienza, Rome, and Indian-American physicist George Sudarshan of the University of Texas share the 2010 Dirac Medal and Prize of the International Centre for Theoretical Physics. The award recognizes their fundamental contributions to the understanding of weak interactions and other aspects of theoretical physics. (Sadly Cabibbo died on 16 August, only 8 days after the announcement. An obituary will appear in the next edition of *CERN Courier*.)

Cabibbo was cited for his important contributions to theoretical physics, including the recognition of the significance of mixing in weak interactions, which established the existence of a new class of physical constants and whose first example is the Cabibbo angle. This angle determines the mixing of strange quarks with non-strange quarks. With the discovery of a third family of quarks and leptons, quark mixing led to the understanding of the phenomenon of CP violation.

Nicola Cabibbo. (Courtesy Massimo Silvano/ICTP Photo Archives)



George Sudarshan. (Courtesy G Sudarshan/ICTP.)

Sudarshan's important contributions to theoretical physics include the discovery (with Robert Marshak) of the V-A theory of weak interactions, which opened the way to the full description of the unified electroweak theory. He has also made innovative discoveries in the field of quantum optics, including the optical equivalence theorem, which provides the foundation upon which the investigations of the manifestly quantum or nonclassical character of the electromagnetic field are based.

ICTP's Dirac Medal is given in honour of Paul Dirac and is awarded annually on the anniversary of his birth, 8 August 1902.

Italy honours theoretician Sergio Ferrara

Sergio Ferrara has been awarded the Commendatore Ordine al Merito della Repubblica Italiana. The Italian Order of Merit of the Republic recognises contributions made to literature, public service and the economy, and for humanitarian activities. Ferrara's ranking as Commander is recognition by the Italian Republic for his contributions to the physics community. An accomplished theoretical physicist, Ferrara also urges young students starting their careers to work with curiosity and enthusiasm. He encourages them to trust their own self-confidence. Ferrara received the award on 8 July from the Italian Ambassador to the United Nations and other International Organizations in Geneva.

Sergio Ferrara, far right, with from left to right: Pasquale d'Avino, minister counsellor at the Italian Permanent Mission to the United Nations and other International Organizations, Rosanna Ferrara, Sergio Bertolucci, CERN's director for research and scientific computing, and Laura Mirachian, the Ambassador to the UN and other International Organizations in Geneva. (Courtesy Elena Gianolio.)

Brookhaven physicists receive accelerator and superconductivity prizes

Robert Palmer, head of the Advanced Accelerator Group at Brookhaven National Laboratory, was awarded the Advanced Accelerator Concepts (AAC) prize in June at the 2010 AAC Workshop held in Annapolis, Maryland. He was honoured for "outstanding leadership in the muon-collider programme and pioneering many concepts in advanced accelerator science".

Palmer is an executive board member of the Muon Collider Collaboration, which is studying the feasibility of building a high-energy muon collider to enable detailed studies of new particles that may be found at CERN's LHC. He has a distinguished history of contributions to accelerator physics and has also made significant discoveries in particle physics. He participated in the discovery of the Ω^- at Brookhaven in 1962, as well as the discovery of neutral currents in the early 1970s at CERN, the charmed baryon at Brookhaven in 1975 and direct single photons at CERN in 1978.

The prize, which consists of $6000, a plaque and a certificate, was made possible by a donation from Bergoz Instrumentation of St Genis-Pouilly, France, manufacturers of electronic instruments for high-energy particle accelerators.

Robert Palmer. (Courtesy T Koeth/Univ. Maryland.)

William Sampson. (Courtesy BNL.)

William Sampson, another senior physicist at Brookhaven, has in turn received the IEEE Council on Superconductivity Award for Significant and Sustained Contributions in the Field of Applied Superconductivity. The IEEE honours him in particular for his contributions to the field of large-scale superconductivity.

In the 1960s, Sampson built some of the first superconducting magnets to exceed 10 T. He also made early models of dipole and quadrupole magnets. In the 1970s, he made wigglers for the National Synchrotron Light Source at Brookhaven, which began operating in 1982. He has also worked on high-temperature superconducting magnets that can operate in high-radiation environments, such as the future Facility for Rare Isotope Beams (FRIB), a nuclear-physics facility that will be operated by Michigan State University

Sampson received the award – which consists of a plaque, a medallion made of niobium and $5000 – at the Applied Superconductivity Conference in Washington, DC, on 2 August.

TRIBUTE

Mikhail Grigorievich Meshcheryakov

This year marks the centenary of Mikhail Grigorievich Meshcheryakov. A well known Russian physicist and a pioneer of research at Dubna, he was born on 17 September 1910 and died 25 May 1994.

Meshcheryakov received his higher education at Leningrad State University, where he graduated with honours in 1936. He then took post-graduate courses for three years under the guidance of Igor Kurchatov at the Radium Institute of the USSR Academy of Sciences. At that time, the USSR's first cyclotron was under construction and pioneering research in neutron physics and the radiochemistry of the products of artificial transformations of nuclei was to begin there. Meshcheryakov's scientific views as a physicist-experimenter evolved in the atmosphere of high-level academic research that Vladimir Vernadsky, Lev Mysovsky and Vitaly Khlopin initiated.

As a post-graduate Meshcheryakov enthusiastically joined the work on the 1-m cyclotron that started up in 1938 and in experiments there he discovered that cross-sections for the radiative capture of fast neutrons strongly fluctuated with the growth of the nuclear-mass number. Meshcheryakov summed up the results of these studies in his thesis, which he successfully defended in 1940. He became head of a laboratory at the Radium Institute that same year.

At the outbreak of the Second World War Meshcheryakov volunteered for the front. After being injured and demobilized in July 1942, he returned to the Radium Institute, which at the time was evacuated to Kazan University. He immediately joined the research on the atomic programme. When the blockade of Leningrad was broken in 1944 Meshcheryakov and colleagues reconstructed the cyclotron and used it to irradiate uranium blocks in connection with the development of industrial technology for the extraction of plutonium from uranium. At the same time, using the cyclotron as a high-resolution mass separator, he conducted a cycle of experiments to determine the isotopic composition of helium of various origins.

In the years 1946–1947, as a scientific expert from the USSR, Meshcheryakov took part in the work of the Technical Committee of the UN Atomic Commission. On his return from the US he was appointed deputy director of the Atomic Energy Institute in Moscow and the scientific leader of the work to design and construct what was at the time the largest accelerator – the 6 m synchrocyclotron – in the future city of Dubna, in the vicinity of the Bolshaja Volga settlement. Meshcheryakov was the director of the Hydrotechnical laboratory, which was based on the synchrophasotron and which later became the Institute of Nuclear Problems. After 1956 this institute became part of the Joint Institute for Nuclear Research (JINR).

A talented scientist and organizer, Meshcheryakov was the head of a large scientific research institute in a city under construction; he carefully considered not only scientific issues but the tasks of city planning. He was the first to define the image of the future Dubna – the city with a special atmosphere of the invisible but constant work of the human mind.

From 1950, Meshcheryakov's scientific interests became concentrated on studies of the strong interactions of nucleons at high energies. He initiated research into nuclear structure using 660 MeV proton beams, which brought about the discovery of the clusterization phenomena in nuclei and considerably influenced further development of relativistic nuclear physics. Unexpected results of the research that he conducted became widely known and were later confirmed in studies at other scientific centres.

Mikhail Meshcheryakov. (Courtesy JINR.)

Meshcheryakov became professor at Moscow State University in 1954. He always paid much attention to the training of scientific staff. He was a member of the Scientific Council on the application of computing techniques and automation means in experimental nuclear physics at the department of nuclear physics of the USSR Academy of Sciences. He was also a member of the editorial boards of journals such as *Atomic Energy*, *Nuclear Physics*, *Nuclear Instruments and Methods*, *Elementary Particle Physics* and *Atomic Nuclei*. He twice received the Soviet State Prize, in 1951 and 1953, and became a Corresponding Member of the Academy of Sciences of the USSR in 1953.

In 1966 Meshcheryakov received an assignment to organize a special laboratory at JINR for the elaboration of methods to apply the latest achievements in computer technology and automation to scientific research. New techniques that emerged at the institute as a result of this work considerably widened the range of experimental and theoretical research and facilitated the development of new scientific trends.

Meshcheryakov belonged to the group of outstanding Soviet scientists who were the first in the country to start the construction of large accelerators, conduct research in the physics of the atomic nucleus and elementary particles, and to bring automation to scientific research.

SUMMER SCHOOL

LHC school gets going again in southern Italy

After a break of four years, the LHC School (formerly the Italo–Hellenic School of Physics) has regathered the threads of its original mission to provide young researchers with the opportunity to acquire techniques indispensable for physics at the LHC directly from experts actively involved. Held on 14–19 June with the theme, "The physics of LHC: theoretical and experimental aspects", the fourth school in the series attracted an audience of some 30 young researchers. They were mainly Italian but a number of students came from elsewhere in Europe. The school was held – as always – at Palazzo Palmieri, a 16th-century baronial residence situated in the centre of Martignano, outside Lecce, in southern Italy.

The aim of the school is to bring young researchers engaged in LHC physics up to date with the tools necessary for their present and future activities. Lasting six days, the 30 hours of lectures were divided evenly between theory and experiment while the students were roughly one third theorists and two thirds experimentalists. The programme this year was substantially enriched by the possibility for discussions about some of the results already obtained at the LHC.

Palazzo Palmieri. (Photos courtesy Consorzio della Grecìa Salentina.)

The theory lectures ranged from electroweak symmetry breaking, Higgs and new physics at the LHC (Riccardo Barbieri) and QCD and Monte Carlo tools for the LHC (Fabio Maltoni) to flavour physics (Giancarlo D'Ambrosio) and heavy-ion physics (Francesco Becattini). The experimental courses covered the current performance and prospects at the LHC accelerator (Stefano Redaelli), trigger commissioning (Margherita Primavera), calibration and alignment in tracking (Rino Castaldi), particle identification (Domenico Di Bari), muons (Margherita Primavera), calorimetry (Davide Pinci), data analysis and distributed computing (Alessandro De Salvo) and the results of preliminary analyses of the LHC experiments: ATLAS (Margherita Primavera), CMS (Rino Castaldi), ALICE (Domenico Di

Bari) and LHCb (Davide Pinci).

Although this fourth edition followed an unplanned break, the intention is now that the school should become biennial, with the possibility of topical workshops in the intervening years. The enthusiasm of the local bodies and the interest shown by the national funding agency, not to mention the satisfaction of the students themselves, has set the scene for the school to be established as a regular fixture for young researchers in their quest towards a career in high-energy physics. Judging by the positive feedback received from students of all events held so far, the school as a whole is well targeted and serves a specific and useful purpose.

The organizers gratefully acknowledge the various bodies whose financial and material aid made the school not only possible but also a success: l'Istituto Nazionale di Fisica Nucleare, l'Università del Salento, il Parco Turistico Palmieri, il Consorzio della Grecìa Salentina and la Banca Monte dei Paschi di Siena.

● For further details about the 2010 school, see www.le.infn.it/lhcschool.

The vaulted lecture room of Palazzo Palmieri.

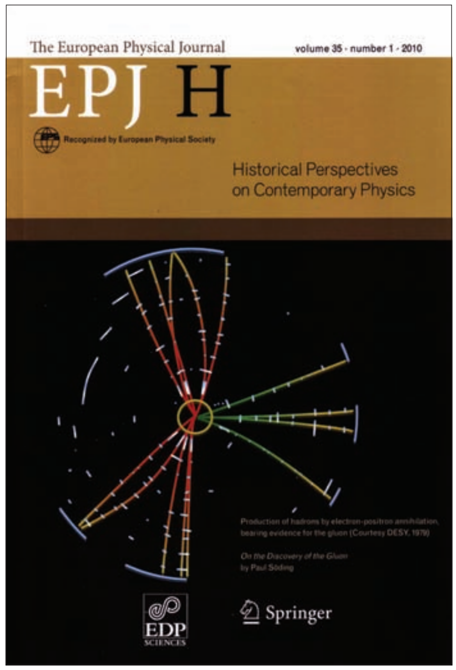
PUBLISHING

EPJ turns to historical perspectives

The *European Physical Journal* has launched a new series devoted to the Historical Perspectives on Contemporary Physics: *The European Physical Journal H* (*EPJ H*). Its basic aim is not only to address the history of physics and the birth of its underlying concepts, but also to serve as a bridge between working physicists and professional historians and philosophers of science.

The publishers see the journal as a place where the experts on both sides can trade ideas and exchange knowledge, especially in the more complex fields of modern physics, where a deep understanding relies on mathematics beyond the level attained by non-practitioners. To this end, contributing physicists will be able to use as much mathematics as necessary, provided that they also include non-technical introductions and, importantly, conclusions. The language of the journal is English, but another aim is to include translations into English of documents of historical interest that are in other languages.

The focus will be on the history of the physics itself, rather than the social history of the subject. Topics to be covered range from particle physics and quantum field theory to nonlinear dynamics and complexity science. The first issue has articles on the discovery of the gluon, the birth of hydrodynamic stability theory, Jorge Sweica's contributions to quantum field theory and the origin and abundances of the chemical elements before 1957.



EPJ H *seeks to be a place to trade ideas, exchange knowledge and catalyse, foster, and disseminate an awareness on the historical background to contemporary physics and, more generally, an understanding about how nature works.*

● For more about *The European Physical Journal H*, see www.springer.com/physics/journal/13129.

NEW PRODUCTS


VACVISION
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The new Vacuum Controller: Intelligent and multi-tasking.
The new VACVISION monitors and controls the entire vacuum process. The large TFT graphic display with touch panel offers intuitive operation, a guided configuration menu (wizard), simple hardware interfacing as well as plug and play functions. The controller automatically detects up to three active vacuum gauge heads, five valves, one fore vacuum and one high vacuum pump. VACVISION offers a basis for flexible vacuum system configuration and smart operation.
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CERN SCHOOL

RF for accelerators comes under scrutiny in Denmark

The CERN Accelerator School (CAS) and Aarhus University jointly organized a specialized course on RF for accelerators in Ebeltoft on 8–17 June. The challenging programme focused on the introduction of the underlying theory, the study and the performance of the different components involved in RF systems, the RF "gymnastics" and RF measurements and diagnostics. This academic part of the course was completed with three afternoon sessions dedicated to practical, hands-on exercises

The school was a success, with 100 participants from 25 countries. Feedback from the participants was extremely positive, praising the expertise and enthusiasm of the lecturers, as well as the high standard and excellent quality of their lectures.

In addition to the academic programme, the participants took time to visit a small industrial exhibition organized by Aarhus University and take part in a one-day excursion, consisting of a visit to the accelerators operated at the university and a boat trip on the Silkeborg Lakes, which ended with a walk to the peak of the Sky Mountain.

● The next specialized CAS course will be on "High-Power Hadron Machines" and will take place in Bilbao in the spring of 2011. Information will be available soon on the CAS website, at www.cern.ch/schools/CAS.

Participants at the CAS in Aarhus pose for the traditional group photo. (Courtesy G Præst.)

MEETING

PHYSTAT 2011 takes place at CERN on 17–19 January. It will deal with the statistical issues related to discovery claims in search experiments, concentrating on those at the LHC. Topics include: model selection methods, inclusion of the effects of systematics, the "Look Elsewhere Effect", practicalities of estimating significance, whether 5 σ should be a universal criterion for discovery, sensitivity of searches, experience from earlier experiments, etc. There will be invited talks by physicists and statisticians, and time for papers and discussion. This is a follow up to the PHYSTAT-LHC meeting at CERN in 2007 and to the recent Banff Workshop on statistical issues related to discovery claims. There is no registration fee but would-be participants should register on the conference website, http://phystat2011.web.cern.ch/phystat2011, where further details are available.

CORRECTIONS

There was an error in the recent article on four decades of the Lindau meeting (*CERN Courier* September 2010 p46). The handover of the presidency of the meetings from Count Lennart Bernadotte to his wife Countess Sonja took place in 1988, not in 1982.

Also, a misprint occurred in the box "The student factor" in the report on the IPAC '10 conference (p16). The students received their prizes from the chair of the Scientific Programme Committee, Akira Noda. Apologies to all concerned.

Delta Tau has announced the Turbo PMAC Clipper, a highly cost-effective multiaxis controller. Based on the Turbo PMAC2 CPU, the new Turbo PMAC Clipper provides a single board with four-axis servomotor or stepper motor control with 32-digital I/O points and a choice of Ethernet or RS232 communication ports. The device is easily expandable to eight axes. Some of the high-performance features include multitasking of up to 16 motion programs and 64 asynchronous PLC programs, and co-ordinate-system translation and rotation in 2D and 3D. For more details, contact Stirling Morley, tel +44 1376 333 333; or e-mail stirling@micromech.co.uk.

Porvair Filtration Group has introduced Sinterflo metal filters to provide optimal performance with the lowest cost of ownership and long filter life for high-temperature gas-filtration applications. Available in stainless steel, Hastelloy, FeCrAlloy and other exotic materials, these filters offer superior performance compared with ceramic or alternative metallic structures. They are available from single elements to complex systems, including cyclones, prefilters, main filters and associated cleaning processes. For more details, contact Claire Webster, tel +44 1489 864 330; e-mail claire.webster@porvairfiltration.com; or visit www.porvairfiltration.com.

Wavelength Electronics Inc has upgraded the WLD3343 General Purpose Laser Diode Driver for higher output current, lower noise, and no leakage current. It provides up to 3 A output in a compact 14-pin DIP package. There are five models, including the standard 2.2 A (WLD3343), a 2.2 A lithium-ion battery-compatible (WLD3343HB), a 2.2 A lower noise version (WLD3343-2L), the 3 A enhancement (WLD3343-3A), and a lower noise 3 A version (WLD3343-3L). The series is ideal for a wide variety of electro-optical instrumentation, including spectrometers. For more details, tel +1 406 587 4910; e-mail sales@teamwavelength.com; or visit www.teamwavelength.com.

OBITUARIES

Gerson Goldhaber 1924–2010

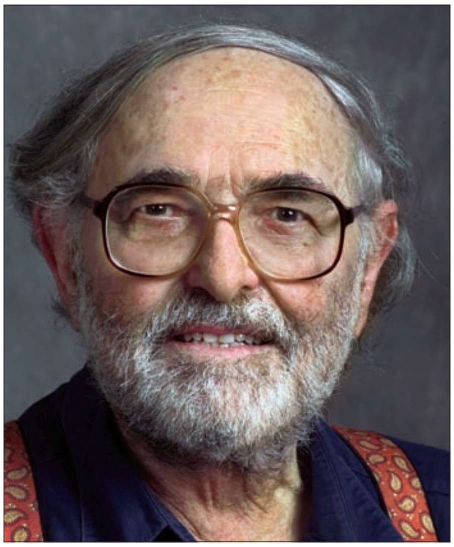
Gerson Goldhaber, whose accomplishments included leadership roles in the first observations of antiproton annihilation, the discovery of hadrons with non-zero charm quantum number and the discovery of the universe's accelerating expansion, passed away on 19 July at his home in Berkeley after a long battle with pneumonia.

Gerson was born in Chemnitz, Germany, on 20 February 1924. To avoid Nazi persecution his family moved to Cairo in 1933 where his father had, many years before, conducted guided tours of Egyptian antiquities. Gerson subsequently moved to Israel, and, in 1947, received an MSc from the Hebrew University in Jerusalem. He gained a PhD in physics from the University of Wisconsin in 1950 and he became a US citizen in 1953. After three years as an instructor at Columbia University, in 1953 he moved to the University of California, Berkeley, where he became full professor in 1963. He was also faculty senior scientist at the Lawrence Berkeley National Laboratory (LBNL). He retired in 1991, but subsequently remained active in research.

In Jerusalem, Gerson had met Sulamith Low, a chemistry student who became his wife in 1947. When the couple moved to Berkeley, she shifted into physics and became Gerson's close research collaborator.

In his thesis research at Wisconsin, Gerson developed a technique to measure gamma-ray spectra from excited nuclei, using photographic emulsions loaded with D_2O. The gamma rays led to observable deuterium photo-disintegrations. At Columbia, he worked with Leon Lederman and others in studies of pion–nucleon interactions in the 100 MeV range, again using photographic emulsions.

At Berkeley, Gerson's research initially focused on beams from the new 6.2 GeV Bevatron. With Gosta Ekspong and others, he used photographic emulsions to follow an antiproton candidate to rest, and demonstrated that the energy released in the form of newly created pions and nuclear fragments significantly exceeded the rest energy of a proton – a result expected for antiproton annihilation. In collaboration with Sula, he also made numerous measurements



Gerson Goldhaber. (Courtesy LBNL.)

of kaon properties and interaction processes, using emulsions and bubble chambers. One important result was the determination of the spin of the K^* meson as 1.

In a reorganization of LBNL in 1963, Gerson, Sula and their postdocs and students joined George Trilling and his colleagues to form a new research group (the TG group) that worked together until 1989. Tragically, during a visit to India in 1965, Sula suffered a sudden stroke and died. In 1969, Gerson married Judith Margoshes Golwyn, a science writer, playwright and poet.

Following several years of detailed K^+–nucleon interaction studies over a wide energy range, the TG group, with strong leadership from Gerson, shifted focus to the study of high-energy electron–positron collisions, using the new SPEAR storage ring/collider at SLAC and the MARK I and MARK II detectors. This research effort was a collaboration with William Chinowsky of Berkeley, and the SLAC groups led by Burton Richter and Martin Perl – the SLAC-LBL collaboration. The next few years saw many discoveries from the collaboration: the J/Ψ, the charm quark, the τ lepton and final-state jet structure. Gerson's great achievement, with François Pierre, was to demonstrate the existence of charm hadrons, with non-zero value of the charm quantum number.

While the collaboration expanded and moved to higher-energy electron–positron experiments at the PEP storage ring and the Stanford Linear Collider, Gerson's research interests shifted in a new direction. In 1989, he joined the Supernova Cosmology Project (SCP) led by Saul Perlmutter. With techniques developed mostly under Perlmutter's leadership, the SCP team made observations of distant type-1A supernova, studying the relationship between redshift and observed luminosity. Gerson played an important role in the discovery, based on the study of 38 supernovae, that the universe's expansion is accelerating rather than decelerating as expected from gravitational attraction.

Gerson's outstanding research accomplishments were made possible by his ability to recognize, even in imperfect experimental data, hints of potentially new and interesting science. He was relentless in pursuing these hints until their origin was understood. His "nose for discovery" influenced in a positive way his choices of scientific direction. His achievements were recognized with numerous honours, including election to the US National Academy of Sciences, being named California Scientist of the Year 1977, and, jointly with François Pierre, the American Physical Society Panofsky Prize in 1991.

Gerson's impact was not confined to research. He and Robert Cahn wrote the important textbook *The Experimental Foundations of Particle Physics* (Cambridge University Press 1989). Starting during the lonely time following his first wife's death, Gerson became interested in art. He did wonderful water-colours, many of which he gave to friends. More recently, he and his wife Judith co-authored two books, *Sonnets from Aesop* and *Sarah Laughed*, for which she wrote the poems and he did a water-colour illustration for each poem.

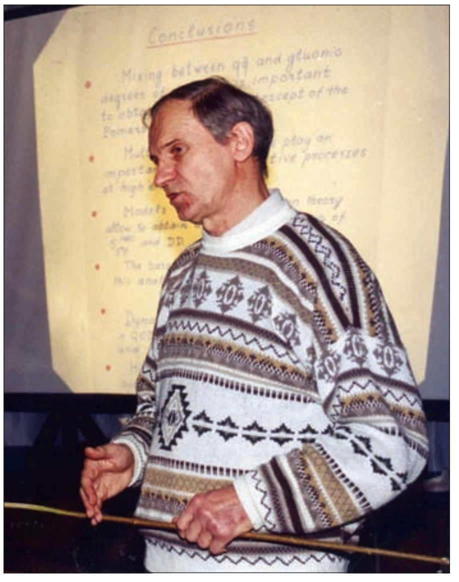
Gerson is survived by his wife Judith, his son A Nathaniel, his daughters Michaela and Shaya, and his grandsons Sam, Ben, and Charles. He is greatly missed by all of us who had the privilege of interacting and working with him.

George Trilling, Berkeley.

Alexei Kaidalov 1940–2010

Alexei Kaidalov, famous for his ground-breaking contributions to Regge theory and the phenomenology of soft hadronic processes, passed away on 25 July after a long and merciless illness.

Kaidalov was born in Moscow on 20 July 1940. He graduated from the Moscow Engineering Physics Institute and was the last student to write his diploma under the supervision of Isaac Pomeranchuk. He then entered the Institute for Theoretical and Experimental Physics in Moscow and gained his PhD in 1968, eventually becoming head of the Laboratory for Strong Interactions. He was among those rare theorists who knew, in a profound way, all fundamental physics, although his passion throughout his life was for strong-interaction theory and high-energy phenomenology. He had a true talent to explain complicated physics in a simple way.



Alexei Kaidalov. (Courtesy ITEP.)

It is difficult to overestimate Kaidalov's impact on understanding intimate details of strong interactions, in particular in the nonperturbative domain. He was the leading world expert (sometimes, the ultimate expert) in all aspects of soft hadronic processes and his judgement was almost always final. He was held in extremely high esteem in both the theoretical and experimental particle-physics communities.

Kaidalov was a creator of the celebrated quark–gluon string model. At the LHC workshop in Evian in 1992, Alvaro De Rújula called his model "immorally successful" – perhaps one of the best compliments a theoretical physicist can ever receive. More than 25 years later, this model is still in high demand and continues to produce remarkable results in the new era of LHC data.

From the 1970s Kaidalov collaborated closely with theorists and experimentalists at CERN and was always interested in all new data from CERN's experiments. He became a member of the ALICE collaboration in 1998 and made important contributions to its physics programme.

In 2003 Kaidalov was elected as a corresponding member of the Russian Academy of Sciences. He also chaired the International Pomeranchuk Prize Committee and was the deputy editor-in-chief of the journal *Physics of Atomic Nuclei*.

Friends know "Aliosha" as an outstanding musician, a dedicated downhill skier, a modest and quiet person, and a very good friend. The depth of his knowledge in art was amazing, but his love of science was overwhelming. This is a great loss for the entire high-energy-physics community.

His colleagues and friends.

Karl Lanius 1927–2010

Karl Lanius, a leading figure in experimental particle physics in East Germany, passed away on 21 July.

Lanius studied physics in Berlin from 1946 to 1952. He finished his PhD at the Humboldt University, where he became professor of physics in 1964. His scientific career then started at the Zeuthen institute close to Berlin, with the study of cosmic rays and nuclear reactions in emulsions. He soon recognized the importance of bubble chambers as a central tool for high-energy physics and also the need for international scientific co-operation.

In 1962, Lanius transformed the Zeuthen laboratory into the Institut für Hochenergiephysik and he continued to lead and shape the institute until 1988. From 1973 to 1976 he also served as vice-director of the Joint Institute of Nuclear Research

Karl Laius. (Courtesy E Manske.)

(JINR) in Dubna. Many of the activities at Zeuthen were connected with the research programmes in both Dubna and Serpukhov. In parallel, he built up close co-operation with CERN and DESY, culminating in participation in the L3 experiment at CERN's Large Electron–Positron collider in 1983 and in joining the H1 experiment at the HERA collider at DESY in 1985. Being attracted by questions of cosmology and astrophysics, Lanius also promoted Zeuthen's first steps into the field of astroparticle physics with the participation in the Baikal experiment in 1988.

His strategic approach to science was accompanied by an atmosphere at Zeuthen that – despite all political restrictions – was remarkably open-minded and pragmatic when compared with other East German research institutions. It was Lanius' remarkable science policy that prepared the ground for the successful unification of the Zeuthen institute with DESY in 1992.

Lanius was elected member of the German Academy of Sciences in Berlin in 1969. He chaired the academy's Klasse Physik from 1988 to 1992 and then the Klasse Naturwissenschaften of the Leibniz Society, the follow-up organization of the formerly East German academy, from 1993 to 1996. He was a vice-president of the International Union of Pure and Applied Physics from 1987 to 1990.

Lanius' parents were communists. His Jewish mother was arrested in Theresienstadt and Lanius himself sent to a youth work camp in 1944. When he was 60, he used the possibility of early retirement offered in East Germany to victims of fascism. He then stepped down from his position as director and worked with the L3 collaboration at CERN from 1988 to 1990.

Later, his interest turned to questions concerning the evolution of mankind, Earth and climate, which he discussed in three books written in the last two decades of his remarkable life. Spending some time nearly every day in "his" old institute, he kept up his interest in modern developments in cosmology, astroparticle and particle physics.

It was Lanius who established experimental particle physics in East Germany. He will be missed by his former colleagues and remembered as a renowned physicist, distinguished science manager and director.
His friends and colleagues.

Robert Lévy-Mandel 1923–2010

Robert Lévy-Mandel, an influential engineer at Saclay and at CERN, passed away on 3 July at the age of 87.

After obtaining a diploma from the Institut polytechnique in Grenoble, in 1948 Lévy-Mandel started work at the Commissariat à l'énergie atomique (CEA), only three years after its creation. He became involved in the development and construction of a Van de Graaff generator for the new Saclay research centre, which opened its doors in 1952. Using this first accelerator, the CEA began nuclear physics studies for military applications and energy production, but then decided to extend the research into the domain being opened up in the US, in particular at Brookhaven. This led to the construction of a weak-focusing 3 GeV proton synchrotron - Saturne - by a group of engineers under the direction of Lévy-Mandel. The machine started up in 1958 and in 1963 Lévy-Mandel was appointed head of the Saturne Synchrotron Department.

In 1966 the Groupement d'Etude pour le Synchrotron National began studies for an alternating-gradient 45 GeV proton synchrotron. Lévy-Mandel led this effort, benefiting from the experience of Pierre Lapostelle from CERN, but the project – Jupiter – was eventually abandoned. The Saclay team went on to lead the construction of the Gargamelle bubble chamber, which was installed at CERN in 1970, and also made contributions to other major facilities, including the Big European Bubble Chamber (BEBC).

In 1971 Lévy-Mandel was invited to CERN by John Adams, who was in charge of the Super Proton Synchrotron (SPS) project. CERN at that time had two laboratories, one at Meyrin and one at Prévessin, each with its own director-general: Willibald Jentschke at Laboratory I and Adams at Laboratory II. Lévy-Mandel was entrusted by Adams with the responsibility for site installation work at the Prévessin laboratory, then under construction. The SPS started up in 1976 and, with the two CERN laboratories combined, Lévy-Mandel joined the directorate, with responsibility for technical services and site management.

Robert Lévy-Mandel, at a CERN Council meeting in 1977, when he was a member of the directorate.

By this time, planning for the Large Electron-Positron collider (LEP) was already in full swing. Emilio Picasso, appointed leader of the LEP project in 1980, asked Lévy-Mandel to produce the safety report for the future accelerator. The task was particularly sensitive as the 27 km tunnel would run under numerous French and Swiss villages, and the plans were meeting determined opposition. Lévy-Mandel produced the Installation nucléaire de base (INB) reports that were submitted to the French authorities to obtain approval for the project. He also set up a programme for consultation with the French and Swiss municipalities and organized numerous briefings for the local authorities together with Henri Laporte, the head of civil engineering. Lévy-Mandel's talent for diplomacy proved particularly valuable in bringing the local authorities on side and allaying their concerns. When he retired in 1988, just before LEP started up, the former mayors of the Pays de Gex organized a farewell dinner in his honour, in recognition of his work during the construction of LEP.

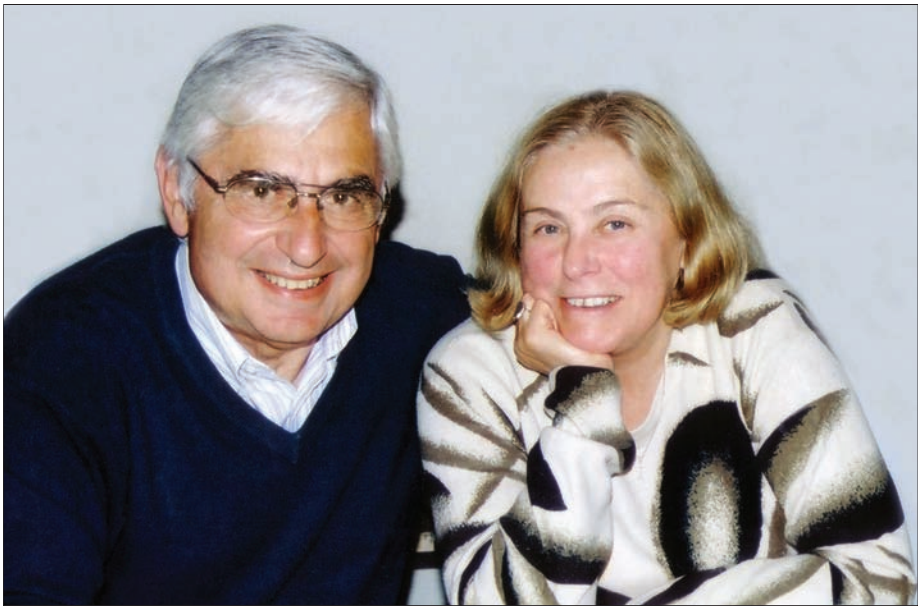
After his retirement, Lévy-Mandel maintained his attachment to CERN, and continued to participate in discussions and work at the laboratory. He will be remembered for his great dignity and tact, as well as for his tireless devotion to CERN and seemingly boundless capacity for work.

Sincere condolences go to his two daughters, Anne and Françoise, to his grandchildren and to the entire family.

Matey Dragomirov Mateev (1940–2010)

Matey Mateev, a leading Bulgarian scientist and eminent theoretical physicist, perished together with his wife Rumiana Mateeva in a car accident near Sofia on 25 July. A teacher of generations of physicists and an organizer of scientific activities, he was dedicated to international collaboration in science.

Mateev was born in Sofia on 10 April 1940, the son of a medical doctor in a family that was part of the old Bulgarian intelligentsia. Graduating at Sofia University, "St. Kliment Ohridski", in 1963 he became an assistant professor of theoretical physics in the university's faculty of physics. International collaboration played an important role in his career from the start. Early in his professional life Mateev won a one-year grant to work at the newly founded International Centre for Theoretical Physics in Trieste. Later, from 1971, he worked for a decade in the Laboratory of Theoretical Physics at JINR in Dubna, where he gained his PhD and a Doctor of Science degree (for a dissertation on the concept of fundamental length in high-energy physics). In 1983 he became full professor at Sofia University, where he taught for 25 years. In 2003 he was elected a member of the Bulgarian Academy of Sciences.



Matey Mateev with his wife Rumiana. Both were killed in a car accident in July. (Courtesy K Koumanov.)

International collaboration has also been a vital element in the development of Bulgarian physics. As an established scientist in his own right, it was natural for Mateev to use his influence – as a minister of national education in the years 1990–1991, and later – to promote international collaboration with Bulgarian physicists for the benefit of future generations. He was, in particular, instrumental in Bulgaria's admission to CERN as a member state in 1999 and he represented his country on the CERN Council in the period 1999–2000. He was also a member of the Scientific Council of JINR from 1993 and chair of the Bulgarian Union of Physicists from 2001.

Mateev was involved in many other activities, participating in work ranging from high-temperature superconductivity to crystal growth. In recent years he wrote, together with Alexander Donkov who passed away a year ago, the first advanced textbook on quantum mechanics in Bulgarian. He continued until the last day of his life his work with Vladimir Kadyshevsky from JINR on a quantum field theory with fundamental length.

Matey, known as Mag by those close to him, was a kind and warm person. He naturally attracted people and had good friends in many countries around the world. We shall miss him.

His colleagues and friends.

Alessandro G Ruggiero 1940–2010

Alessandro Ruggiero, senior physicist in the Collider-Accelerator Department at Brookhaven National Laboratory passed away at his home on 26 June after a long battle with cancer.

Alessandro Ruggiero's story is one of the search for new ideas and improvements to particle accelerators, which sent him to live in many locations around the globe. Sandro, as he was known by his friends and colleagues, was born on 10 April 1940 in Rome. He studied at the Institute of Physics of the University of Rome and gained his PhD in 1964, based on work done at the electron synchrotron at the Laboratory Nazionali di Frascati. His first move took him to CERN in 1966 on a two-year fellowship to work on the CERN Electron Storage Accelerator Ring and the Intersecting Storage Rings. Together with Andrew Sessler and Vittorio Vaccaro he developed a systematic description of collective beam instabilities in terms of stability charts and coupling impedances, which had a lasting influence on accelerator theory. The time at CERN stimulated his interest in all aspects of accelerator physics, a field he never left.

In 1970 Sandro accepted an appointment at Fermilab and the US subsequently became his new home and he became a citizen in 1980. The period from 1970 to 1984 at Fermilab allowed him to establish himself as a first-class theoretical accelerator physicist. As a member of the theory group, he not only studied beam-intensity effects in accelerators and storage rings in general terms, but also solved known problems. He is credited with having made major contributions to the concept and design of the two-ring antiproton source for the Tevatron, especially the stochastic cooling method in the Accumulator and the design of the Debuncher. In 1985, Sandro accepted a post as senior physicist at the Argonne National Laboratory. He was attracted by the proposal to build the Argonne Wakefield Accelerator Facility. At the same time, he successfully led an inter-laboratory group to improve the performance of ALADDIN, the 1 GeV synchrotron-radiation facility in Wisconsin.

Sandro had previously shown interest in ISABELLE, the precursor to the Relativistic Heavy Ion Collider (RHIC) at Brookhaven, by providing the beam-stability analysis at the workshop held in 1975. So, when Brookhaven's future direction as an accelerator laboratory was being discussed after the ISABELLE project was terminated, he was invited to explore the options for a heavy-ion collider. In 1987 he went to Brookhaven as senior physicist with tenure and stayed there until his untimely death. He was lured by the possibility of influencing the design and construction of the proposed RHIC, which he could do as head of the Accelerator Physics Group. He applied his expertise of beam dynamics and instabilities to the various components of RHIC – from the Tandem via the Booster and the Alternating Gradient Synchrotron to the collider itself – resulting in a stable, high-intensity machine.

Alessandro Ruggiero. (Courtesy LBNL.)

Sandro was always driven by the search for challenges, as well as their implementation in new projects. He participated in the study and design of the Brookhaven-designed Accumulator ring for the Spallation Neutron Source at Oak Ridge National Laboratory. He became involved in proton radiography for the Stockpile Stewardship programme of the US Department of Energy (DOE) and a facility for nuclear waste transmutation in conjunction with Lawrence Livermore National Laboratory. He conceived and promoted a circular RF quadrupole as an alternative to a ring of conventional magnets in collaboration with the Accelerator Physics Group at the University of Naples. He participated in the study of a non-scaling, fixed-field, alternating-gradient accelerator as a proton driver for isotope production, a muon collider or a neutrino factory. He studied and produced papers on the formation of crystal beams. Although drawn mainly to new concepts and proposals, he was equally active in the measurements of the beam at RHIC and the interpretation of its instabilities and performance limitations.

Sandro was an eminent accelerator physicist, respected by his peers worldwide. He was an adjunct professor of physics at the University of Wisconsin in Madison and taught accelerator physics to young students at the US Particle Accelerator School. He had more than 200 publications to his credit, organized accelerator conferences and was the editor of several workshop proceedings. He was a member of many review committees for the DOE and for foreign projects. His outstanding contributions to physics were recognized when he was elected a fellow of the American Physics Society for "contributions to accelerator theory, including instabilities and nonlinear dynamics, to accelerator complex designs notably the Antiproton Source and the Relativistic Heavy Ion Collider and to accelerator architecture investigations of spallation neutron sources".

With Sandro's death, the accelerator community has lost a true innovator and a lively personality. He will be missed by his friends and colleagues, at Brookhaven and around the world. He is survived by his wife Amalia (Liucci) Ruggiero, children Sara and Filippo, and grandchildren.

Harald Hahn, with input from Thomas Roser, Vittorio Vaccaro and Claudio Pelligrini.

RECRUITMENT

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Please contact us for information about rates, colour options, publication dates and deadlines.

The **Faculty of Natural Sciences** offers at the Erlangen Centre for Astroparticle Physics (ECAP) in the Department of Physics two tenured

W2-Professorships in Experimental Physics

(succession of Prof. Dr. E. Steffens and Prof. Dr. C. Stegmann)

The successful candidate will represent experimental physics in research and teaching. We seek candidates who are internationally recognised experts in experimental astroparticle physics or in closely related fields of particle physics. It is expected that the successful candidates will extend or adequately supplement the current research activities in the Erlangen Centre for Astroparticle Physics (ECAP), i.e. ground-based gamma ray astronomy, neutrino astronomy, and detector development. Links to the other ECAP research areas (astronomy, quantum gravity) would be desirable. Teaching requirements include, but are not limited to, modern particle physics.

Qualifications include university undergraduate and doctoral degrees, good teaching skills, and a habilitation or equivalent other qualification, which may have been gained outside the University or within a "Juniorprofessur".

The successful candidate will be expected to take over administrative duties and also to attract external funding.

At the time of appointment the candidate must not exceed 52 years of age. The Ministry for Science, Research and Art, with approval by the Ministry of Finance, may grant exemptions to this rule. The appointment will be made by the University of Erlangen-Nürnberg.

The University of Erlangen-Nürnberg is an equal-opportunity employer and is committed to a profamily policy. We strongly encourage women to apply in an effort to increase female representation in research and teaching.

The University of Erlangen-Nürnberg persues a policy of intensive study support for its students and therefore requires that its teaching staff maintain a substantial student contact time by being present at the university.

All other qualifications being equal, handicapped persons will be given priority.

The positions are to be filled as soon as possible.

Application documents (curriculum vitae, list of publications and teaching activities, copies of degree certificates but no publications) and a brief statement of research interests must be sent not later than **November 1st, 2010**, to: Dekan der Naturwissenschaftlichen Fakultät der Universität Erlangen-Nürnberg, Universitätsstrasse 40, D-91054 Erlangen, Germany.

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The newly established **International Institute of Physics of the Federal University of Rio Grande do Norte** (IIP-UFRN) in Natal, Brazil, seeks candidates for five Visiting Full Professors and thirteen Postdoctoral Associates in Theoretical Physics. The IIP will favor candidates with broad scientific interests and experience in the fields of: Condensed Matter Theory, Statistical Physics, Complex Systems, Mathematical Physics, String Theory, Quantum Field Theory, High Energy Physics, Astrophysics and Cosmology.

The starting date of these appointments is negotiable and it can start as early as February, 2011. All positions can be extended up to four years. Applicants for the Visiting Professorships should send their CVs with a list of recent publications, a statement of research interests and a tentative research plan. Applicants for the Postdoctoral positions should add to this list of requirements three recommendations letters. All these documentation should be sent directly to **visitingpositions@iip.ufrn.br**.

For further information access our website **http://www.iip.ufrn.br/**

HEP (ATLAS) Post Doc Position for UNIVERSITY OF JOHANNESBURG – *Faculty of Science, Department of Physics*

The Physics Department seeks to appoint a Post Doctoral Research Fellow in Experimental High Energy Physics (HEP) at its Auckland Park Kingsway Campus.

Applications are welcomed.

The University of Johannesburg is a founding member of the SA-ATLAS group and is also part of the SA-CERN Programme. The group currently comprises two staff members and three graduate (Phd, MSc) students. The group is working closely with Ketevi Assamagan (co-convenor of the Higgs working group), focusing on Higgs and SUSY physics with an emphasis on the muon sector. The HEP research infrastructure includes the University of Johannesburg Research Cluster (280 cores, 8GB storage) which is a component of South African National Grid with both OSG and gLite interoperability. This cluster is currently in the process of becoming an ATLAS - Tier 3 site attached to BNL. The successful applicant is expected to conduct their own research within the area mentioned above as well as to mentor the students in the group. An on-site visit to CERN of an aggregate period of at least 6 months per year is included.

The duration of the Post Doc funding is two years and can be extended by application for additional years. The Physics Department has 21 teaching members, and the successful Post Doc candidate would be welcome to consider a small teaching load if they wish to. The University is situated in the leafy suburbs of Johannesburg North, in a cosmopolitan area in excellent relationship to all services and facilities of a modern city.

Requirements: A completed PhD degree in Physics with experience in experimental High Energy Physics. Previous ATLAS experience will be an advantage.

Assumption of duties: As soon as possible.

Enquiries: Prof SH Connell, tel: +27 11 559-4380. mail: shconnell@uj.ac.za

Web sites:
http://www.uj.ac.za, http://physics.uj.ac.za, http://physics.uj.ac.za/wiki/psi/ATLAS/ATLAS

Field of interest: hep-ex. Deadline: October 2010. Contact: Simon H Connell.

Email: shconnell@uj.ac.za

Letters of Reference should be sent to: shconnell@uj.ac.za

facilities installed in Halls A, B, C, and D. The Deputy also serves as the Division Safety Officer and manages to oversee the Physics Division EH&S program.

The Deputy Associate Director provides support for the infrastructure necessary for assuring a user-friendly atmosphere, serves as a member of the Technical Advisory and Scheduling Committees, and advises the Associate Director on short-range experimental priorities. In particular, the Deputy has primary responsibility for overseeing/managing the details of the beam time schedule consistent with the broad directions defined by the Scheduling Committees.

The successful candidate will be an internationally recognized scientist in nuclear physics or a related field. The position requires a Ph.D. and significant relevant experience in Nuclear Physics or related field, and a demonstrated track record of resource and technical management or significant projects in design, construction, commissioning and/ or operation.

Hall A Group Leader

The Hall A Group Leader provides overall management of the physics research group for the hall. This includes leading the development of the research program through collaboration with users, staff, and advisory committee. The Hall leader oversees the staging and execution of the scientific experiments. Additionally, the Hall Leader is responsible for the provision of appropriate experimental equipment for the balance of operations at 6 GeV and with special emphasis on the 12 GeV era, which will begin in 2013. The responsibilities also include management of all Hall scientific, post doc, engineering and technical staff, budgeting, planning and resource allocation.

The successful candidate will be an internationally recognized expert in the forefront of nuclear/ particle physics. A record of scientific excellence as demonstrated by extensive publication in nuclear/ particle physics is required. A Ph.D. in Experimental Nuclear or Particle Physics or the equivalent combination of education, experience, and specific training is required.

Interested candidates should submit a CV, publication list and letters of reference.
More information or to apply: http://www.jlab-jobs.com/

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Jefferson Lab

Postdoctoral Research Positions
LIGO Laboratory

California Institute of Technology (Caltech)
Massachusetts Institute of Technology (MIT)

The Laser Interferometer Gravitational-Wave Observatory (LIGO) has as its goal the development of gravitational wave astronomy. The LIGO Laboratory is managed by Caltech and MIT, and is sponsored by the National Science Foundation. It operates observatory sites equipped with laser interferometric detectors at Hanford, Washington and Livingston, Louisiana. The initial detectors have achieved design sensitivity and a data set spanning more than a year of coincidence operation has been collected. Analysis is ongoing, with extensive participation by the LIGO Scientific Collaboration (LSC). Further observation is now underway, with incrementally improved instruments. A major upgrade (Advanced LIGO) is underway in parallel. In addition, a vigorous R&D program supports the development of enhancements to the detectors as well as future capabilities.

The LIGO Laboratory may have several postdoctoral research positions at Caltech, MIT and at the two LIGO observatory sites. Successful applicants will be involved in the operation of LIGO itself, analysis of data, both for diagnostic purposes and astrophysics searches, as well as the R&D program for future detector improvements. Expertise related to astrophysics, modeling, data analysis, electronics, laser optics, vibration isolation and control systems is desirable. Most importantly, candidates should be broadly trained physicists, willing to learn new experimental and analytical techniques, and ready to share in the excitement of building, operating and observing with a gravitational-wave observatory. Appointments at the post-doctoral level will initially be for one-year with the possibility of renewal for up to two subsequent years.

Applications for post-doctoral research positions with LIGO Laboratory should indicate which LIGO site (Caltech, MIT, Hanford, or Livingston) is preferred by the applicant. Applications should be sent to **HR@ligo.caltech.edu** (Electronic Portable Document Format (PDF) submittals are preferred).

Applications should include curriculum vitae, list of publications (with referred articles noted), and the names, addresses, email addresses and telephone numbers of three or more references. Applicants should request that three or more letters of recommendations be sent directly to **HR@ligo.caltech.edu** (Electronic Portable Document Format (PDF) submittals are preferred. Consideration of applications will begin December 1, 2010 and will continue until all positions have been filled.

Caltech and MIT are Affirmative Action/Equal Opportunity Employers
Women, Minorities, Veterans and Disabled Persons are encouraged to apply
More information about LIGO available at www.ligo.caltech.edu

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The candidate will have experience of detector applications found in Synchrotrons and Particle Accelerators and be able to take a leading role in the design, manufacture and test of such devices.

Salary will be dependent on qualifications and experience.

For further information please send your CV to kevin.oliver@diamonddetectors.com or call +44 1202 441 031

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Wilson Fellowship in Experimental Physics

The Wilson Fellowship program at Fermilab seeks applications from Ph.D. physicists of exceptional talent with at least two years of post-doctoral work. The fellowships are awarded on a competitive basis and support physicists early in their careers by providing unique opportunities for self-directed research in experimental physics. Fellows will work on the Fermilab particle physics experiment of their choice. The Fermilab experimental program includes collider physics at both the Tevatron and the LHC, studies of neutrino and astroparticle physics, as well as R&D and planning for experiments at future colliders and high intensity beams.

The Wilson Fellowships are tenure track positions with an annual salary fully competitive with university assistant professorships. The appointment is for an initial term of three years and can be renewed for an additional two years upon the completion of a successful review after the first two years.

Each candidate should submit a research statement, not to exceed 5 pages, which gives a focused description of the candidate's research program while being a Wilson Fellow, a curriculum vitae, and should arrange to have four letters of reference sent to the address below. Application materials and letters of reference should be received by October 29, 2010.

Materials, letters, and requests for information should be sent to:
Wilson Fellows Committee
Fermi National Accelerator Laboratory
MS 122, Attention: Ms. Cathryn Laue
P.O. Box 500, Batavia, IL 60510-0500
Email: wilson_fellowship@fnal.gov

Additional information is available at:
http://www.fnal.gov/pub/forphysicists/fellowships/robert_wilson/

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UNIVERSITY of ROCHESTER

Tenure Track Faculty Position in Experimental Particle Physics in the Department of Physics and Astronomy

The Department of Physics and Astronomy at the University of Rochester invites applications for a tenure-track faculty position in Experimental Particle Physics. With this position, we seek to broaden the research portfolio of our existing program, which includes research in hadron collider physics at CMS (LHC), CDF and D0, neutrino physics at MINERvA and T2K and quark flavor physics at CLEO and BES. We are particularly interested in considering candidates with a research interest in non-accelerator based particle physics or particle astrophysics, but will consider candidates across the spectrum of Experimental Particle Physics.

Applicants should have a Ph.D., an outstanding record of research, and a commitment to excellence in teaching at both the undergraduate and the graduate level. We seek applications from junior-level candidates; an appointment at a more senior level can be considered for exceptionally well qualified applicants. Each candidate should submit a letter of application, a curriculum vitae including a list of publications, and a description of research and teaching plans. The candidate should arrange for at least four letters of recommendation to be sent to:

HEP Faculty Search Committee, c/o Ms. Shirley Brignall
Department of Physics and Astronomy, University of Rochester
Rochester, NY 14627

Applications may also be submitted by email sent to **shirl@pas.rochester.edu**. Applications will be considered on an ongoing basis beginning in November 2010.

The University of Rochester has a strong commitment to diversity and actively encourages applications from candidates from groups underrepresented in higher education. The University of Rochester is an Equal Opportunity employer and encourages applicants from members of minority groups and women. All applications are considered without regard to race, sex, age, religion or national origin. Salary will be competitive.

POSTDOCTORAL POSITION

High Energy Gamma-Ray Astronomy
and Particle Astrophysics

University of California, Los Angeles

The University of California Los Angeles (UCLA) invites applications for a Postdoctoral research position in high energy gamma-ray astronomy to strengthen the experimental astroparticle physics group. UCLA participates in forefront research in the areas of high-energy gamma-ray astronomy, ultra-high energy cosmic rays and neutrinos, and dark matter detection. The successful candidate will be expected to become involved in the design and prototyping of the future ground-based gamma-ray observatory CTA/AGIS and also to take part in the data analysis and ongoing operation of VERITAS.

The UCLA high energy gamma-ray astrophysics group has been actively involved in the world-wide effort to develop the next generation array of imaging atmospheric Cherenkov telescopes known as the Cherenkov Telescope Array (CTA) and formerly known in US as the Advanced Gamma Ray Imaging System (AGIS). The group's efforts are focused on the design and prototyping of the optical system for a novel Schwarzschild-Couder telescope as well as on simulation studies of the CTA performance. The group also participates in operation of Very Energetic Radiation Imaging Telescope Array System (VERITAS http://www.astro.ucla.edu/~veritas/) and conducts analysis and research utilizing data from VERITAS and Fermi Gamma-ray Space Telescope.

We encourage candidates with an experimental background in high energy particle physics, astrophysics, or an observational background in astronomy to apply for the position. A Ph.D., or equivalent degree, in physics or astronomy is required. Applicants should send a CV and arrange for three letters of recommendation to be sent to:

Prof. Vladimir Vassiliev
Department of Physics and Astronomy
University of California
Los Angeles, CA 90095-1547

The deadline for receipt of applications is November 1st, 2010. Screening of candidates will begin upon receipt of completed applications and will continue until the position is filled.

For inquiries please contact Prof. Vassiliev at vvv@astro.ucla.edu.

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Lecturer in Experimental Particle Physics

School Chemistry & Physics (Ref: 16200)

The Australian Research Council recently funded a Centre of Excellence in Particle Physics (CoEPP) at the Tera scale, involving the Universities of Melbourne, Monash and Sydney with the University of Adelaide.

As part of this national initiative, to participate in research using the ATLAS detector at the Large Hadron Collider, we are seeking to appoint a high calibre and dynamic Experimental Particle Physicist in a tenurable position. Candidates with research expertise in experimental particle physics are encouraged to apply. Experience at CERN or another major particle physics laboratory is essential. The successful candidate will have a strong commitment to excellence in research, teaching and student learning. In addition, you will have an outstanding research track record and will be expected to participate in the research of the CoEPP using ATLAS. You will also contribute to undergraduate and postgraduate teaching, the supervision of students, and assist with the administrative responsibilities of the Physics discipline.

Information about the CoEPP may be obtained from the Associate Director at the University of Adelaide, Professor Anthony Thomas, +61 8 303 3547, email: anthony.thomas@adelaide.edu.au

This tenurable position is available from 1 January 2011.

Salary: (Level B) $75,425 – $89,569 per annum, plus an employer superannuation contribution of 17% applies.

Closing Date: 15/11/2010

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Contact: Ms Jeanette Roulston
Email: jeanette.roulston@adelaide.edu.au
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Postdoctoral Position in Astroparticle Physics
at the
Institute of Physics, Academia Sinica, Taiwan

Applications are invited for a postdoctoral position in astroparticle physics with the AMS (Alpha Magnetic Spectrometer) Experiment at Institute of Physics, Academia Sinica, Taiwan, to work at CERN, Geneva.

AMS is a TeV magnetic spectrometer to search for antimatter, dark matter, strangelets and other unexpected phenomena, as well as to measure precisely cosmic ion spectra aboard the International Space Station from 2011 to 2020 and beyond.

Academia Sinica is the leading research institute in Taiwan. Its research in particle physics includes the ATLAS experiment at CERN and the reactor neutrino experiment TEXONO at Taiwan.

Candidates should have a Ph.D in astroparticle physics at the date of the appointment. Applicants should send a curriculum vitae, a list of publications, a brief statement of research interests, and arrange for at least three letters of recommendation to be sent via email to **Prof. Shih-Chang Lee (phsclee@phys.sinica.edu.tw)**.

The position will remain open until filled.

INFN Istituto Nazionale di Fisica Nucleare

POST-DOCTORAL FELLOWSHIPS FOR NON ITALIAN CITIZENS IN THE FOLLOWING RESEARCH AREAS

THEORETICAL PHYSICS (N. 15)
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The INFN Fellowship Programme 2010/2011 offers 35 (thirtyfive) positions for non Italian citizens for research activity in theoretical (n. 15) or experimental physics (n. 20).

Fellowships are intended for young post-graduates who are under 35 years of age by November 15, 2010.

Each fellowship, initially, is granted for one year and then, may be extended for a second year.

The annual gross salary is EURO 28.000,00.

Round trip travel expenses from home country to the INFN Section or Laboratory will be reimbursed, also lunch tickets will be provided for working days.

Candidates should choose at least two of the following INFN sites, indicating their order of preference.

- INFN Laboratories:
Laboratori Nazionali di Frascati (Roma), Laboratori Nazionali del Gran Sasso (L'Aquila), Laboratori Nazionali di Legnaro (Padova), Laboratori Nazionali del Sud (Catania);

- INFN Sections in the universities of:
Bari, Bologna, Cagliari, Catania, Ferrara, Firenze, Genova, Lecce, Milano, Milano Bicocca, Napoli, Padova, Pavia, Perugia, Pisa, Roma La Sapienza, Roma Tor Vergata, Roma Tre, Torino, Trieste.

The research programs, must be focused on the research fields of the Section or Laboratory selected (**http://www.infn.it**).

Applications, in electronic form, must be sent to INFN no later than November 15, 2010.

To register, candidates must use the website **http://www.ac.infn.it/personale/fellowships/**

The application form requires:

- statement of research interests;
- curriculum vitae;
- three reference letters (specifying name, surname and e-mail of each referee).

Theoretical fellowships must start from september to december 2011. Requests for starting earlier accepted.

Experimental fellowships must start no later than april 2011. Requests to posticipate accepted.

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BOOKSHELF

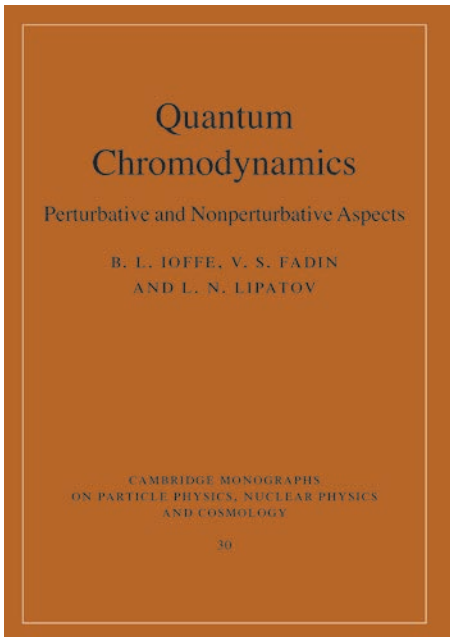
Quantum Chromodynamics: Perturbative and Nonperturbative Aspects by Boris L Ioffe, Victor S Fadin and Lev N Lipatov, Cambridge University Press. Hardback ISBN 9780521631488, £110.00 ($180). E-book ISBN 9780511717444 $144.

The latest addition to the large library of books devoted to the strong interaction, *Quantum Chromodynamics: Perturbative and Nonperturbative Aspects*, is a long awaited gem. For a long time I witnessed the efforts of one of the editors, Peter Landshoff, waiting for the manuscript finally to come to life. The authors, Boris Ioffe, Victor Fadin and Lev Lipatov, are outstanding theoretical physicists and true masters in the field. They have made crucial contributions to a theory that, despite Titanic efforts, has kept its most intimate mysteries as secret as in its childhood days.

Before highlighting its content, it is fair to say that this is not an easy book to read; it is more of a wise companion to work with. There is a clear intention to present the results from first principles, departing from other more "user friendly" textbooks. There are numerous references to research papers to help the reader reach a deep understanding of the discussions presented in the text. The underlying spirit is that learning must follow from full control of the technical details, leaving analogies and "pretty pictures" for "amateurs".

In almost 600 pages, the authors have been able to cover only selected topics in line with their research interests. The final result, a collage of perturbative and nonperturbative aspects of the theory, is nevertheless attractive. In many newspapers there are weekly columns dedicated to reviews of the best moves of famous chess games: the final results are known but we are still delighted with the details of certain moves. Let us follow this philosophy and comment on the most remarkable "games" in this book.

It begins by introducing quantization, with a lucid discussion of the Gribov ambiguity and renormalization schemes. It continues with the spontaneous violation of chiral symmetry and introduces chiral-effective theories at low energies. The axial and scale anomalies are then presented with care. The nontrivial structure of the QCD vacuum is also explored, first introducing tunnelling in quantum mechanics, followed by a superb description of instantons



and topological currents. To illustrate the divergent nature of quantum field theory, the authors provide many examples on how to estimate higher-order corrections ranging from renormalons to functional approaches – this is highly recommendable. QCD sum rules are then explained in detail, together with a nice discussion on the determination of the running of the strong coupling and condensates from low-energy data. Different meson and baryon properties are derived in depth.

When the perturbative window is opened, the evolution equations in the parton model take central stage. The presentation here is very original, full of useful intermediate steps and dealing with less well known subjects such as parton-number correlators. Parton distributions for unpolarized and polarized nucleon targets, quasipartonic operators and infrared evolution equations at small Bjorken x are included in the menu. Jet production, starting with e^+e^- annihilation into hadrons, also appears. I recommend that the reader pay special attention to the sections devoted to colour coherence.

The last two chapters are closest to my heart: the Balitsky-Fadin-Kuraev-Lipatov (BFKL) approach and high-energy QCD. This subject attracted a great deal of attention in physics at the HERA collider at DESY, and is returning in a rather unexpected way: the anti de Sitter/conformal-field theory (AdS/CFT) correspondence. The original derivation of the BFKL equation, including the next-to-leading-order kernel, is presented. Special emphasis is put on using the dominant degrees of freedom at high energies, the reggeized gluons and the solid bootstrap conditions that they fulfil. The book closes with a presentation of an effective action to describe reggeized gluon interaction, the appearance of integrability, the current view of the hard pomeron in supersymmetric theories and its connection to graviton exchange in dual theories. This line of research has a bright future, but this will be the subject for other books. For the time being, remember to keep this one, not at your bedside, but on your work table.

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Relatività Generale e Teoria della Gravitazione by Maurizio Gasperini, Springer. Paperback ISBN 9788847014206, €25.72 (£19.99).

Maurizio Gasperini's book is a textbook on the theory of general relativity (GR), but it does not present Einstein's theory as the final goal of a course. Rather, GR is seen here as an intermediate step towards more complex theories, as already becomes clear from the table of contents. In addition to the standard material on Riemannian geometry, which always accompanies the development of the physical content of GR, and on the solutions of the Einstein equations for the case of a weak field (including a treatment of gravitational waves) and for the case of a homogeneous and isotropic system (including black holes), there are also chapters on gauge symmetries (local and global), supersymmetry and supergravity.

Given the purpose of the book, it is not surprising to find the treatment of the formalism of tetrads (vierbein), forms and duality relations, which constitute the bridge between the Riemannian manifold describing space–time and gravity and the flat tangent space with Minkowski metric. For the same reason, the author considers the general case in which the torsion of the curved space–time is not null (as in Einstein's GR) in order to address the general case of a curved manifold, which is needed for the theory of the gravitino (i.e. of a local supersymmetry between fermions and bosons).

Other nice aspects of the book are the analogy between the Maxwell equations in a curved Riemannian manifold and in an optical medium, the computation of the precession of Mercury in the context of both the special and general theories of relativity, as well as several exercises whose solutions are a valuable ingredient of the book. Given the relatively small number of pages (fewer than 300), I can understand why a few stimulating aspects have been omitted ("gravitomagnetism" or Lense–Thirring precession, Hawking radiation and a discussion of the topological aspects left free by GR), but I sincerely hope that they could be included in a future edition.

Special mention should be made of the last four chapters, which deal with the Kasner solution of the Einstein equations in a homogenous but anisotropic medium, with the bridge between the curved Riemannian manifold and the flat tangent space, with quantum theory in a curved space–time and with supersymmetry and supergravity. These make the book different from most texts of its kind. In conclusion, I warmly recommend reading this book and hope that an English translation can help it reach a wider audience.
Diego Casadei, New York University and CERN.

Books received

Let There Be Light: The Story of Light from Atoms to Galaxies by Alex Montwill and Ann Breslin, Imperial College Press. Hardback ISBN 9781860948503, £47 ($85). Paperback ISBN 9781848163287, £26 ($48). E-book ISBN 9781860948510, $111.

This book is devoted to the key role played by light and other electromagnetic radiation in the universe. Readers are introduced to philosophical hypotheses, such as the universality of natural laws, and then guided to practical consequences, such as the rules of geometrical optics and Einstein's relationship, $E = mc^2$. Most chapters feature a pen-picture of a relevant scientific figure. Going a step beyond the popular level, the book provides an overall view for undergraduate and postgraduate physics students that is often missing in their courses. It will suit general readers with basic mathematics, as well as teachers.

Approaches to Quantum Gravity: Toward a New Understanding of Space, Time and Matter edited by Daniele Oriti, CUP. Hardback ISBN 9780521860451, £60 ($110). E-book ISBN 9780511512407, $88.

With contributions from leading researchers in this field, this book presents the fundamental issues involved in the construction of a quantum theory of gravity and a quantum picture of space and time. It introduces the most current approaches and reviews their main achievements, thus providing a complete overview of the field for graduate students and researchers. Part I introduces the problem of quantum gravity, parts II to IV present current approaches, including string/M theory and loop quantum gravity, and part V covers effective models of quantum gravity. Each part ends in questions and answers, in which the contributors explore the merits and problems of the various approaches.

General Relativistic Dynamics: Extending Einstein's Legacy Throughout the Universe by Fred I Cooperstock, World Scientific. Hardback ISBN 9789814271165, £41 ($51). E-book ISBN 9789814271172, $62.

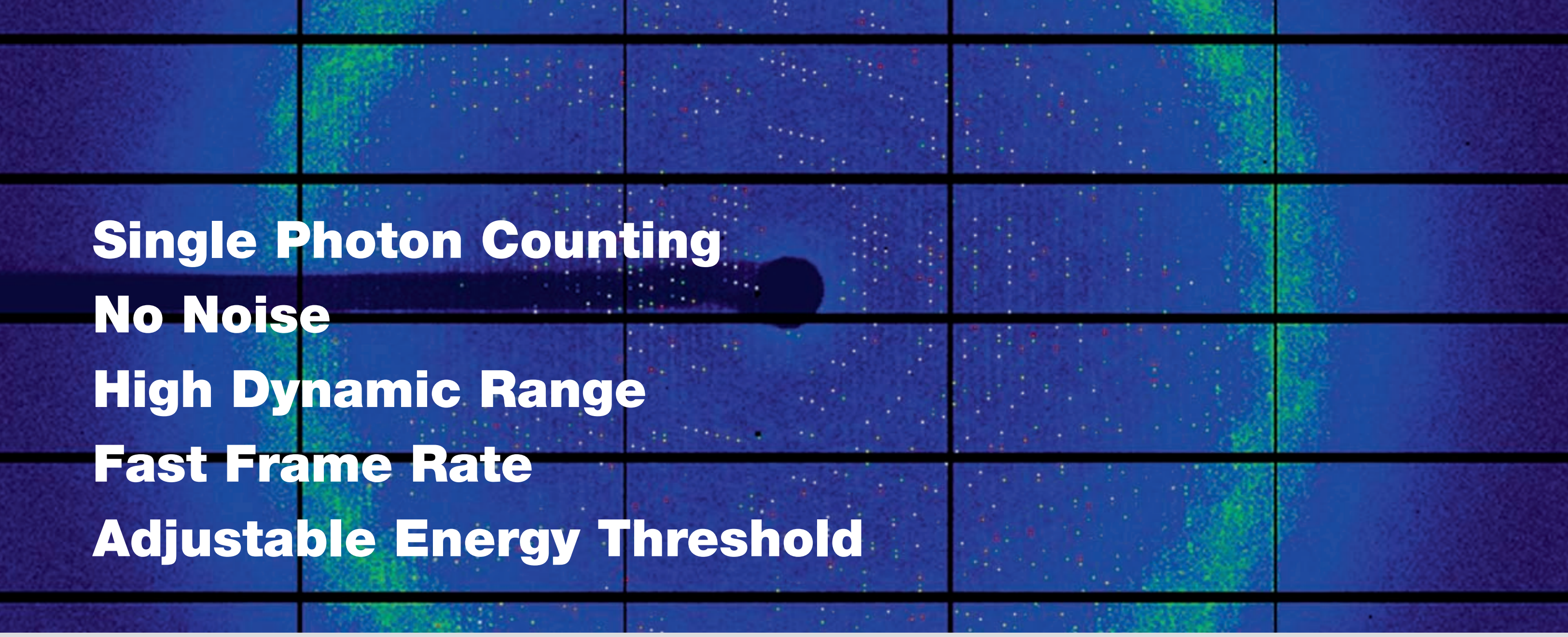
Bringing Einstein's general relativity into action in new ways, Fred Cooperstock presents the case that Einstein's theory of gravity can describe the observed dynamics of galaxies without invoking the "dark matter" required in models based on Newtonian gravity. Drawing on his experience as a lecturer as well as on his research, the author covers the essentials of Einstein's special and general relativity at a level accessible to undergraduate students. The early chapters provide an introduction to relativity for readers who have little or no knowledge in the subject. Later, general relativity is used to extend the concept of the Planck scale, to address the role of the cosmological term and to analyse the concept of "time machines".

Feynman Motives by Matilde Marcolli, World Scientific. Hardback ISBN 9789814271202, £36 ($48). Paperback ISBN 9789814304481, £18 ($24). E-book ISBN 9789814271219, $62.

Matilde Marcolli presents recent and ongoing research aimed at understanding the relation between the computations of Feynman integrals in perturbative quantum field theory and the theory of motives of algebraic varieties and their periods. One of the main problems in the field is understanding when the residues of Feynman integrals in perturbative quantum field theory evaluate to periods of mixed Tate motives. Two different approaches to the subject are described: a "bottom up" approach; and a "top down" approach developed by Marcolli and Alain Connes. The text is based partly on lecture notes for a graduate course given at Caltech in 2008.

Quantum Mechanics with Basic Field Theory by Bipin R Desai, CUP. Hardback ISBN 9780521877602, £55 ($95).

This textbook covers, step by step, important topics in quantum mechanics, from traditional subjects such as bound states, perturbation theory and scattering, to more current topics that include coherent states, quantum Hall effect, spontaneous symmetry breaking, superconductivity and basic quantum electrodynamics with radiative corrections. A large number of topics are covered in concise chapters and are explained in simple but mathematically rigorous ways. Derivations of results and formulae are carried out from beginning to end, without leaving students to complete them. With more than 200 exercises to aid understanding of the subject, this textbook provides a thorough grounding for students planning to enter research in physics. Several exercises are solved in the text and password-protected solutions for others are available to instructors from the publisher's website.



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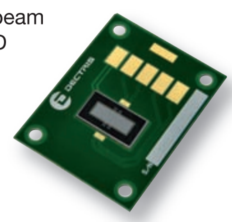

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