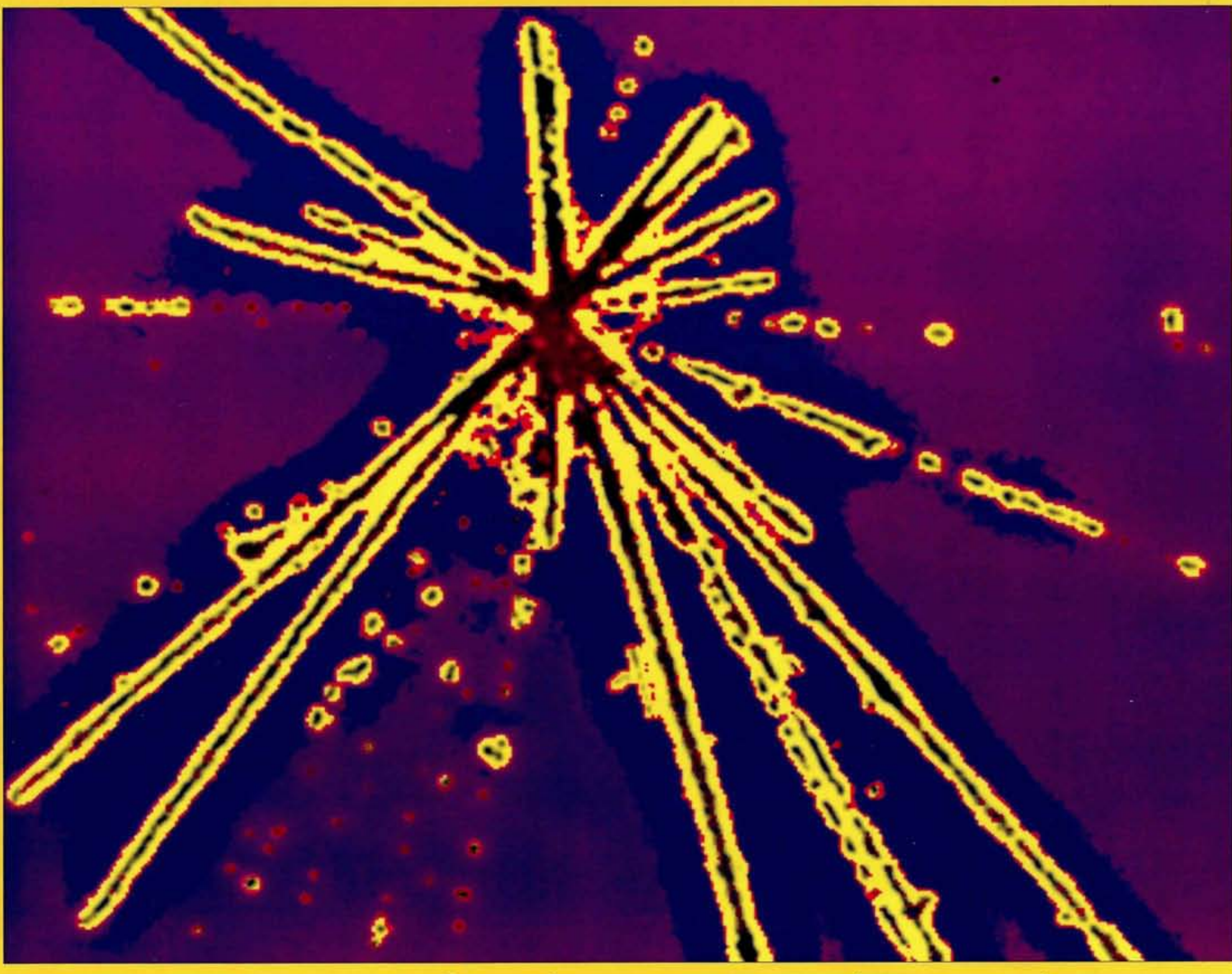
INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERN COURIER

VOLUME 43 NUMBER 3 APRIL 2003



Renaissance for hypernuclear physics

HERA
New polarization record p5

CHINA
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QCD
DESY Theory Workshop p24

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

CERN Courier (ISSN 0304-288X) is distributed to member state governments, institutes and laboratories affiliated with CERN, and to their personnel. It is published monthly, except for January and August, in English and French editions. The views expressed are not necessarily those of the CERN management.

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US/Canada Published by *Cern Courier*, 6N246 Willow Drive, St Charles, IL 60175. Periodical postage paid in St Charles, IL. Fax: 630 377 1569. E-mail: vosses@aol.com. Postmaster: send address changes to: Creative Mailing Services, PO Box 1147, St Charles, IL 60174

Published by European Organization for Nuclear Research, CERN, 1211 Geneva 23, Switzerland. Tel: +41 (22) 767 61 11
Telefax: +41 (22) 767 65 55

Printed by Warners (Midlands) plc, Bourne, Lincolnshire, UK

ISSN 0304-288X

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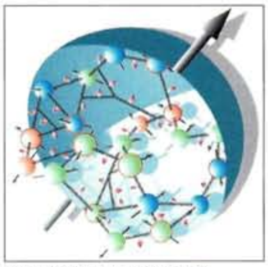
New spin rotators for HERA II p5



QCD inside the proton p24

Spiro takes over at IN2P3 p29

Cover: The first observed hypernucleus was found 50 years ago in a cosmic-ray event in emulsion, but now the FINUDA detector at the DAFNE collider is using a range of modern detection techniques to investigate hypernuclear physics (p13). (This computer-enhanced image shows the interaction where the hypernucleus formed; the complete unmodified image can be seen on p14.)

DESY

HERA II puts collisions in a spin

With only days to go before a scheduled long shutdown began on 3 March, the upgraded HERA collider – HERA II – succeeded in running with polarized positrons at three interaction regions, soon reaching a polarization of 50%. This is a first not only for DESY, the laboratory that is home to HERA, but also for the world.

Electron and positron beams in storage rings have a natural tendency to become polarized with the spins of the particles perpendicular to the direction in which the beam is travelling. However, in 1994 HERA made polarization history when spin rotators were used to convert this vertical polarization to a longitudinal polarization, with the spins oriented along the particles' direction of motion. This enabled the HERMES experiment in particular, which directs the polarized beam at a gas target, to begin its measurements of collisions between protons and polarized electrons in order to investigate the origin of the spin in the proton – something that is still not well understood (see p24).

With the HERA upgrade in 2000/2001, spin rotators were also installed at the collision regions where the H1 and ZEUS experiments are located. The removal of compensating solenoids in these regions and the use of stronger quadrupoles for focusing in the arcs of the collider made the conditions for polarization of the positron beam more difficult in HERA II. However, on 24 February, longitudinal polarization was achieved at the three interaction regions where pairs of spin rotators are now installed.

One of the two new spin rotator sections near the H1 detector, with a vertical dipole magnet in the foreground.

Nearly 80 new magnets were installed in the HERA tunnel for the upgrade in 2000/2001 to enable a higher luminosity.

The machine ran for many hours, with the pairs of rotators flipping the spins along the beam direction before the interaction regions and back again as the beam emerged from the detectors, 47 000 times a second. Initially, the solenoid magnets of H1 and ZEUS remained off, but on 2 March, the day before the shutdown, the solenoids were switched on and a polarization of 50% was achieved for collisions in the detectors.

Shortly before the shutdown, the machine crew was also able to achieve a peak luminosity of 2.7×10^{31} cm^{-2} s^{-1} for the first time, exceeding the maximum luminosity achieved by HERA I. This indicates that the four-fold increase in luminosity expected with HERA II is in fact achievable, and this will be a major goal when the machine restarts after the 18-week shutdown. During this time, work will take place on the vacuum system and on some parts of the H1 and ZEUS detectors. Systematic tests by the experiments and machine crew have revealed the source of the high background rates that unexpectedly caused problems after the machine and detector upgrades, and which made data-taking in the two experiments extremely difficult. The aim will be to reduce these high background rates, so that HERA II can begin to perform as planned.

German government pronounces on TESLA projects

The German Federal Ministry of Education and Research gave the go-ahead on 5 February for the TESLA X-ray laser to be built at DESY as a European project. At the same time, it pledged continued support for R&D on the TESLA linear collider, while recognizing that decisions on the location of such a machine must be made at an international level. These decisions were part of a package to support large-scale projects in basic research, worth €1.6 billion, which also includes approval of a new accelerator complex at the GSI laboratory in Darmstadt.

DESY is to receive half the costs of the TESLA X-ray laser, which total €673 million, from the German government. The next step will be for DESY to work with interested European partners to develop the appropriate financial, technological and organizational framework for the project. The aim will be to make a decision within about two years on the construction of the machine, which will take around six years.

The Ministry also recognized the importance of the TESLA linear collider for Germany, by agreeing continued support for R&D work at DESY. This will allow DESY to continue working at an international level on the coordination and decision processes, which are currently in progress around the world.

Albrecht Wagner, chairman of the DESY Directorate, has welcomed the decisions. "The possibility to realize the TESLA X-ray laser as a European project at DESY opens up outstanding research possibilities", he said after the announcement by the Ministry. "For the linear collider for particle physics, which is being planned on a longer term basis, DESY is able to continue the international research work." Wagner also said that the decisions represent "a great recognition of the achievements of the TESLA collaboration, which have been widely acknowledged throughout the world."

NEUTRINOS

The curtain goes up on OPERA

The first module for the target tracker for OPERA (Oscillation Project with Emulsion-tRacking Apparatus) was centre stage at the Institut de Recherches Subatomiques (IReS) in Strasbourg in January, when the OPERA collaboration met there to launch the construction of the detector. The target tracker is being built in Strasbourg, where two halls at IReS have been provided for its construction.

Now that the latest results from the KamLAND experiment have indicated a large mixing angle (LMA) solution for the oscillation of solar neutrinos, OPERA has increased its chances of making the next discovery in the field of neutrino oscillations. Using the CERN muon neutrino beam to Gran Sasso (CNGS), OPERA aims to observe an unambiguous $\nu_\mu \rightarrow \nu_\tau$ oscillation. The scheduled start-up of the CNGS beam over the summer of 2006 leaves the OPERA collaboration with little time to build and install its detector in Italy's Gran Sasso Underground Laboratory. The main purpose of the meetings in Strasbourg was to define and plan all the construction and installation phases.

The OPERA detector combines photographic emulsion and electronic detection techniques, and comprises a target part and a spectrometer part (*CERN Courier* June 2001 p4). The target part consists of alternate walls of lead/emulsion bricks and modules of scintillator strips for the target tracker. The main purpose of the tracker is to identify the brick where a neutrino interaction is likely to be. The 7 m long scintillator strips will have grooves into which wavelength-shifting fibres will be glued and read out by 64-channel multianode photomultipliers. Computer-operated robotic manipulators will extract the bricks identified by the tracker. The emulsions will then be developed and scanned using automated microscopes.

Members of the OPERA collaboration around the first module ($1.7 \times 7.5\,m^2$) of the target tracker, which was built in one of the two halls at IReS that are being used for this purpose.

The spectrometer part, which is essential to detect muons emerging from neutrino interactions, will consist of a precision drift-tube tracker, a magnet producing a 1.55 Tesla magnetic field and RPCs inserted into the magnets. The collaboration comprises some 150 physicists from a wide range of countries and expects to be data-taking for the period 2006–2011.

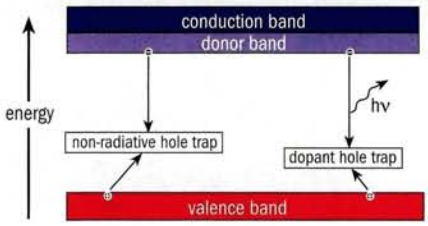
DETECTORS

Doubly doped semiconductor makes a fast scintillator

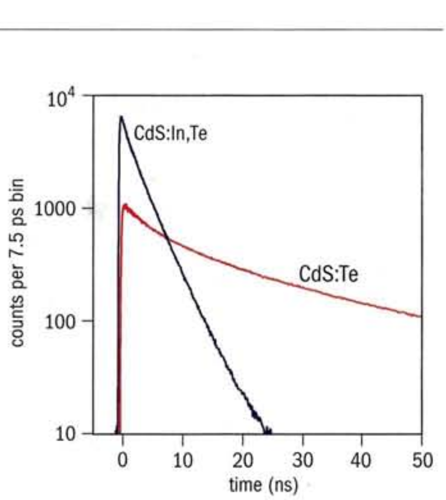
At cryogenic temperatures some semiconductors can convert ionizing radiation into visible light with high efficiency and speed. In cadmium sulphide, for example, electron-hole pairs produced by ionizing radiation promptly form excitons with a radiative decay time of about 0.2 ns. However, at room temperature almost all of the holes are trapped on non-radiative centres, that is, crystal defects and impurities.

Now Stephen Derenzo, Edith Bourret-Courchesne, Mattias Klintenberg and Marvin Weber at the Lawrence Berkeley National Laboratory (LBNL) have found that if one impurity is added to trap the holes and another impurity is added to provide an abundant supply of electrons, then bright fast scintillation can occur at room temperature. They hope that their work will lead to a new class of fast, luminous scintillators based on radiative electron-hole recombination in direct-gap semiconductors.

Many inorganic scintillators such as tellurium-doped cadmium sulphide work by combining ionization electrons and holes to form an exciton, but the excited state promptly converts into a triplet (with electron spins aligned) that produces light slowly because the transition to the singlet ground state is spin forbidden. The work at LBNL shows that it is possible to overcome this speed limitation by adding additional different impurity atoms to make the material n-type, as this provides an abundant supply of electrons of both spins to combine with the ionization holes.



A codoped direct-gap semiconductor provides a fast route to scintillation through dopant band to dopant trap recombination.



Adding indium to tellurium-doped cadmium sulphide speeds up the scintillation action dramatically.

The team successfully applied this strategy to cadmium sulphide by codoping it with tellurium and indium. The tellurium is an efficient isoelectronic hole trap and the indium is used to make the material bulk n-type, which provides a band of donor electrons near the bottom of the conduction band. When an electron or X-ray produces holes and electrons in this material, many of the holes are promptly trapped on tellurium atoms in less than 0.05 ns. They then recombine with electrons from the donor band to produce scintillation light with a decay time of 3.5 ns. The light has a wavelength spectrum that peaks at 620 nm and is the same as that of tellurium-doped cadmium sulphide, which has a primary decay time of 3 microseconds.

Derenzo and his colleagues believe that among the vast combination of host crystals and codopants, there are many fast new scintillators that can be developed, and that band structure calculations can guide the search. They are currently exploring the possibility of using ionized acceptor impurities to trap the ionization holes, and codoping other semiconductors such as lead iodide, which has good efficiency for detecting gamma rays and produces 200 000 electron-hole pairs per MeV.

Further reading

S Derenzo, M Weber & M Klintenberg 2002 Temperature dependence of the fast, near-band-edge scintillation from CuI, HgI_2, PbI_2, ZnO:Ga and CdS:In. *Nucl. Instr. Meth.* **A486** 214.

S Derenzo, M Weber, M Klintenberg & E Bourret 2002 The quest for the ideal inorganic scintillator. *Nucl. Instr. Meth.* (in press) LBNL-50779.

NETWORKS

Laboratories link up to win Internet land speed record

The transfer of data equivalent to two feature-length movies on DVD between California and Amsterdam in less than one second has been recognized as a new record by the Internet2 consortium. The operation, which achieved an average speed of more than 923 megabytes per second, was by an international team from several laboratories and involved a number of different networking systems.

The team comprised members of NIKHEF, SLAC, Caltech and the University of Amsterdam, with support from CERN. They used the advanced networking capabilities of TeraGrid, StarLight, SURFnet and NetherLight, together with optical networking links provided by Level 3 Communications and Cisco Systems. The transfer involved standard PC hardware running Debian GNU/LINUX in Amsterdam and redHat Linux in Sunnyvale. The team is supported by the EU-funded DataTAG project and by the US Department of Energy.

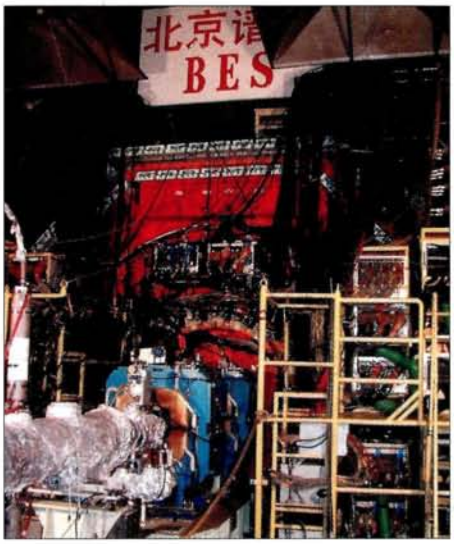
The Internet2 Land Speed Record is an open and ongoing competition run by Internet2, a consortium of 200 universities that are working with industry and government to develop network applications and technologies. The record-breaking event, which took place during the SC2002 conference in Baltimore in November, was judged on a combination of the bandwidth used and the distance covered using standard Internet (TCP/IP) protocols. By transferring 6.7 gigabytes across 10 978 km in 58 seconds, the transfer set a record of 9891.60 terabit metres per second.

PARTICLE FACTORIES

China agrees upgrade of its particle collider

On 10 February, the Chinese government approved the Beijing Electron–Positron Collider Upgrading Program (BEPCII), finally making the long expectation of the Chinese high-energy physics community a reality. When complete in 2006, BEPCII will add a new "factory class" particle collider to the world scene, adding new momentum to research on tau–charm physics. China hopes that the physics potential will attract groups from other countries to join and help the Chinese physicists meet the technical challenge and share the cost of increasing detector performance to ensure first-class results.

The BEPC machine will be upgraded to become a double-ring collider, with a luminosity 100 times higher than at present. (Mike Dykes, Daresbury Laboratory.)



The BES detector will also be upgraded to adapt to the new high event rate of BEPCII. (Mike Dykes, Daresbury Laboratory.)

The existing Beijing Electron–Positron Collider (BEPC), with a beam energy in the 1–2.5 GeV range, was constructed between 1984 and 1988. The Beijing Spectrometer (BES) is the only detector on this machine, and the research programmes that started in 1989 have concentrated on tau–charm physics. The luminosity of BEPC can reach $1 \times 10^{31}\ cm^{-2}\ s^{-1}$ at a beam energy of 1.89 GeV, and over the past 10 years BES has obtained many important experimental results. For example, the precision of the tau mass measurement made in 1992 was 10 times higher than previous measurements, and played an essential role in testing lepton universality. Moreover, since its start-up BES has accumulated about 66 million J/Ψ events and 18 million Ψ' events – the largest data samples in this energy range (*CERN Courier* December 2002 p6).

The main physics aims for the future at BEPC are precision measurements of charm physics and the search for new particles and new phenomena, mainly in the energy region of the J/Ψ and Ψ'. However, this requires both a major upgrade of BEPC to increase its luminosity by two orders of magnitude, and a major upgrade of BES to reduce its systematic errors and to adapt to the high event rates and small bunch spacing in BEPCII.

With the construction of an additional ring, BEPCII will be a double-ring collider that approaches most of the specifications of a particle factory (*CERN Courier* October 2001 p6). It will have superconducting micro-beta magnets, a 500 MHz RF system with superconducting cavities and a low impedance vacuum system. The second ring will be accommodated in the existing tunnel of BEPC, with a large horizontal crossing angle of 11 milliradians at the southern interaction region. There will be 93 bunches per ring with a total current of 910 mA per ring. The peak luminosity of BEPCII will be $10^{33}\ cm^{-2}\ s^{-1}$ at a beam energy of 1.89 GeV, which is about 100 times higher than that of BEPC. The upgrade of the linac will provide injection at energies up to 1.89 GeV for "top-up" injection. The positron injection rate will rise from the current 5 mA per minute to 50 mA per minute.

BESII, the current detector at BEPC, will be upgraded to BESIII. Most of the detector components will be rebuilt with up-to-date techniques to include a main drift chamber with small cells, aluminium field wires and helium-based gas; an electromagnetic calorimeter of caesium-iodide crystals of 15 radiation lengths (28 cm); plastic scintillators for time-of-flight; a 1 Tesla superconducting solenoid magnet; and nine layers of RPCs interleaved with the iron plates of the return yoke for muon identification.

Most of the existing utilities at BEPC will be used for BEPCII, after some upgrading. A cryogenics system at 4.2 K will be installed for three types of superconducting devices. The special design of BEPCII will keep the electron beam in the outer ring running during dedicated synchrotron radiation, so there will be no changes to the synchrotron radiation beam lines and the experimental stations, although the beam current will be increased from 140 mA at 2.2 GeV to 250 mA at 2.5 GeV.

The total estimated budget for BEPCII is around 640 million Chinese Yuan (about €70 m). The Chinese government will provide funding to cover the costs of the machine and the major part of the detector, while remaining detector costs are expected to come from international collaboration. There is international co-operation to help the Institute for High Energy Physics (IHEP) in Beijing with the design and R&D of BEPCII, as well as to produce some key devices. For example, the Brookhaven National Laboratory in the US is helping with the superconducting micro-beta magnets, and KEK in Japan is assisting with the superconducting RF cavities and the superconducting solenoid magnet. In May 2002, SLAC hosted a review on the design report of BEPCII, and detailed design is now underway. The construction of BEPCII should begin soon and is expected to finish by the end of 2006, with physics running scheduled for the beginning of 2007.

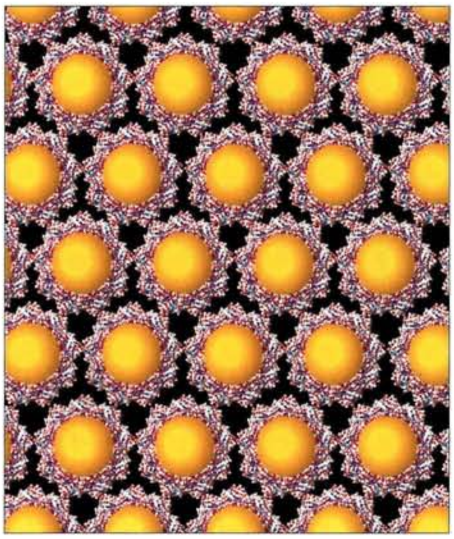
Hesheng Chen, IHEP, Beijing.

Edited by Archana Sharma

Bioengineered nanomachines

Nano-circuit fabrication using a living bacterium? Science fiction seems to have met with reality with the news that researchers at the NASA Ames Research Center, the SETI Institute and the Argonne National Laboratory have demonstrated the assembly of a new generation of tiny machines for electronic and photonic devices built on biological systems.

Bioengineered nanoscale arrays are stacked using genetically engineered proteins as templates to create honeycomb-like patterns of gold and a semiconducting material. First, a protein is isolated from *Sulfolobus shibatae*, a robust bacterium that lives in geothermal hot-springs and can tolerate near-boiling temperatures and high acidities. It is then genetically modified to create a chemically active site on its edge, and cloned into a routinely used form of *Escherichia coli* bacteria. Heating the resulting mix destroys the *E. Coli* proteins, permitting the isolation of large amounts of the heat-tolerant *Sulfolobus* protein.



Genetically engineered proteins form a template that creates an array of gold or semiconductor which is one-fifth the size of those produced by lithographic techniques. (NASA/ANL.)

The protein forms chaperonins or natural ring structures only 10–20 nm across. These are then applied to substrates such as silicon wafers, where they self-assemble into large, hexagonal, periodic patterns. When nanoparticles of gold or cadmium selenide-zinc sulphide, a semiconducting material, are added they adhere only to active sites around the hole in each protein ring.

The regular arrays of nanoparticles that result are very similar to the patterns used in the microelectronics industry, with the added advantage that they are much smaller. Arrays of nanoparticles like these could be used to make more compact computer memories, sensors or logic devices.

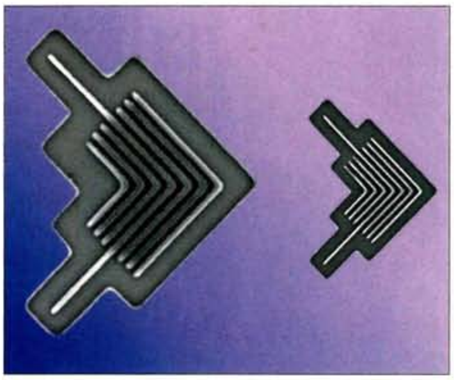
Further reading

http://amesnews.arc.nasa.gov/releases/2002/02_122AR.html.
http://www.anl.gov/OPA/news03/news030214.htm.

Extreme ultraviolet lithography paves the way for crowded circuits

A couple of decades ago, the electronic equivalent of today's handheld computers was a room full of hardware and a truck-load of cables and cards. Since then computers and electronics have become much more compact, due mainly to advances in lithography. Creating circuits of smaller and smaller features uses shorter and shorter wavelengths of light. Limits imposed by current refractive optical systems use light in the deep ultraviolet range, and can print features with a resolution of around 100 nm at wavelengths of about 248 nm. Creating smaller features requires the extreme ultraviolet range, and this implies working with shorter wavelengths to create the templates used to engrave fine features on silicon or metal surfaces.

In moving from sub-micron to nanotechnologies, extreme ultraviolet projection lithography is now the leading contender. Researchers at the Advanced Light Source synchrotron radiation facility at the Lawrence Berkeley National Laboratory are testing this lithography and have produced 50 nm lines with 50 nm spacing, and isolated lines that are only 39 nm wide.



Extreme ultraviolet lithography can easily create 70 nm features (left) but can also allow printing of 39 nm features (right). (LBNL.)

Further reading

Naulleau *et al.* 2002 *Journal of Vacuum Science Technology* **B 20(6)** 2829.

Superconductivity found in plutonium

Researchers from the Los Alamos National Laboratory and the University of Florida, US, and the Institute for Transuranium Elements, Germany, have observed superconductivity in a plutonium-based material for the first time. They discovered that an alloy of plutonium, cobalt and gallium exhibits superconductivity at temperatures below 18.5 K. Although well below the temperatures at which the high-Tc copper oxide-based materials become superconducting, 18.5 K is nonetheless an unusually high transition temperature. This has led the researchers to suggest that the plutonium compound is a new kind of superconductor, and could provide a bridge between high-Tc materials and the known heavy fermion superconductors based on uranium and cerium, which have transition temperatures of around 1 K. *Physicsweb*

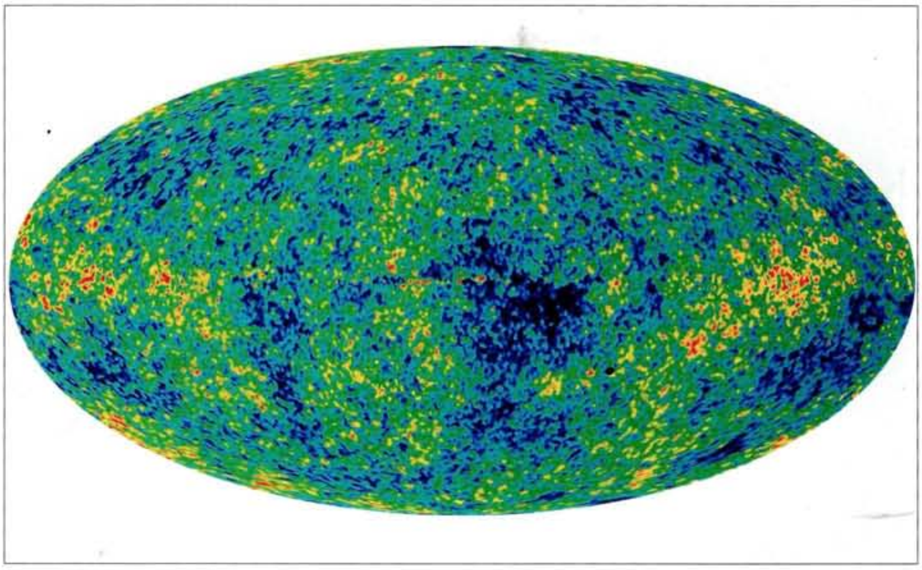
Further reading

J L Sarrao *et al.* 2002 *Nature* **420** 297.

Microwaves map the early universe in detail...

The eagerly awaited first full-sky map from the Wilkinson Microwave Anisotropy Probe (WMAP) has been released by NASA. The satellite, which has been observing the cosmic microwave background radiation from its orbit around the L2 Sun–Earth Lagrange Point since October 2001, provides the sharpest view yet of the early universe. Among the satellite's new findings is that 73% of the universe is in the form of dark energy, while only 4% is in the form of ordinary, baryonic matter.

WMAP (formerly MAP) – named after David Wilkinson of Princeton University who was a pioneer of cosmic background studies and who died last year – has an angular resolution some 40 times better than that of its predecessor, the Cosmic Background Explorer (COBE). This improved resolution enables it to resolve temperature fluctuations in the 2.73 K background radiation of only millionths of a degree.



The oldest light in the universe as revealed by the WMAP satellite. Red indicates the warmer regions, blue the cooler ones. (NASA/WMAP Science Team.)

By combining the new data with other kinds of measurements, the WMAP team can say that this radiation dates back to 380 000 years after the Big Bang, and that stars first ignited 200 million years after the Big Bang. The new results also imply that the universe is 4% baryonic matter, 23% cold dark matter and 73% dark energy in a form more like a cosmological constant than a negative-pressure energy field. The WMAP satellite is also able to measure the polarization of the radiation, and this has provided new evidence for inflation in the early universe. The results have already ruled out a "textbook example" of a particular inflation model.

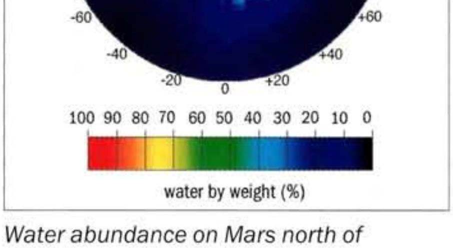
Further reading

http://map.gsfc.nasa.gov/m_mm/pub_papers/firstyear.html.

...while neutrons map the ice on Mars

The Los Alamos National Laboratory (LANL) has released the first global map showing the distribution of hydrogen just below the surface of Mars, as measured by the instruments on NASA's Mars Odyssey spacecraft. The neutron spectrometer, which was built by LANL, detects the neutrons emitted when cosmic rays strike the Martian surface. Hydrogen in the soil can slow down and absorb the neutrons, and so regions where a low intensity of intermediate-energy neutrons is found, indicate soil enriched in hydrogen, most probably in the form of water–ice.

The Mars Odyssey spacecraft has been observing the planet for an Earth year, which is equivalent to a little more than half a year on Mars. This has allowed the team at LANL to see both poles without the obscuring seasonal layer of frozen carbon dioxide. The poles are the main regions where the hydrogen occurs, but the LANL researchers were surprised to find areas near the equator with relatively large concentrations of hydrogen, close to 10% in some places.



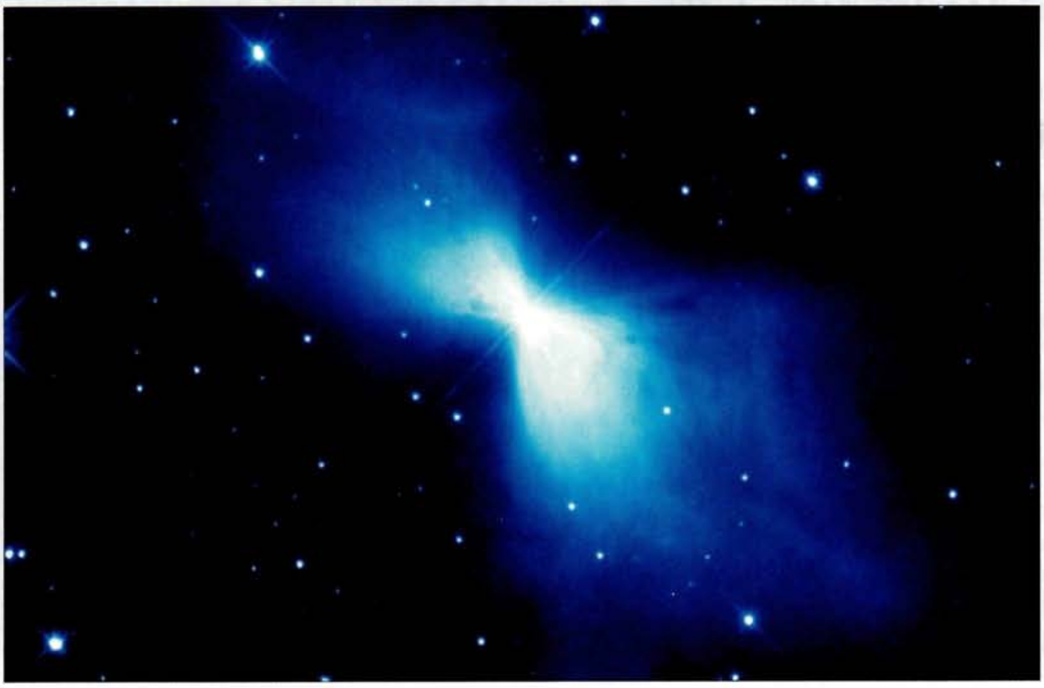
Water abundance on Mars north of 45 degrees latitude; the southern pole shows a similar distribution. (LANL.)

The LANL researchers estimate that there is a sufficient amount of water to cover the planet to a depth of 13 cm or more. The challenge now is to work out just how the water ended up in the soil and the rocks beneath the Martian surface, and to develop further theories of hydrology and climate on Mars.

Further reading

http://www.lanl.gov/worldview/news/releases/archive/03-019.html.

Picture of the month

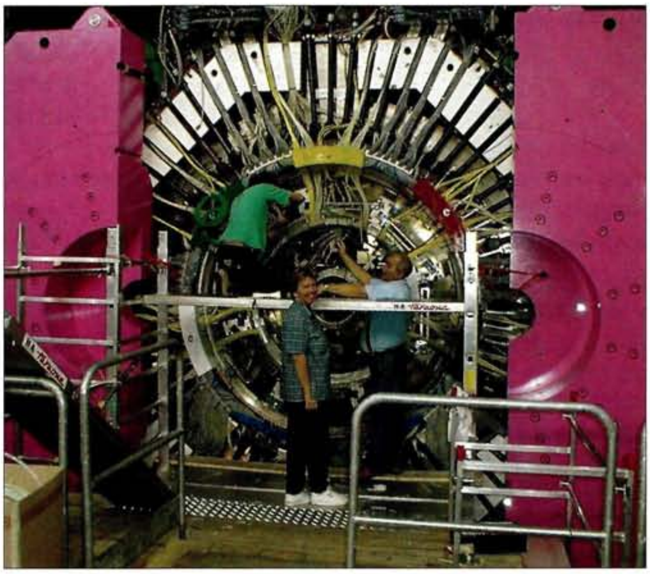


At 1.9 K, the superconducting magnets for CERN's Large Hadron Collider may be colder than the cosmic background radiation, but astronomers have now found an even colder place, the Boomerang Nebula, 5000 light-years from Earth. The two-lobed cloud, shown in this false-colour image that was made by the Hubble Space Telescope, has apparently been created by gas and dust expanding rapidly from an old central star. The gas has cooled to about 1 K as a result of the expansion. (R Sahai and J Trauger (JPL), NASA/ESA.)

DAFNE goes hypernuclear

A new experiment at the Frascati laboratory's ϕ-factory is set to investigate the strange world of the hypernucleus

In 1953 Marian Danysz and Jerzy Pniewski, two Polish physicists studying cosmic radiation, observed the first hypernucleus. The interaction of a high-energy proton with a nucleus in the emulsions they were using as a detector produced a hyperfragment – a nucleus containing a Λ particle. This pioneering observation initiated a new field of fundamental research – hypernuclear physics. The hypernucleus itself provides a unique laboratory suitable not only for studying nuclear structure in the presence of a strange quark, but also for probing weak interactions between baryons.



The FINUDA detector during installation at DAFNE.

During the past 50 years, hypernuclei have been copiously produced at CERN (during the 1960s and 1970s), BNL (1970s–80s) and KEK (1980s–90s), first using extracted beams of negative kaons, and subsequently employing much more intense beams of positive pions. Now, in the year of the 50th anniversary of hypernuclear physics, the INFN's Frascati National Laboratory in Italy is about to start an intense and innovative programme of hypernuclear studies.

The DAFNE ϕ-factory

The Frascati laboratory is home to DAFNE (Double Annular ring for Nice Experiments), an electron–positron collider dedicated to the production of large numbers of the ϕ resonance. DAFNE consists of two almost circular rings, one for the electrons and the other for the positrons, which overlap in two straight sections where the beams collide head-on. The energy of each beam is set to 510 MeV/c^2 in order to produce the ϕ(1020) particle.

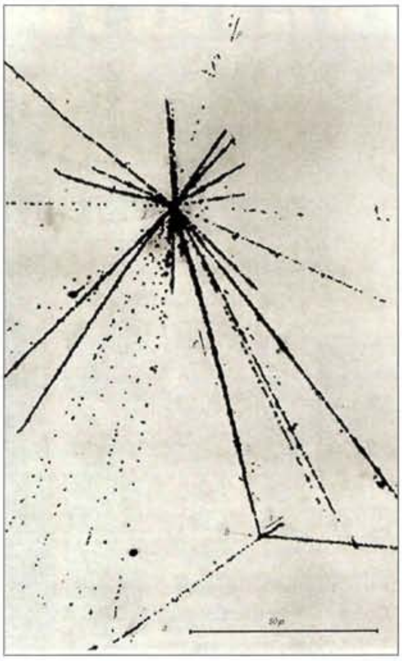
DAFNE is currently the only running ϕ-factory in the world, and was designed with the main aim of exploring rare physical phenomena with very high accuracy. The interest in the ϕ resonance arises from the fact that it decays mainly to a kaon–antikaon pair – particles that showed such unexpected features, right from their discovery in 1947, that a new physical entity called "strangeness" was introduced to explain their characteristics. Now DAFNE is producing ϕ particles at the rate of 12 million per day, and further improvements are predicted. The ϕ-factory is a clean and abundant source of low-energy neutral and charged kaons (~16 MeV/c^2 kinetic energy) suitable for exploring the open problems related to the strange flavour degree of freedom.

The study of neutral kaons led to the discovery in 1964 of a unique phenomenon: the violation of CP symmetry by the weak interaction. Detailed measurement of the fundamental parameters of this violation is still one of the most challenging open problems of modern physics. The KLOE (K Long Experiment) apparatus, located in the first DAFNE interaction region, is devoted mainly to these studies.

Charged kaons, on the other hand, can be used to insert strangeness inside a nucleus, as a probe to investigate the strong force that "glues" matter together. The DEAR (DAFNE Exotic Atoms Research) experiment is using negative kaons from DAFNE to produce kaonic atoms and study their properties. The goal is the precise measurement of the strong interaction shifts and the widths of the K_α line of kaonic hydrogen. After a test period with nitrogen, the DEAR collaboration has completed data-taking with hydrogen.

However, the main user of charged kaons – more precisely negative kaons – will be the FINUDA experiment (FIsica NUcleare a DAfne). When a K^- interacts with a neutron in a nucleus, it can transform it into a Λ hyperon, turning the nucleus into a hypernucleus. The FINUDA experiment, located in the second interaction region of the Frascati machine, is starting data-taking this year to explore the physics of hypernuclei in a completely new way.

Before explaining more about FINUDA, it should be mentioned that the high currents (more than 1 A) circulating inside the DAFNE machine produce high fluxes of synchrotron radiation in the UV and soft X-ray wavelength region. This radiation is used to perform high-quality studies of solid-state and biological physics. Photons in the soft X-ray energy range (1–7 keV) are extracted from the DAFNE wiggler with a horizontal collection angle of 15 mrad; the beam is then split into two separate lines. A third beamline, SINBAD (Synchrotron Infrared Beamline at DAFNE), operates in the infrared range. Here the photons are extracted from one of the DAFNE bending magnets with a vertical acceptance angle of about 40 mrad. ▷



Above: inside the DAFNE hall; the FINUDA detector is visible on the left.
Right: the first observation of a hypernucleus. A cosmic ray coming in from the top right collides with a nucleus in the emulsion to create the star of tracks. One of the fragments from the collision disintegrates lower down the image to produce three new tracks. The faintest of these, travelling towards the lower left, is probably due to a pion. The total energy released in the disintegration is consistent with the decay of a lambda particle in the original nuclear fragment.

The FINUDA experiment

The highly innovative FINUDA experiment is the first hypernuclear physics experiment to take place at a collider, and has prompted a new era in this field of research. The specific aim of FINUDA is to produce hypernuclei by stopping the negative kaons originating from ϕ decay in a nuclear target. The reaction involved is: $K^- + {}^{A}Z \rightarrow {}^{A}_{\Lambda}Z + \pi^-$. By precisely measuring the momentum of the outgoing π^-, it is possible to determine the energy level of the hypernucleus ${}^{A}_{\Lambda}Z$ produced. This approach has some advantages when compared with other experimental techniques using extracted K^- beams on a fixed target. The low kinetic energy of the DAFNE kaons allows them to be stopped in a very thin target (~ 0.1 g/cm^2 compared with some g/cm^2 for fixed-target experiments). Therefore, the energy straggling of the π^- that tags the hypernucleus formation is strongly reduced, and so high-resolution spectroscopic studies are possible. Moreover, kaons at DAFNE are emitted isotropically, and the detector acceptance can therefore be quite large. This feature, combined with a good machine luminosity, provides high hypernuclear counting rates: with $L = 10^{32}$ cm^{-2}s^{-1}, more than 100 hypernuclear events per hour are expected.

FINUDA will investigate a wide programme of high-statistics studies on different hypernuclei. This is possible because the target station of the apparatus is segmented, and up to eight different solid-state targets can be mounted into the detector at the same time. The FINUDA apparatus itself is a complex magnetic spectrometer designed to detect both the π^- emitted in hypernucleus formation, and the products of hypernuclei decay. This is a unique feature in the panorama of studies in hypernuclear physics, which will enable simultaneous exploration of hypernuclear spectroscopy and hypernuclei decay modes.

The Λ particle is the lightest hyperon, so it is stable from the point of view of the strong interaction, and allows the formation of stable nuclear systems. Its lifetime in free space is typically 260 ps, before it decays through a weak interaction, emitting a nucleon and a pion. Nevertheless, since the momentum of the outgoing nucleon is below the Fermi momentum, when the Λ particle is embedded in nuclear matter, the Pauli principle inhibits this decay process. Therefore, when a Λ hyperon is attached to a nucleus, it experiences new decays – the so-called "non-mesonic decays" – for which few data are available. These processes are essentially weak interactions between the Λ particle and a nucleon, resulting in a pair of nucleons of high momentum ($\Lambda + N \rightarrow N + N$). These reactions are extremely interesting because they allow us to explore the four-fermion, strangeness-changing, baryon–baryon weak interaction. This is a good way to study the ΛN interaction, as it is very difficult to produce hyperon beams.

Another important aspect of non-mesonic Λ decays is related to the $\Delta I = 1/2$ empirical rule. The weak decay of hyperons may occur, in principle, with isospin change $\Delta I = 1/2$ or $3/2$. However, the values of the experimental decay branching ratios imply a dominance of a factor 20 of $\Delta I = 1/2$ over $\Delta I = 3/2$. Nevertheless, experimental analysis of some non-mesonic decay channels seems to suggest a strong violation of this rule. The latest measurements of the ratio between neutron- and proton-induced decay modes performed at KEK on ${}^{28}_{\Lambda}Si$ and ${}^{12}_{\Lambda}C$ give results close to 1 or greater, while theoretical calculations, imposing the $\Delta I = 1/2$ rule, predict values well below unity. Precise measurements of the relative branching ratios of the non-mesonic decays could therefore provide new information about the relative importance of the $\Delta I = 1/2$ and $\Delta I = 3/2$ amplitudes of the weak Hamiltonian.

Charged particles emitted following hypernucleus production and/or decay are detected in the FINUDA cylindrical magnetic volume (1.1 T, 1 m radius, 2 m length) by four different detectors, each one optimized for a different task. Silicon microstrips detect the hypernuclear vertex, drift chambers and straw tubes reconstruct charged-particle trajectories, and plastic scintillators produce the trigger signal and detect neutrons.

Each element of the FINUDA apparatus is a small gem of mechanics and electronics. As low-energy particles are involved, only light materials have been used for the construction to minimize disturbance of the particle properties. For the same reasons, the whole detector is embedded in a helium atmosphere. In fact, if air is left inside the apparatus, the momentum resolution $\Delta p/p$ would be worsened from 0.3% to 1.5%. A momentum resolution of 0.3% will provide an energy resolution for hypernuclear levels of about 750 keV/c^2, the best ever achieved with a magnetic spectrometer.

The design, assembly and installation of the FINUDA detector, which began in 1997, has involved around 50 physicists, mainly Italians, together with a dozen engineers and technicians. This January the detector rolled into the DAFNE beamline, and data collection will begin soon. This year's data-taking will be performed with the following target set: two ^{6}Li, one ^{7}Li, three ^{12}C, one ^{27}Al and one ^{58}V. Three targets of carbon are necessary to produce $^{12}_{\Lambda}$C, the most studied hypernucleus, in order to calibrate the spectrometer and measure, with high statistics, the non-mesonic decay channels. With 250 pb^{-1}, the non-mesonic decays ($\Lambda + p \rightarrow p + n$; $\Lambda + n \rightarrow n + n$) will be measured with a statistical accuracy better than 10%, a world record for this kind of measurement. On the other hand, with ^{6}Li targets, some light hypernuclear systems ($^{6}_{\Lambda}$He, $^{5}_{\Lambda}$He, $^{4}_{\Lambda}$He, $^{4}_{\Lambda}$H) will be produced and studied, while heavier targets have been chosen to start a complete survey of hypernuclei with different atomic numbers.

Marian Danysz (left) and Jerzy Pniewski, who first observed a hypernucleus.

Despite its age, hypernuclear physics is seeing a renaissance. Large new projects are planned or are starting at the Jefferson Laboratory in the US, the Japanese Hadron Facility at Tokai, and the new European Hadron Facility under study at GSI. In all of these laboratories, which exploit different production techniques, hypernuclei will be used to shed new light on the non-perturbative QCD sector and on fundamental symmetries in the low-energy domain. To fulfil this programme, detailed spectroscopic studies will be performed on hypernuclei with single or even multiple strangeness content, together with high-resolution researches on spin observables of the ΛN potential. FINUDA, with its present programme, and with future upgrades oriented towards γ-ray hypernuclear spectroscopy, is the first step into this new era.

Paola Gianotti, *INFN Frascati.*

The eventful story of charmonium singlet states

The search for spin zero, odd parity states of charmonium has in the past led to strange and contrary results, but the picture is now becoming clearer.

The discovery of the J/Ψ particle in November 1974 by the teams led by Burton Richter at SLAC and Sam Ting at Brookhaven came as a great surprise. However, after a period of uncertainty, ended by the discovery of the Ψ′ at SLAC, the J/Ψ was identified as a bound state of a charm quark and an antiquark, $c\text{-}\bar{c}$, which had been explicitly predicted in 1970 by Sheldon Glashow, John Illiopoulos and Luciano Maiani. In the J/Ψ and the Ψ′, the spins of the c and $c\bar{c}$ are parallel and form a triplet state (spin 1) associated with a space wave function of orbital momentum l=0. However, as in positronium (e^+e^-), there also exist singlet states in which the spins are antiparallel, with orbital angular momentum l=0 or $l \geq 1$, as shown in figure 1.

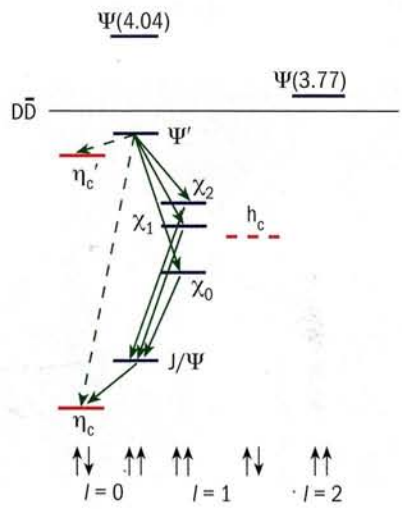


Fig. 1. Low-lying states of charmonium, with some radiative transitions.

The story of the experimental search for the l=0 singlet states and the efforts of theoreticians to explain the successive and contradictory experimental results, is an interesting one. The table on page 18 summarises the history of the ground and first excited singlet states, η_c and η_c' (or $\eta_c(2S)$). Δm and $\Delta m'$ give the hyperfine splittings, or in other words, the mass differences between these singlet states and the related triplet states.

In the late 1970s, experiments found Δm, the mass difference between the η_c and the J/Ψ, to be about 300 MeV (Braunschweig *et al.* 1977, Apel *et al.* 1978). However, this result was difficult to swallow for two reasons. First, naive estimates of the hyperfine splitting give much smaller values, and second, the radiative decay width $J/\Psi \rightarrow \eta_c + \gamma$ is proportional to Δm^3, so any theory correctly predicting Δm ~300 MeV would overestimate this width. This is why most theoreticians were extremely sceptical about the result from the DASP experiment (Braunschweig *et al.* 1977). Fortunately, the Mark II and Crystal Ball groups found in $J/\Psi \rightarrow \eta_c + \gamma$ what we believe is the true η_c, with a splitting of Δm = 119 MeV (Himel *et al.* 1980, Partridge *et al.* 1980).

A little later, the Crystal Ball group also found a candidate for the η_c', again by radiative decay, but from the Ψ′ (Edwards *et al.* 1982). The $\Delta m' \cong 90$ MeV splitting they found is acceptable – for instance Wilfried Buchmuller, Yee Jack Ng and Henry Tye found 80±10 MeV in a QCD-inspired calculation (Buchmuller, Ng and Tye 1981). However, the ratio $\Delta m'/\Delta m$ seems difficult to accept. First, a naive estimate using a Fermi-like hyperfine interaction suggests that $\Delta m'/\Delta m$ is related to the ratio of the leptonic widths of the Ψ′ and J/Ψ. This gives $\Delta m'/\Delta m \cong 0.6 \pm 0.1$, which is hardly consistent with the Crystal Ball result. In addition, there are effects due to the coupling of the $c\bar{c}$ bound states to the charm–anticharm meson pairs, $D^{(*)}\bar{D}^{(*)}$, as we pointed out in 1981. The coupling to the very close $D\bar{D}$ threshold is allowed for a vector state, so this should make the Ψ′ lower than predicted by naive potential–model calculations. The pseudoscalar η_c, on the other hand, does not couple to $D\bar{D}$ and so is shifted much less. Using the Cornell model (Eichten *et al.* 1978, 1980), we found that this effect reduces $\Delta m'$ by at least 20 MeV.

The puzzling Crystal Ball result on η_c' was never confirmed. Searches for the η_c' in formation experiments in proton–antiproton collisions, first at the ISR and then at the Fermilab accumulator, were unsuccessful. This may be because these experiments had too high a resolution in energy, and perhaps because of prejudice that the η_c' would not be too close to the Ψ′. The coupling of the η_c' to proton–antiproton might also be less favourable than for η_c. Meanwhile the η_c was seen at LEP, in its $\gamma\gamma$ decay mode, but no signal was found for the η_c'.

Charmonium can also be investigated through B decay, as proposed by several authors (e.g. Eichten *et al.* 2002). The Belle experiment at KEK, whose primary purpose is to study the CP violation in B decays, has seen both the η_c and η_c' in two distinct channels, which we can call Belle I and Belle II. The BaBar experiment at SLAC should also produce similar results.

In Belle I, the decays $B \rightarrow K\eta_c(\eta_c') \rightarrow KK_SK^-\pi^+$ reveal two main peaks, as in figure 2 (Choi *et al.* 2002). The first is clearly the η_c, while the second is most likely the η_c', as the background from $B \rightarrow K + J/\Psi$ or $K + \Psi'$ is expected to be rather small. This implies that $m(\eta_c')$ = 3654±6 MeV, i.e. $\Delta m'$ = 32±6 MeV, which is much smaller than the Crystal Ball-obtained value, and even smaller than we expected from the effect of the coupling to charm–anticharm channels.

In Belle II, the reaction studied is $e^+e^- \rightarrow J/\Psi + c\bar{c}$, i.e. double ▷

A summary of the η_c and η_c' results (masses are given in MeV).

Year	η_c	Δm	η_c'	$\Delta m'$	Source
1976–1978	2830	267	3460	426	DASP Braunschweig 1977; Serpukov Apel 1978
1980–1982	2980±9	117±9	3594±5	92±5	MARK II Himel 1980; Crystal Ball Partridge 1980; Edwards 1982
1987	2982.6±2.5	114±2.6	not seen		R704 ISR Baglin 1987
1992–1999	2985.4±2.1	112±2.1	not seen		E760-835; Ambrogiani 2001; Patrignani 2001
1990s	~2980	~117	not seen		LEP
2000	~2976±3	121±3	not seen		BES Bai 2000
2002	2979±2	118±2	3654±6	32±6	Belle Choi 2002
2002	2962±12	135±12	3622±12	64±12	Belle Abe 2002
2002	2980±2	117±2	not established		Particle Data Group

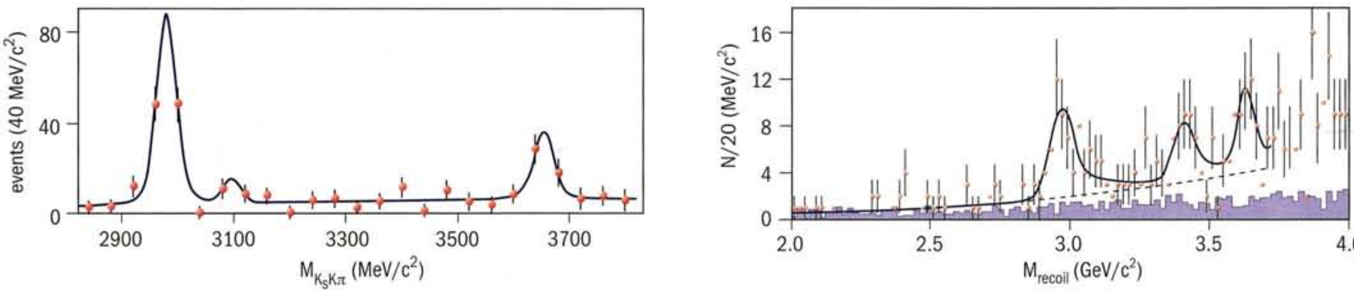


Fig. 2. Graphs showing mass spectra in the Belle experiment from B decay (left) and double charm production (right).

$c\bar{c}$ production with one pair constrained to match the J/Ψ (Abe *et al.* 2002). The recoil spectrum against the J/Ψ gives a set of $c\bar{c}$ bound states. If the process takes place via e^+e^- annihilating into one photon, charge conjugation conservation strictly forbids J/Ψ and Ψ', and three peaks corresponding to η_c, χ_0 and η_c' can be seen (figure 2). This time $\Delta m'$ is somewhat higher, about 60 MeV, which is more consistent with our 1981 expectation. On the other hand, the η_c is shifted with respect to the standard value of the Particle Data Group. The imperfect agreement between Belle I and Belle II will hopefully disappear in the final analysis and in particular it should be decided whether or not a background $B \rightarrow \Psi' + K$ or (unlikely) $e^+e^- \rightarrow J/\Psi + \Psi'$ contributes to the observed spectrum. In any case, we are very close to the complete clarification of the η_c', with a mass much closer to the Ψ' than was indicated by the Crystal Ball group.

Theory also predicts a $c\bar{c}$ singlet P-state called h_c. Paradoxically, the corresponding state in positronium has only been observed relatively recently (Conti *et al.* 1993). First indications for h_c came from the R704 experiment at the ISR, in which a cooled antiproton beam collided with a gas jet target (Baglin *et al.* 1986). This was at the time when the ISR was to be stopped and dismantled. At the request of one of us (A M), a few extra days running were granted by the director-general, Herwig Schopper, but no firm conclusion could be reached. Years later a similar experiment, E760, was carried out at Fermilab and gave strong indications of the h_c at the same mass that happens to agree with the most naive prediction, i.e. the weighted average of the triplet P-state masses (Armstrong *et al.* 1992). However, these indications have disappeared in the latest experiment, E835 (Patrignani *et al.* 2001). Assuming that E760 was right, it is tempting to wonder if the same scenario will not repeat itself with the Higgs search: indication in the last runs of LEP of a Higgs at 115 GeV, which might be right and so be definitely seen years later with the LHC.

Further reading

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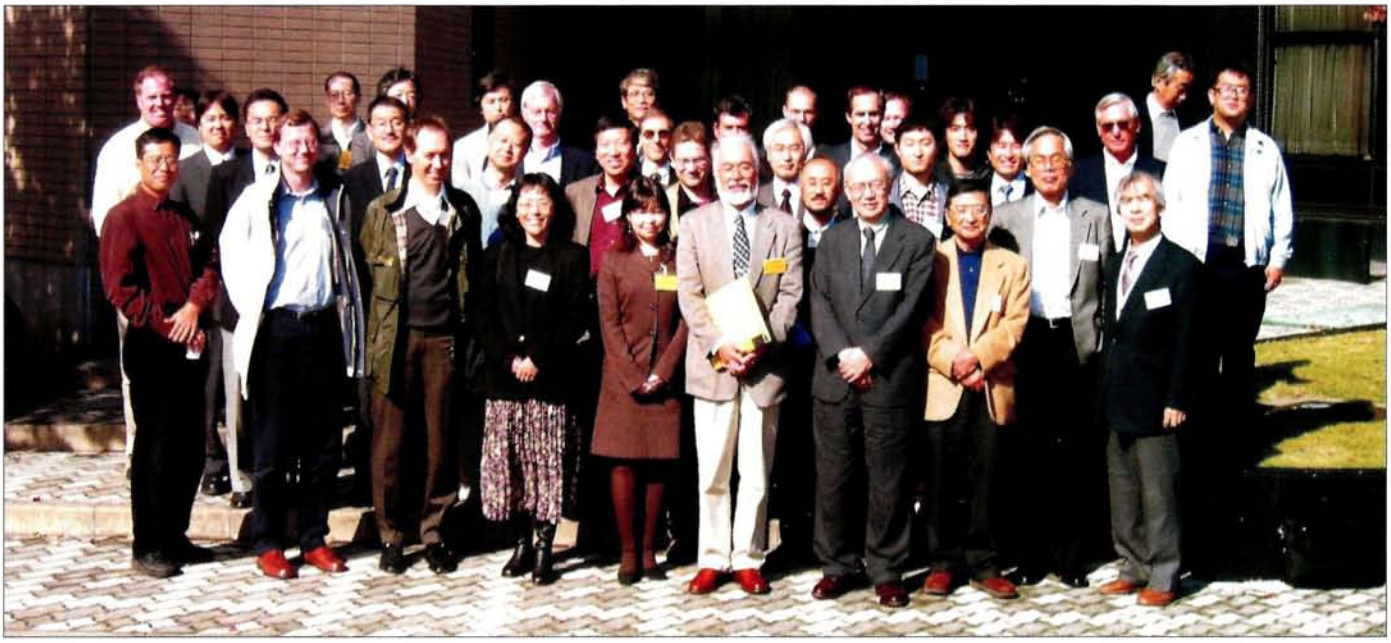
André Martin, *CERN and* **Jean-Marc Richard**, *Institut des Sciences Nucléaires – CNRS-IN2P3 Université Joseph Fourier, Grenoble.*

Induction acceleration looks to the future

It was a milestone event in the history of induction accelerators when more than 55 experts assembled at KEK in October 2002 for an international workshop on Recent Progress in Induction Accelerators – RPIA2002.



The participants of the Recent Progress in Induction Accelerators Workshop, which was held at KEK on 29–31 October 2002.

They came from 15 different institutes and three private companies. Their purpose: to discuss recent progress in induction accelerators and the key technologies that are common to the different communities of heavy-ion inertial fusion and high-energy accelerators. The workshop focused on four topics:

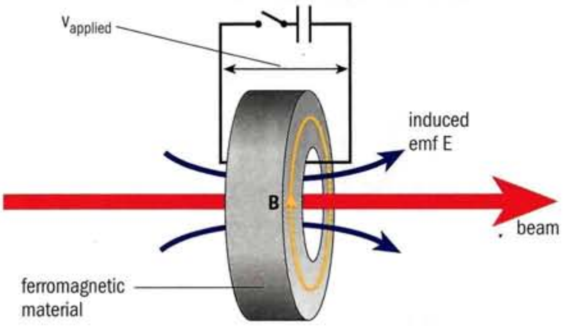
- A review of developments in induction acceleration since the first demonstration by Nicholas Christofilos, applications, and up-to-date activities in energy research and high-energy physics.
- New concepts and ideas using induction acceleration.
- Key technologies, such as magnetic materials and solid-state modulators, which are indispensable for the realization of high-gradient accelerating fields and low-loss, high rep-rate operation.
- Beam dynamics specific to extremely high-intensity beam linacs, circular induction accelerators and hadron colliders employing a so-called super-bunch.

In his welcome address, Hirotaka Sugawara, director-general of KEK, stressed the importance of investment in accelerator R&D when he talked of the recent activities of ICFA as well as the status of ongoing and future projects at KEK.

The review of the history of induction accelerators ranged from the late 1960s with the first machine, ASTRON, to the recent Advanced Test Accelerator and Experimental Test Accelerator at the Lawrence Livermore National Laboratory (LLNL). A large variety of applications were also reviewed, from early applications to electron ring acceleration and high-power microwave generation. More recently, electron induction linacs have successfully demonstrated their capability as high-intensity electron beam drivers for free-electron lasers (at LLNL, KEK, the Japan Atomic Energy Research Institute (JAERI) and CESTA in France), as a relativistic klystron at LLNL/LBNL, and as a backward wave oscillator at JAERI.

The Virtual National Laboratory (VNL) in the US has recently focused on R&D work for a heavy-ion inertial fusion driver, using 4 GeV bismuth beams, with a 2 kA/beam and a 10 ns pulse length. The workshop heard about the US Heavy Ion Fusion Accelerator Program, ▷

How does it work?



The basic principles of induction acceleration. Courtesy of the Virtual National Laboratory for Heavy-Ion Fusion, see http://hif.lbl.gov/tutorial/tutorial.html.

In an induction accelerator, a changing magnetic field produces the electric field that accelerates beam particles. A pulsed voltage causes a magnetic field to build around a ferromagnetic ring, known as a core. The change in magnetic flux around the core induces an electric field along its axis, according to Faraday's law. The voltage pulse is timed so that the electric field is present when beam particles pass through the core. Induction accelerators can handle very large currents (up to 10 kA) but generate much lower voltages than typical RF accelerators.

So far, induction accelerators have demonstrated particular advantages in low-energy, high-current applications. However, recent developments in core materials and pulse modulators offer the promise of a wider variety of applications.

which is concentrating on three areas: source/injector development, low energy transport, and neutralization in ballistic focusing. The goals and key issues of an Integrated Beam Experiment, which is planned to verify the concept, were also discussed. A complementary simulation study at Tokyo Institute of Technology has shown that halo formation during the last bunch-compression stage is a big concern. Details of the solid-state power modulator (1 MHz burst frequency), developed for precise waveform control in this programme, were presented at the workshop and extensive results from measurements on the magnetic properties of possible core materials were reported. The latter will serve as a database for future applications.

In X-ray radiography the DARHT-2 accelerator (20 MeV, 2 kA, 2 μs duration) at LLNL has succeeded the earlier generation of electron induction linacs. A novel technology for a high-frequency induction kicker system was reported and the importance of beam–plasma interactions near an X-ray target was discussed – both topics are of particular importance in X-ray radiography.

Moving on from linear machines, the concept of an induction synchrotron – a circular induction accelerator proposed by Ken Takayama and Junichi Kishiro in 1999 – was discussed. By using super-bunches, such a machine is capable of accelerating a beam of two to four times higher intensity than in a conventional RF synchrotron. An outline of the POP experiment in the KEK 12 GeV PS was given. In addition, the current status of R&D work on the 1 MHz rep-rate modulator and 2.5 kV/unit accelerating cavity for the POP experiment were reported.

The concept of a super-bunch hadron collider is regarded as a natural extension to the concept of an induction synchrotron and is expected to provide a luminosity 10 times higher. A typical example was reviewed and specific beam physics issues, such as parasitic beam–beam effects in the super-bunch collisions and the head–tail instability of a super-bunch, were discussed. A super-bunch option for the LHC upgrade plans triggered some interesting arguments at the workshop, where the figure of merit for employing a super-bunch was extensively discussed. Regarding barrier bucket beam handling, which should play a crucial role in super-bunch acceleration, an experimental result using an RF barrier bucket in the Fermilab Recycler Ring and a novel stacking technique were reported.

Four hot topics in current high-energy physics experiments were presented at the workshop: Tevatron Run II, K2K, MiniBoone and NuMI/MINOS, and the LHC. It was stated that most current hadron collider detector components could not survive a 10-fold increase in luminosity, so the possibility of such high luminosity is now challenging experimentalists. In the meantime, an increase of a factor of three to four in beam intensity should have a big impact on future neutrino oscillation experiments.

Details of a newly developed magnetic material, FINEMET, which is regarded as one of the core materials suitable for an induction accelerating device, were reported by the manufacturer, who pointed out its relatively large swing width, low core-loss, high Curie temperature and small dependence of μQf on flux density. Various applications using FINEMET include an induction cavity, a high-gradient and low-Q RF cavity (magnetic alloy loaded cavity), and an accelerating device for a beam chopper. The characteristics and basic performance of the semi-conducting switching elements of the MOSFET and the Static Induction (SI) Thyristor were also reviewed, together with the capability and future of the SiC-MOSFET, which is under development and promises a high breakdown voltage and lower on-resistance. It was reported that a solid-state power modulator is reliable in many applications, including a fast kicker pulser for an electron induction accelerator (MOSFET, ±18 kV, 10 ns rise/fall times, 16–200 ns pulse widths, multi-pulse burst) or for proton/electron ring accelerators (50 kV, 5 MHz burst, 73 ns flat-top), and a klystron modulator for the Next Linear Collider (IGBT, 500 kV, 3 μs, 120 Hz), KEKB injector (SI Thyristor, 45 kV, 6 μs, 50 Hz) or the Japan Linear Collider (IGBT, 500 kV, 1.6 μs, 150 Hz).

Overall the discussions on modern induction accelerators revealed two distinct trends: high-gradient and low rep-rate induction acceleration, and low-gradient and high rep-rate induction acceleration. The former is used in heavy-ion inertial fusion drivers, while the latter should be indispensable in a circular machine such as an induction synchrotron or super-bunch hadron collider. Because devices independently developed in the two different communities are based on common technologies, the mutual exchange of information will become more and more important if each community is to realize its dreams.

Further reading

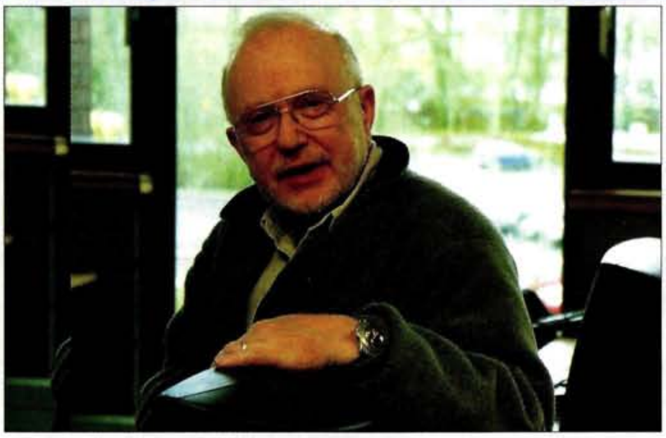
Details of the workshop are at http://conference.kek.jp/RPIA2002.

Ken Takayama, *KEK.*

Ireland invests in a scientific future

The Irish government is investing in a new initiative to encourage leading scientists and engineers to move to Ireland. **William Harris**, director-general of Science Foundation Ireland, explains.

The SFI research fellow



"The SFI grant is essential to my work. Without it I would not have brought my research effort to Ireland. It makes it possible for me to develop a professional staff that will add continuity to my work. Hitherto, I worked only with graduate students – each of whom worked on a small piece of the pie. The result was a lot of 'crumbs', each of which was good, but which do not fit together in a coherent whole. SFI has provided me with the resources to do the job right."

David Parnas is an SFI research fellow on a five-year fellowship investigating mathematical foundations, practical notations, and tools for reliable flexible systems in computing. He will receive funding of €6.3 million over five years. He has relocated from McMaster University, Canada, to the University of Limerick.

In 1938, the prime minister of Ireland, Eamon de Valera, invited Erwin Schrödinger to join the newly established Institute for Advanced Studies in Dublin. Today, the Irish government is echoing this lead with a new initiative. In February 2000, following an investigation by the Irish Technology Foresight panel into the issues pertaining to basic research in Ireland, the Irish government established Science Foundation Ireland (SFI). Its remit is to attract world-class research scientists and engineers in information and communications technology (ICT) and biotechnology to academic appointments in Ireland. Under the Irish National Development Plan 2000–2006, SFI was allocated €646 million. It has been charged with investing this money in individuals who are most likely to generate new knowledge, leading-edge technologies and competitive enterprises. The intention is that SFI will help Ireland to diversify, and its economy to grow, by recruiting and retaining creative individuals with advanced research experience in areas that are critical to the development of a knowledge-based economy. By the end of 2002, SFI had committed approximately €152 million to projects and teams working in these areas.

SFI recognizes that the future competitiveness of the Irish economy will be increasingly based on the quality of the intellectual capital available to stimulate innovation, excellence and entrepreneurship. Therefore, its aim is to use the resulting capability to create a reservoir of ideas, skills and talent that will profit Ireland in the future. To meet this goal, SFI is working in partnership with all tertiary educational institutions in Ireland, both to raise the quality of research and to increase the amount carried out. The best way to achieve this is by investing in creative and successful teacher-scholars who are in these institutions, and who have been selected on a competitive basis. The focus is on enhancing Ireland's strengths in the fields that underpin biotechnology and ICT, as these fields currently promise more than others to drive scientific and economic advancement in the decades ahead.

About SFI's programmes

Since its establishment, SFI has developed five flexible programmes for making its grants and awards. SFI Fellow Awards are five-year awards to attract senior, distinguished researchers to Ireland in the fields underpinning biotechnology and ICT; the grants are normally up to €1 million or more per year. Investigator Programme Grants are four-year awards to recruit leading researchers in the science and engineering sectors that underpin biotechnology and ICT. These grants can be as large as fellowships, but are usually between €100 000 and €250 000 per year. Centres for Science, Engineering and Technology Grants – Campus–Industry Partnership (CSET) – have been established to fund researchers who will build collaborative efforts that develop internationally competitive research programmes together with researchers from industry. Such grants can be valued at up to €5 million per year initially, for up to five years, and they are to support research partnerships linking scientists, engineers and industry. E T S Walton Visitor Awards (named after Ireland's Nobel prize winning accelerator pioneer) have been insti- ▷

The nanotechnology researcher

"Bringing a research project to Ireland presents some unique challenges...It is the exciting possibility of being involved in developing these opportunities that had the biggest influence on my decision to bring my research here".

Suzi Jarvis is a physicist working on nanotechnology research at Trinity College Dublin. She left the National Institute of Advanced Science and Technology in Japan to move to Ireland because of the new funding opportunities available from SFI.

tuted with the aim of bringing international researchers to Ireland for periods of up to one year. These grants usually total €200 000 per year, including salary, laboratory and moving expenses. SFI Workshop and Conference Grants are set up to support events either sponsored by or involving Irish scientists and research bodies that reach an international scientific audience.

SFI has initially concentrated on assessing research activities within Ireland's R&D community, and establishing and completing the funding for a core set of internationally competitive research programmes. Grants and awards to successful researchers are made after a process of international peer review of research proposals by distinguished scientists and engineers. The reviewers apply the criteria approved by SFI's board – namely, quality of the idea, quality of the recent track record of the researcher, and strategic relevance of the research.

In summary, SFI is seeking to support the continued growth and development of a thriving research base from which the country can benefit. Its aim is to support innovative and creative individuals in carrying out their work in Ireland, and we look forward to making additional investments in researchers in both ICT and biotechnology, using our grants and awards programmes.

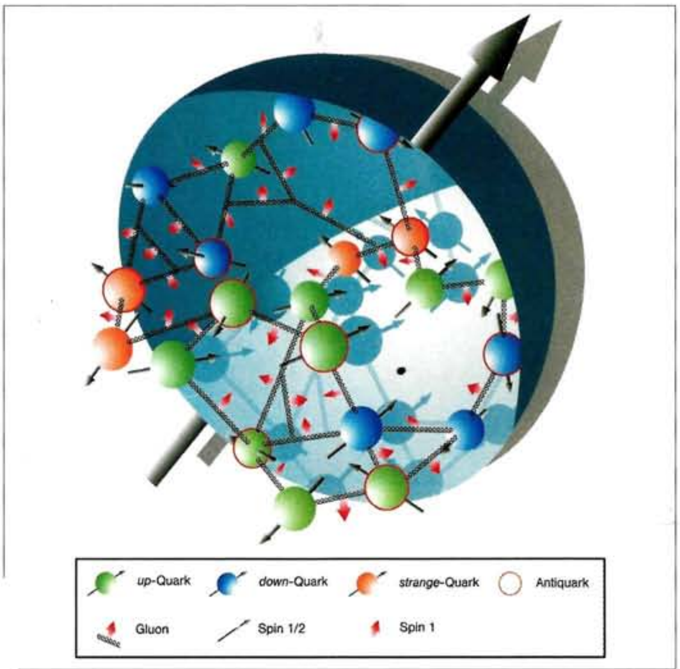
Further reading

SFI issues calls for proposals at intervals throughout the year. Interested parties can subscribe on the SFI website at www.sfi.ie for e-mail alerts when calls for proposals are made. For further information, e-mail info@sfi.ie.

William C Harris, *director-general, SFI.*

The continuing challenge o

Thirty years after quantum chromodynamics was invented, tackling its difficulties continues to fascinate a host of theorists – and often proves a necessity for unravelling the limits of the Standard Model – as the 2002 DESY Theory Workshop revealed.



he host of quarks, antiquarks and gluons inside a proton all ave intrinsic spin, but their constant movement also creates rbital angular momentum. Understanding how these ıdividual angular momenta together yield the total spin of the proton is still proving to be a challenge. (DESY Hamburg.)

Quantum chromodynamics (QCD), the theory of the strong force, is a marvellous example of how the physical laws that describe a large variety of complex phenomena can be condensed into a very simple and elegant mathematical structure, known as non-abelian gauge theory. The fundamental equations can be written down in a single line, yet they describe how the nucleons acquire their masses from "nothing", or how two nucleons smashed together at high energies disintegrate into dozens of new particles bundled into "jets" – the visible manifestations of the quarks and gluons. The fundamental equations are extremely hard to solve. At higher energies where the strong force weakens, the equations may be expanded in a perturbation series, where each new term demands more sophisticated analytical or numerical methods of computation. At energies of the order of the proton mass, the equations can only be solved by large-scale computers.

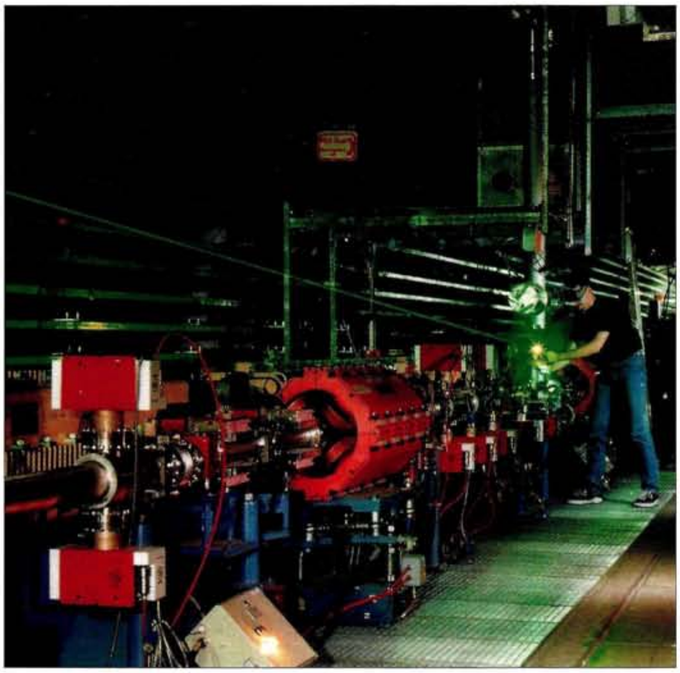
From September 24–27, 2002, approximately 130 high-energy physicists gathered in Hamburg at the annual DESY Theory Workshop to discuss their recent advances in the development of computational methods, and their successes (and sometimes failures) in comparing their calculations with experiments that continue to become more precise or to explore new phenomena. As emphasized by many talks at the workshop, these efforts go far beyond understanding how hadronic phenomena work. As the high-energy community gathers its resources to attack the fortress of the Standard Model, which has stood unconquered for the past 30 years, the strong interaction is a faithful, though not always loved, companion. Whether protons collide at the LHC to produce perhaps the Higgs boson or new particles, whether B mesons decay at SLAC and KEK to reveal the subtle asymmetry of matter and anti-matter, or whether the anomalous magnetic moment of the muon is measured to a part in a billion, an accurate computation of strong interaction effects will be required to ascertain finally a failure of the Standard Model.

Inside the proton

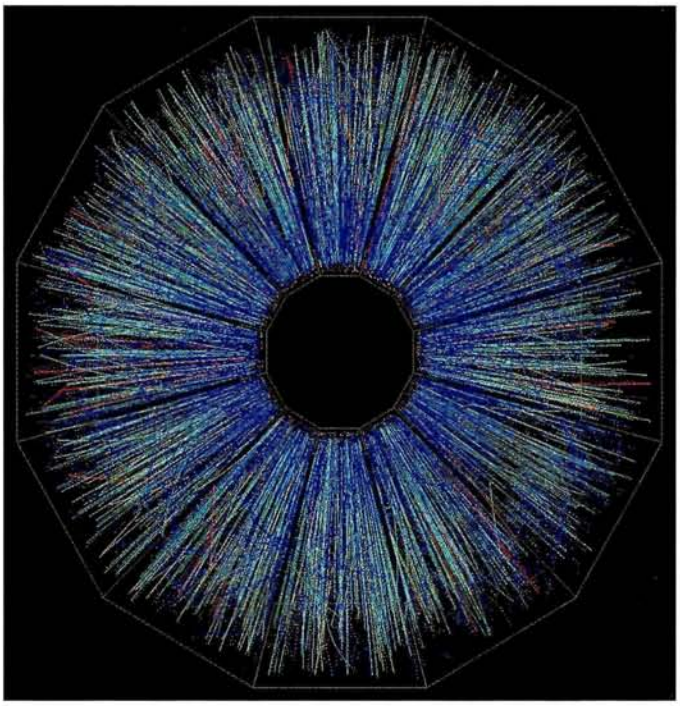
What is a proton? The answer is more difficult than just "three quarks". In high-energy collisions the proton appears as a bunch of quarks and gluons collectively called partons. The (longitudinal) momentum distributions of these partons are fundamental input to the computation of any proton collision. James Stirling of Durham reviewed the current knowledge of parton distributions and concluded that the global fit is satisfactory. Methods are now being developed to assign reliable errors to these functions, which may soon be known with higher ("next-to-next-to-leading order") theoretical accuracy. Closely related to the conventional parton distributions are the diffractive parton distributions, which give the probability of finding a parton in the proton under the additional condition that the proton stays intact in the collision. One of the surprising results of DESY's HERA experiments is that this probability remains large, even at the highest momentum transfers. The physical interpretation of this was provided by John Collins of Penn State, who also emphasized that models of soft interactions in diffractive scattering should be taken as models for the corresponding parton distributions.

At high collision energies the number of partons with small momentum fraction x of the proton increases rapidly and the conventional, perturbative equations should break down. They should be replaced by an equation that sums logarithms in x, known as the BFKL equation. In the leading approximation, the solution to the BFKL equation overestimates the growth of high-energy cross sections. Victor Fadin of Novosibirsk discussed the progress made towards a next-to-leading approximation. With many parts now being

f quantum chromodynamics



Polarized electrons from HERA are used by the HERMES experiment to study the different contributions to the spin of the proton. During HERA operation, the green laser beam is directed inside the beam pipe against the electron beam, to observe to what extent the electrons are polarized. (DESY Hamburg.)



Heavy-ion collisions at RHIC – such as this event in the STAR detector – are providing a window into nuclear matter under extreme conditions of temperature and density. (Brookhaven National Laboratory.)

completed, the calculation of the so-called photon impact factor is required before a comparison with experiments can be attempted. Whatever the result, at very small momentum fraction the growth of parton densities must stop. As explained by Alfred Mueller of Columbia, this occurs for quarks because the Pauli principle limits the number of fermions per phase space cell. For gluons, however, "saturation" already occurs classically when the density of gluons is so high that their combined field strength is non-perturbatively large. Mueller discussed the applicability of a classical description and estimates of the saturation scale during various stages of the collision process under the conditions at HERA and at Brookhaven's RHIC collider.

The experimental verification of these phenomena at HERA remains ambiguous, according to Brian Foster of Bristol. He also showed an impressive amount of jet data – all in agreement with QCD computations – and demonstrated that the strong coupling constant can now be determined from electron–proton collisions with high accuracy. The HERA collider has become a veritable QCD factory, providing data over many orders of magnitude in momentum transfers and for many final states that probe different aspects of the strong interaction. Understanding the transition to soft, non-perturbative physics remains one of the most difficult challenges. This transition appears to be surprisingly smooth. Hans-Günther Dosch of Heidelberg showed that a simple model which views the QCD vacuum as an ensemble of Gaussian gauge field fluctuations, allows many features of soft hadronic interactions at high energy to be related to properties of the QCD vacuum.

The spin of the proton is 1/2, but how is it distributed over the various partons? A decade ago the "spin crisis" was proclaimed, after it was observed that the quarks carry only a fraction of the total spin. The talks by Elke-Caroline Aschenauer of DESY and Daniel Boer of Amsterdam highlighted that experimentalists and theorists still struggle to account for the remainder. For example, the gluon's contribution to the spin remains largely unknown and its direct determination requires less inclusive measurements than polarised deep-inelastic scattering. Getting hold of orbital angular momentum is even harder and demands the introduction of new theoretical concepts ("generalized parton distributions"), which can be constrained by observing Compton scattering of virtual photons off protons.

Lattice calculations

Perturbative approximations are not adequate for *ab initio* calculations of hadron masses or, more generally, hadronic matrix elements, which are governed by strong-coupling physics. In these cases numerical simulation of QCD on a discrete space–time lattice provides ▷

the only systematic approach. Lattice QCD benefits greatly from the increasing speed of computers, where the scale of machines is currently set by TeraFlops (10^{12} operations per second). However, as emphasized by several speakers at this workshop, conceptual progress and the improvement of simulation algorithms play at least an equally important role.

As emphasized by many talks at the workshop, efforts now in QCD go far beyond understanding how hadronic phenomena work.

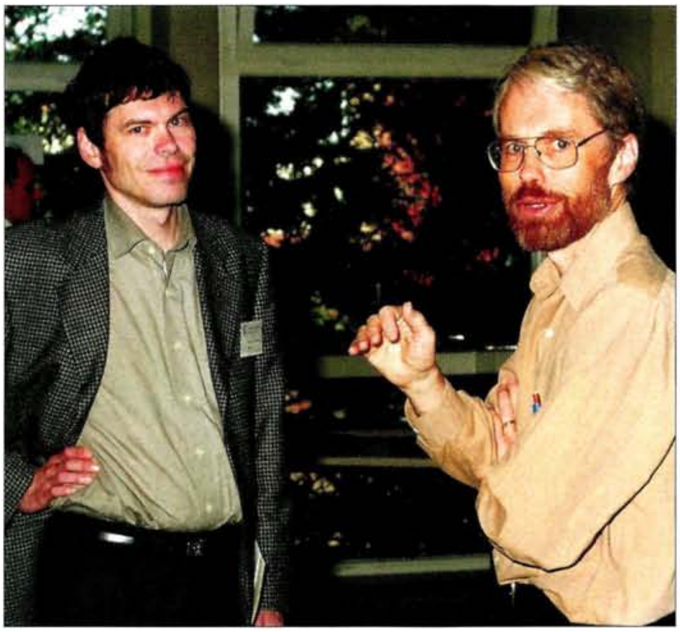
Most calculations are still performed with a truncated version of QCD, which neglects quark–antiquark quantum fluctuations. Allowing quarks to fluctuate is costly, as discussed by Sinya Aoki of Tsukuba, and forces the use of smaller, coarser space–time lattices. Aoki showed that the computed hadron spectrum is in much better agreement with observations for dynamical quarks, but pointed to the need for better algorithms that would allow the simulation of light quarks with masses closer to their real values.

A different avenue was pursued by Hartmut Wittig of DESY, who reviewed the various methods to put massless (but still non-dynamical) quarks on the lattice. This became a real possibility a few years ago when it was discovered that QCD at finite lattice spacing has an exact symmetry that approaches the conventional chiral symmetry in the continuum limit. Wittig showed that the efforts to put this into practice are now bearing fruit for quantities such as the strange quark mass or the quark condensate, where the chiral behaviour is particularly important. Chiral symmetry is also important for kaon physics, where results from lattice calculations have a large impact on the interpretation of direct and indirect CP-violating effects. Indirect CP violation in kaon decay to two pions poses a particular challenge to lattice theorists, since the relevant matrix elements include final state interactions. Chris Sachrajda of Southampton described new ideas to extract these matrix elements by exploiting the finite size of the lattice.

Another impressive demonstration of progress in lattice gauge theory was given by Martin Lüscher of CERN. Using a new algorithm that allows the computation of large Wilson loops, he showed that the large-distance behaviour is consistent with the assumption that the low energy limit of SU(N) gauge theory is a bosonic string theory. Moreover, the perturbative regime joins smoothly to the string regime at a distance of about 0.5 fm.

Heavy quarks

Charm and bottom quarks are produced in large numbers at today's high-energy colliders. The theory of single-inclusive heavy meson production and of quarkonium production was reviewed by Bernd Kniehl of Hamburg, who described the efforts to treat heavy quark mass effects correctly at all energy scales. He also concluded that, with the exception of polarisation measurements, the non-relativistic factorization approach to quarkonium production appears to be supported by existing data. A particularly interesting quarkonium system consists of a top–antitop pair. Although this system decays after little more than 10^{-25} s, the strong Coulomb force the quarks exert on



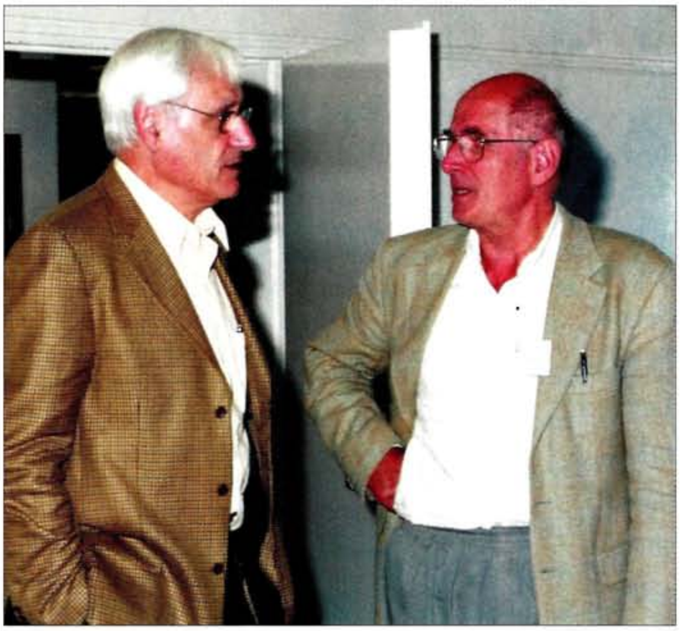
Bernd Kniehl and John Collins.

each other leaves a visible enhancement in the energy dependence of the production cross section. This can be used (at an electron–positron collider) to determine the top quark mass to an accuracy of less than a permille. Thomas Teubner of CERN showed that many of the theoretical difficulties involved in the calculation of the threshold cross section have now been solved with non-relativistic effective field theory. Very similar calculations also determine the bottom and charm quark mass from quarkonium systems.

A complementary method uses inclusive heavy quark production in e^+e^- collisions far above the production threshold. The corresponding hadronic spectral functions also provide an indispensable source of information for other fundamental constants, such as the strong coupling, the hadronic contribution to the electromagnetic coupling (at the scale of the Z mass) or the anomalous magnetic moment of the muon. The accuracy needed for these quantities is reflected in the development of sophisticated symbolic manipulation programs, which enable the computation of thousands of multi-loop Feynman diagrams. Matthias Steinhauser of Hamburg discussed recent advances, particularly in including quark mass effects and their impact on precision determinations of the coupling constants. Similar methods of algebraic reduction of Feynman integrals are now also being applied for jet physics, where many further difficulties come from the more complicated kinematics. The new frontier, stated Nigel Glover of Durham, is set by next-to-next-to-leading order calculations. He explained that while all the two-loop virtual effects are now completed, the construction of a usable Monte Carlo program that combines them with bremsstrahlung effects will probably require another few years of hard work.

QCD and the Standard Model

Many processes that would otherwise provide clean probes of fundamental interactions are ultimately sensitive to QCD through quantum fluctuations. One particularly well known example is the flavour-changing neutral current process $B \rightarrow X_s\gamma$, reviewed by


Eduardo de Rafael and Hans-Günther Dosch.

Mikolaj Misiak of Warsaw, where strong interaction effects double the predicted branching fraction. Experiment and theory currently agree, but to what precision can one compute strong interaction effects? Misiak explained how quark mass renormalization prescriptions influence the prediction, but concluded that the dominant uncertainties can still be reduced by perturbative calculations. They would however be very difficult. The discussion was continued with a review of exclusive heavy meson decays, where the problem of hadronization is even more direct. Understanding decays such as $B \rightarrow \pi\pi$, which can now be studied in detail at the B factories, is crucial in order to ascertain the (in)consistency of the Kobayashi–Maskawa mechanism for CP violation in the quark sector. Gerhard Buchalla of Munich reported progress in applying QCD factorization methods to exclusive B decays, which have led to new insights into dynamical details of these reactions.

The anomalous magnetic moment of the muon has remained a hot topic since the announcement of the result by Brookhaven in 2001 (*CERN Courier* April 2001 p4 and September 2002 p8). The experimental value, precise to 0.7 ppm, is not quite in agreement with the theoretical result, but whether the discrepancy is the first signal of a breakdown of the Standard Model is a matter of debate. The blame could once more be on the strong interaction. The current status of theoretical calculations was presented by Eduardo de Rafael of Marseille and Fred Jegerlehner of DESY. A controversy on the sign of the so-called light-by-light scattering contribution, a tiny but relevant quantum effect has now been settled, bringing the prediction in better agreement with the data. However, the size of the effect itself remains quite uncertain. Another important development concerns hadronic photon vacuum polarisation effects, which must be determined from low-energy data, in particular around the ρ meson resonance. This year has seen new results from CMD-2 and from an analysis of τ-decays at LEP. Unfortunately, the two do not agree, the difference being more than twice the estimated error. Depending on the input, the theoretical muon anomalous magnetic moment is now 1 to 3 standard deviations smaller than Brookhaven's experimental result.

QCD also matters in the production of new particles, foremost the Higgs boson. Michael Krämer of Edinburgh reviewed higher order calculations of Higgs, Higgs with top–antitop, and supersymmetric particle production. All these processes are now under good theoretical control. Krämer emphasized, however, that the calculation of signal processes must be accompanied by an equally detailed understanding of backgrounds.

Extreme conditions

The investigation of quark or nuclear matter under extreme conditions of temperature and density has a long history, with possible applications to neutron stars and quark-to-nuclear matter phase transitions in the early universe. With the advent of heavy-ion collisions, most recently (and on-going) at Brookhaven's RHIC collider, these phenomena are now subject to terrestrial explorations. An interpretation of the first RHIC results was given by Miklos Gyulassy of Columbia, who described the geometric and saturation effects that appear in the collisions of large nuclei. Some of these effects are clearly seen in the data. He also explained how the pattern of energy loss should reveal information about the matter density in the collision region. While the dynamics of a nuclear collision is extremely complicated, the thermodynamics of strong matter is amenable to simulations in lattice QCD. The critical temperature and energy density at the phase transition are now rather well determined, says Edwin Laermann of Bielefeld, at least in the approximation that all quarks are massless. The influence of the strange quark mass on the phase diagram is a very interesting question. Recent theoretical developments concern lattice simulations at finite chemical potential. The difficulty lies in numerical cancellations that occur for a complex action. Laermann explained that it is now possible to investigate small chemical potentials using expansions, reweighting methods or analytic continuation from imaginary chemical potentials.

The phase diagram in the direction of chemical potential was illustrated in the concluding talk by Krishna Rajagopal of MIT, who showed that gluon exchange makes the Fermi surface unstable, rendering dense quark matter a BCS-like colour superconductor. Many more phenomena can occur, depending on the number of quark flavours or the strange quark mass, such as a condensation of colour and flavour quanta in an intertwined pattern. The workshop concluded with the tantalizing speculation that quark matter could actually be crystalline, and a review of the possibilities of detecting this phenomenon in supernovae explosions or pulsar quakes.

The plenary talks were preceded by introductory lectures on Deep Inelastic Scattering and Jets (Keith Ellis of Fermilab), Lattice QCD (Karl Jansen of NIC and DESY), Non-perturbative Methods (Andreas Ringwald of DESY) and Finite-temperature Field Theory (Dietrich Bödeker of Bielefeld), which were very well received both by students and experts. The interest of the community in strong interaction physics was also reflected by around 35 parallel session talks given by young researchers from different countries.

Martin Beneke, *RWTH Aachen*.

APPOINTMENTS

Michel Spiro takes over as head of nuclear and particle physics in France

Michel Spiro has been appointed director of IN2P3, the National Institute for Nuclear Physics and Particle Physics in France, and as director of the Department of Nuclear and Particle Physics of the National Centre for Scientific Research (CNRS). He succeeds Jean-Jacques Aubert, who will be taking on other responsibilities.

Spiro joined the Saclay laboratory of the French Atomic Energy Commission (CEA) in 1970. By 1991 he had risen to become head of Particle Physics at the Department of Astrophysics, Particle Physics, Nuclear Physics and Associated Instrumentation (DAPNIA), which he led until 1999. He then became the assistant scientific director of IN2P3, where he was responsible for astroparticles and neutrinos, before being appointed as director of DAPNIA in 2002.

Michel Spiro, here describing the status of searches for dark matter at the CAPP '98 workshop at CERN, is now directing French research in nuclear and particle physics.

Spiro's early work in particle physics led him to participate in the discovery of the intermediate bosons, W and Z, with the UA1 collaboration at CERN. He later became involved with the GALLEX experiment for the detection of solar neutrinos, and in the brown dwarf experiment that became the EROS project searching for dark matter.

Head of the Particle Physics Division of the French Physics Society from 1984 to 1988, Spiro became secretary of the High-Energy Nuclear Physics Division of the European Physics Society in 2000 and then president in 2001.

CONFERENCES

Pomeranchuk conference brings scientists from around the globe together in Moscow

Some 150 scientists from Russia, Ukraine, the US, Germany, Finland, Switzerland, the Czech Republic, Italy and Japan came to Moscow in January to attend the International Conference "I Ya Pomeranchuk and physics at the turn of centuries". Dedicated to the memory of Isaak Yakovlevich Pomeranchuk (1913–1966), on what would have been his 90th birthday, the conference was organized by the Institute for Theoretical and Experimental Physics (ITEP), where Pomeranchuk founded his school of theoretical particle physics, and by the Moscow Engineering Physics Institute (MEPhI), where he lectured and supervised many students. The conference covered various fields of physics that were influenced by Pomeranchuk, including high-energy physics and quantum field theory, the physics of liquid helium-3, condensed matter physics, astrophysics and cosmology, and the physics of electromagnetic processes in matter. During the conference, the Pomeranchuk Prize for 2002 was presented to Bruce DeWitt of Texas University, Austin, US (*CERN Courier* October 2002 p31).

Left to right: Nikolay Narozhny of MEPhI, Nobel prize winner Douglas Osheroff of Stanford University, Lev Okun of ITEP and Bruce DeWitt of Texas University.

The scientific director of ITEP Mikael Danilov (right), presenting the Pomeranchuk Prize for 2002 to Bruce DeWitt.

On 4 February, two young particle physicists received the prestigious INOUE Science Foundation Prize for Young Researchers, for work that they had done for their PhD theses while at the University of Tokyo. The INOUE prize is awarded on an annual basis to 30 Japanese researchers of age 35 or less, for significant contributions made to fundamental science. It covers the fields of engineering, agricultural science, biology and medicine, as well as physics.

Takeo Higuchi (right), now at KEK, received the prize for his work with the Belle Collaboration on CP violation in neutral B-meson decays at the KEK-B factory. **Masaki Hori** (second from right) was chosen for his work on the atomic cascade of antiprotonic helium atoms, which was done as part of the PS205 experiment at CERN's Low Energy Antiproton Ring. Hori is now a CERN fellow working on the ASACUSA experiment, which continues this line of research at the AD.

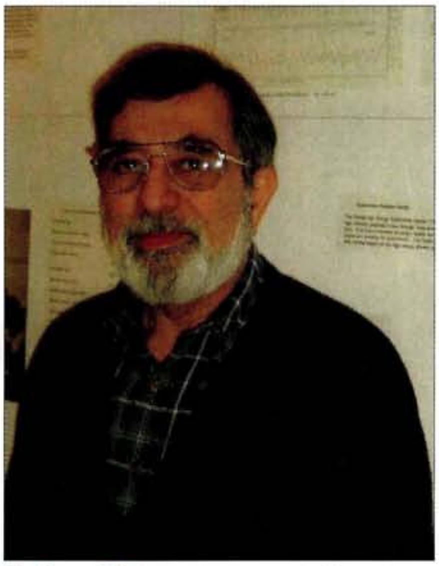
Here, Higuchi and Hori are seen at the award ceremony with, from the left, **Ryugo Hayano** (ASACUSA spokesperson, University of Tokyo), **Hiroaki Aihara** (co-spokesperson for Belle, University of Tokyo), **Junko Hiraga** from the Institute of Space and Astronautical Science, who received the prize for her work on high-spatial resolution X-ray CCD detectors, and well known theorist **Katsuhiko Sato** (University of Tokyo).

The TESLA Collaboration Board has nominated **Carlo Pagani** as TESLA project leader for a term of two years, to coordinate the international research and development work related to the superconducting TESLA linear collider and X-ray laser. Pagani, professor at the University of Milan where he leads the INFN group, is an enthusiastic supporter of TESLA who has worked in a leading position in the collaboration from the beginning. He specializes in cryostats, superconducting resonators and the photocathodes needed for the particle source. He takes over from Dieter Trines, who is a member of the DESY directorate and head of the accelerator department.

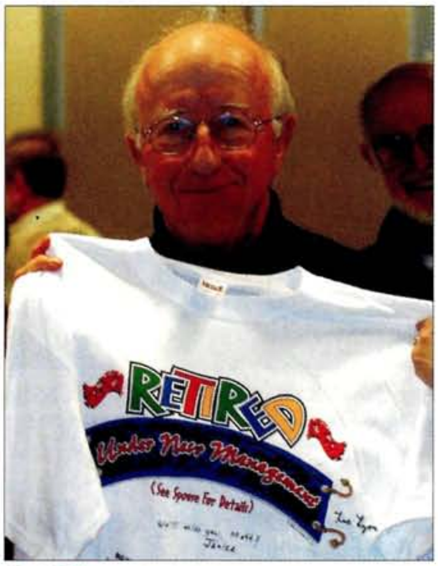
The German Physical Society (DPG) and the British Institute of Physics have awarded the Max Born Prize for 2003 to **Brian Foster**, in recognition of his important contributions to experimental particle physics. Head of Particle Physics at the University of Bristol, Foster has worked for many years at DESY in Hamburg, where he has made decisive contributions to the study of the quark–gluon structure of the proton. He was also involved in the construction of the BaBar experiment at SLAC, and is a member of numerous expert committees, including the evaluation committee of the German Science Council.

Foster will receive the award – which is made in even-dated years to a German physicist and in odd-dated years to a British or Irish physicist – at the annual conference of the DPG in Hanover at the end of March.

José Valle, who heads the Astroparticle and High Energy Physics Group at IFIC/CSIC and the University of Valencia, has received the A v Humboldt – J C Mutis Research Award. This bi-lateral award, which was named after the German naturalist and explorer Alexander von Humboldt and the Spanish botanist José Celestino Mutis, is made in recognition of accomplishments in the fields of research and teaching, and entitles the holder to promote scientific cooperation with research institutions in Germany. Valle will begin with a first visit to the University of Tübingen this summer.



Nariman Mistry retired recently from the Laboratory for Elementary Particle Physics (formerly the Laboratory of Nuclear Studies) at Cornell after a distinguished career going all the way back to his graduate work. He was one of two graduate students on the Columbia experiment at Brookhaven that established the existence of the muon–neutrino. At Cornell he was a pioneer in rho photoproduction, made many contributions to CESR and CLEO, and was an internationally recognized expert on storage-ring vacuum systems. Most recently, he supervised the group that developed the superferric wiggler magnets for the modifications to enable CESR to run at high luminosity at lower energies.



Matt Allen, who led the teams responsible for the design and building of the RF systems of SPEAR I and II and PEP I and II, retired in January after 37 years at SLAC. He also headed the Klystron Department, which built the 65 MW klystrons for the energy upgrade of the SLAC linac for the SLC. As an associate director, Allen led the effort that prepared SLAC for the DOE "Tiger Team" inspection, and he has served on many international committees and advised on accelerator construction for both particle physics and light sources. His final project resulted in a guest house being built by Stanford University at SLAC, which is scheduled to open next July.

The University of Florida celebrated the 60th birthday of **Pierre Ramond** with a "PierreFest" on 1–2 February, which was attended by many distinguished theoretical physicists, including Murray Gell-Mann, Yoichiro Nambu and Ed Witten, as well as many of Ramond's former students and postdocs and his close family and friends. Ramond, seen here (right) with former student **Deog Ki Hong**, earned his PhD from Syracuse University in 1969 and obtained positions at Fermilab, Yale University and Caltech, before finally settling down at the University of Florida, where he holds the title of "distinguished professor". He is well known for his contributions to several areas of physics and mathematics, in particular supersymmetry, string theory, and the origin of neutrino masses. During the two days, the speakers recalled Ramond's achievements in theoretical physics, relating them to ongoing research, and reminisced about their past interactions with Ramond and his influence on their work.

NEW PRODUCTS

Acqiris is offering ready-to-use, customer off-the-shelf (COTS) solutions for data conversion. Acqiris digitizer cards are based on the latest proprietary waveform digitizer chips, offering sampling rates from 500 MS/s to 4 GS/s, both 8-bit and 12-bit, and bandwidth up to to 1 GHz. The company has also expanded its Cougar data acquisition series to include two new models (the Cougar3400-2 and Cougar3400-4), which use the latest 12-bit 400 MS/s digitizer technology. Further details are available via the website at http://www.acqiris.com.

Optima Research has introduced its WavesScope wavefront sensor, which offers fast, accurate wavefront measurement for laser light sources, as well as for lenses, mirrors and complete optical systems. Unlike interferometers, the WavesScope sensor does not require a coherent monochromatic source. For further information, contact Mark Nicholson, e-mail mark.nicholson@optima-research.com.

Heraeus Sensor-Nite GmbH has recently announced a new generation of surface-mount platinum sensors for temperature measurement. The SMD603 device, which measures 1.6 x 0.8 mm, is half the size of its predecessors. For further information, call Bruno Rudnitzki on +49 6181 35 80 53, or e-mail bruno.rudnitzki@sensornite.com.

NAG has announced a numerical library – the AMD Core Math Library (ACML) – optimized for AMD platforms. This results from joint work with AMD to produce a core library for existing and upcoming AMD processors, including the Opteron and Athlon 64 processors. For further information, contact Katie Carstairs (katie.carstairs@nag.co.uk, +44 (0)1865 511245) or Rob Meyer (meyer@nag.com, +1 630 971 2337) or see www.nag.com.

Tecost GmbH has developed a low-cost, ecological and simple system to measure radioactivity in liquids. A microprocessor-driven interface can be connected to a PC via RS232, and software provides calculated activities. For more details, e-mail office@tecost.ch or see www.tecost.ch.

Schelde Exotech wins ATLAS award

On 12 February, representatives of the firm Schelde Exotech, from the Netherlands, were at CERN to receive a prize for best ATLAS supplier. The award was for the construction of the two vacuum chambers for the ATLAS endcap toroid magnets. With a diameter of 11 m and a volume of 550 m^3, these vacuum chambers consist of large aluminium plates reinforced by a system of stainless-steel tubes. To obtain the undulating shape required, the firm had to develop a special assembly and welding technique. Despite the size of the chambers, a very high degree of precision has been achieved, and the chambers, which were delivered in July 2002, were built in such a clean environment that it proved possible to obtain a very high vacuum after only a few days of pumping. The vacuum chambers were designed by the UK's Rutherford Appleton Laboratory (RAL), and the work was carried out under contract with the NIKHEF Laboratory in Amsterdam.

Representatives of the firm Schelde Exotech hold their award for best ATLAS supplier, as they stand with members of CERN, RAL and NIKHEF in front of one of the two vacuum chambers built by the firm.

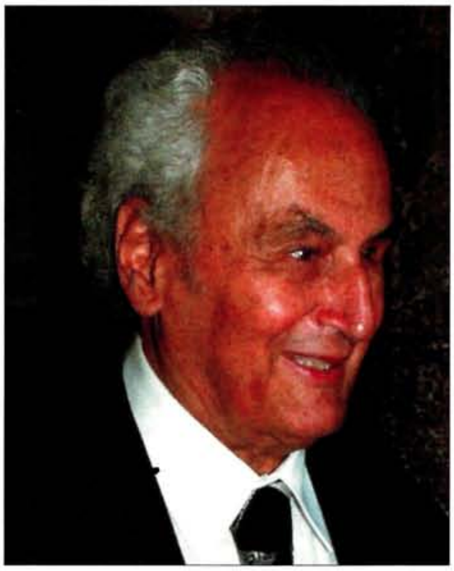
Christine Boesz (left), inspector general at the US National Science Foundation, visited CERN on 13 January. She toured the LHC experiments with US involvement (ATLAS and CMS) and met with CERN's director-general, **Luciano Maiani**. One of her principal roles is to report to the US Congress on how public money is being spent on research projects.

The CMS crystal laboratory was one of the stops on the itinerary of **His Excellency Leonid Skotnikov** (centre), Ambassador of the Russian Federation to the United Nations and other international organizations in Geneva, during his first visit to CERN on 29 January. Here, CERN's Phillipe Bloch described the work with the lead tungstate crystals that are being produced for the CMS Electromagnetic Calorimeter by the Bogoroditsk Techno-Chemical Plant in Russia. During his visit, the Ambassador also saw other examples of Russian contributions to CERN's research programme in the CMS magnet assembly hall, the LHC superconducting magnet test hall and the ATLAS assembly hall. Seen here with the Ambassador are (from left to right), **Vitali Kaftanov** (Institute for Theoretical and Experimental Physics), **Phillippe Bloch**, **Nicolas Koulberg** (CERN) and **Felix Grishaev** (Mission of the Russian Federation).

Institute of Physics Publishing (IOPP), who produce *CERN Courier*, welcomed **HRH Prince Andrew** (right), when he visited their premises in Bristol, UK, on 3 February as part of a tour of companies who have received the Queen's Award for Enterprise. IOPP won its current award in 2000 for outstanding achievement in international trade. This was the latest of three consecutive Queen's Awards to IOPP, each held for five years. The Prince is seen here with **Julia King**, chief executive of The Institute of Physics.

OBITUARIES

George Marx 1927–2002



George Marx, the emblematic figure of the past 50 years of Hungarian physics passed away on 2 December 2002 after two years of a courageous fight against illness, during which he continued working – as a physicist, teacher and prominent figure in Hungarian society.

George enrolled on the physics and chemistry courses at the University of Budapest in 1945, where his interest soon turned towards astronomy and theoretical physics. His first publications dealt with classical physics, and he also applied the concepts of classical physics to problems such as the motion of nucleons in the macroscopic background field of pions, or the calculation of the cross section of resonant gamma-absorbtion on nuclei. He was a very early advocate in the Hungarian physics community of George Gamow's idea of the hot early universe as the correct approach to the history of the universe.

The first problem he attacked in particle physics decided his professional fate. He became an influential researcher on the physics of leptons with the publication of a proposal for a new exact conservation law in 1952. In parallel with, and independently of Jakov Zeldovich in the Soviet Union, and Emil Konopinski and H M Mahmoud in the US, he proposed that in addition to the electric and baryonic charges, a third fermionic charge is also conserved, which today is called lepton number. His short paper, written in German, was made known to the wider particle physics community by Eugene Wigner, with whom he began a lifelong correspondence and friendship. He eagerly followed the revolutionary discoveries in weak interactions of elementary particles during the second half of the 1950s, and soon established important personal contacts with leading researchers on both sides of the Iron Curtain.

George's research became focused on neutrinos for the first time in a paper published in 1960 in *Science*, where prospects of neutrino astronomy were discussed, including the detectability of neutrinos originating from the Earth. With his younger collaborators, he published several papers in the 1960s on the possibility of detecting cosmic, supernova, solar and terrestrial neutrinos. During this period he organized the first international particle physics conferences in Hungary, and at the end of the decade founded, with colleagues from Austria and Czechoslovakia, the most important and durable Central–Eastern–European co-operation in theoretical particle physics – the Bratislava–Budapest–Vienna Triangle.

His deep conviction that neutrinos play a key role in both particle physics and cosmology led him to organize a meeting concentrating exclusively on these elusive objects at Lake Balaton in 1972. This was the start of the very successful Neutrino Conference series, and he remained as chairman of its International Advisory Committee until 2002.

His work on the astrophysical bound on the mass of neutrinos was especially fruitful. This was formed in very intense discussions with Zeldovich, and realized in collaboration with a young diploma student. George can be considered one of the great promoters of astroparticle physics and of the modern evolution of cosmology in the 1970s.

His original ideas and readiness for lively professional discussions made him a central figure in the global high-energy community in the 1970s, when he served as chairman of the High Energy Physics Board of the EPS. A series of very successful conferences at Lake Balaton and in Budapest embodied his talent for getting together the most active and talented physicists. The grove of oak trees in the quiet spa of Balatonfüred planted by giants such as Pontecorvo, Dirac, Feynman, Reines, Zeldovich and Wigner helps us remember these wonderful conferences.

George also had a mission to teach. He was heavily involved in the modernization of the physics curriculum in secondary schools and wrote several textbooks in co-operation with high-school teachers. When inexpensive personal computers appeared on the market, he initiated the publication of simulation programs for a wide range of physical phenomena. As an impressive speaker, he was regularly asked to organize seminars for teachers in Asia and Africa by Unesco, and organized his last teacher's conference on nuclear education only last summer.

His devotion underpinned the "golden age" of the Hungarian (Eötvös) Physical Society. He proposed and realized the integration of high-school physics teachers into the Society, which at nearly 110 years old became one of the strongest scientific organizations in Hungary. George himself served several times as secretary general or president of the Society, and remained an active member of its presidential board until his death. His favourite institution inside the Society was its monthly bulletin *Fizikai Szemle* (Review of Physics). He was elected editor-in-chief in 1957, and the December 2002 issue still reflects his editorial talent and enthusiasm.

Finally, he was one of the most widely respected Hungarian intellectuals, who frequently wrote essays in daily newspapers or literary monthly journals arguing in favour of rational and scientific solutions to many social problems. He convincingly argued that the true heroes of Hungarian history in the 20th century are not emperors, prime ministers, dictators, or revolutionaries, but famous scientists of Hungarian origin. His book (written originally in English) *The Voice of Martians*, which describes the lives of 28 famous Hungarian scientists of the 20th century, was on the list of bestsellers for several weeks in 2000. Its title reflects the anecdote that the isolated Hungarian language used by Wigner and his friends in the offices of Princeton (when Einstein was absent) was considered as a proof of their alien origin. The Hungarian press announced George's death with the headline "Farewell Martian".

Andras Patkos, Eötvös Loránd University, Budapest.

OBITUARIES

Arthur Bradbury Clegg 1929–2002

Arthur Clegg, who has died aged 73 years, was responsible for setting up the High Energy Physics Group at the University of Lancaster, where he was one of the founding professors of the Physics Department.

Arthur began life near Liverpool. After national service as an instructor in the army, he went to King's College, Cambridge, where he obtained a doctorate degree in nuclear physics in the Cavendish Laboratory under the supervision of Sir Denys Wilkinson. His work in this group was recognized in the citation for the award of an honorary fellowship of The Institute of Physics to Wilkinson. After Cambridge, Arthur became interested in higher energies and went to CalTech, where he worked on one of the world's first electron synchrotrons, which was being constructed there.

In 1958 Arthur rejoined Wilkinson, who had moved to Oxford, to continue research in nuclear physics. Arthur then formed his own group to do experiments at the Harwell cyclotron. Later, he became interested in particle physics and moved to the higher energy Nimrod proton synchrotron at the Rutherford Laboratory. Arthur was interested in the quark structure of baryons and realized that electrons were better tools to investigate this subject. He became a member of the committee that steered the construction of the electron synchrotron, NINA, and the formation of the Daresbury Laboratory.

In 1966 Arthur was invited to join the new University of Lancaster to form a high energy physics group. He was delighted by this invitation because it allowed him to move closer to his beloved Lake District. He worked at NINA for some years. However, on realizing the importance of even higher energies, he and his group went to work at the ISR, the first proton collider ever built, in the CHLM collaboration (CERN, Hamburg, Lancaster and Manchester). Later, he moved with his group to the Omega Photoproduction Collaboration at CERN, studying meson photoproduction. He continued this work at even higher energies at DESY, where he joined the H1 collaboration at HERA.

Under his leadership, the group at Lancaster thrived and today takes active roles in the ATLAS and D0 collaborations. The foundations he laid in Lancaster played a significant part in the award of the top grade of 5*A to the department in the latest UK research assessment exercise.

On the exterior Arthur was the stereotypical "absent-minded professor", but he was far from absent-minded, having a razor sharp mind and a photographic memory with total recall. He had an amazing ability to delve into the details of problems, and loved a good argument, especially if he could see it leading to the development of a junior person. Arthur was also good at developing personal relationships, and generations of students and young lecturers remember his enthusiastic and inspirational guidance with gratitude. Despite this, however, he did not suffer fools gladly, and punished foolishness wherever and whenever it occurred.

As a young man Arthur had a passion for mountaineering. When the accelerators were off he would sometimes demonstrate his rock-climbing skills by mounting the higher points of the experimental apparatus. From here he would regale his colleagues with stories of Alpine exploits with famous mountaineers. He made a number of first ascents of Alpine classics, as well as pioneering developments of crags in Scotland. One of his major enjoyments in later life was hill walking with friends and family, and he was a frequent visitor to the Lake District.

Sadly in his late fifties he developed Parkinson's Disease. He continued to work despite this and even in his last year was tussling with a detail of quark wave functions in hadrons. Arthur Clegg had a passion for truth in physics and he strove for it throughout his life.

Terry Sloan, University of Lancaster.

LETTERS

CERN Courier welcomes letters from readers. Please e-mail cern.courier@cern.ch. We reserve the right to edit letters.

Magnets in space

I recently read the PAMELA article (*CERN Courier* October 2002 p24), which I found especially interesting since I had the opportunity to work with Nobel Laureate Louis Alvarez in the 1970s on a similar space experiment.

The article states that the PAMELA experiment utilizes a 0.48 T magnetic spectrometer, and that one end of the apparatus will look down towards Earth while the other end looks out into space. This is very difficult to do because the magnet will align itself with the Earth's magnetic field, and it will be very costly in terms of fuel to keep the spacecraft orientated in any other direction. In the design of the Superconducting Magnetic Spectrometer (SCM) experiment proposed by Alvarez, I had designed a quadrupole magnet system that eliminated the effect of the Earth's magnetic field.

I am curious to know how the PAMELA collaboration is addressing this issue. In addition, we found that the magnetic field from the SCM adversely affected the control moment gyros on the satellite.

Anthony J Favale, Advanced Energy Systems, Medford, New York.

Mark Pearce, KTH Stockholm and the PAMELA collaboration, replies:

The PAMELA magnetic design, and in particular the reduction of the dipole moment, is based on the work of Manlio G Abele (*Structures of Permanent Magnets*).

The magnetic dipole has been evaluated by means of measurements and calculations, and the design and realization checked by colleagues at TSsKB who are responsible for the satellite upon which PAMELA is mounted. As you mention, on-board there is a system to control and correct the position of the satellite.

TSsKB are confident of the possibility of controlling the satellite position, compensating the PAMELA magnet's small residual interaction with the Earth's magnetic field.

MEETINGS

Imaging 2003, an International Conference on Imaging Techniques in Subatomic Physics, Astrophysics, Medicine, Biology and Industry is being held in Stockholm, Sweden, on 24–27 June. For further information see http://www.nuclear.kth.se/imaging2003/index.htm.

PIC 2003, the 23rd meeting in the Physics in Collision series, is being held in Zeuthen, Germany, on 26–28 June. The programme includes neutrino physics, astroparticle physics, flavour physics, QCD and electroweak precision physics. For further information, including registration details, see http://www-zeuthen.desy.de/pic2003/.

The 11th Lomonosov Conferences on Elementary Particle Physics will be held at the Moscow State University on 21–27 August. Topics this year include electroweak theory, tests of the Standard Model and beyond, heavy quark physics, non-perturbative QCD, neutrino physics, astroparticle physics, quantum gravity effects and physics at future accelerators. For further information see http://www.icas.ru/english/confer.htm.

The Eighth International Workshop on Topics in Astroparticle and Underground Physics (TAUP 2003) will be held on 5–9 September at the Institute for Nuclear Theory and Center for Experimental Nuclear Physics and Astrophysics, University of Washington, Seattle, Washington, US. Topics being covered are cosmology and particle physics, dark matter and dark energy, neutrino physics and astrophysics, high-energy astrophysics and cosmic rays, and gravitational waves. Attendance is limited. For further information see http://int.phys.washington.edu/taup2003.

The CERN Accelerator School and DESY Zeuthen will hold a course on **Accelerator Physics** on 15–26 September at DESY and the Seehotel, Zeuthen, Germany. This intermediate-level course will be of interest to staff from laboratories, universities and companies manufacturing accelerator equipment. For further details see http://www.cern.ch/schools/CAS/.

PLSRNC-1, the First Coordination Meeting on Perspectives of Life Sciences Research at Nuclear Centres is being held on 22–26 September at Zlatny Piasatsi (Golden Sands), Bulgaria. The main objective of the meeting is to outline the role and perspectives of research development in life sciences at nuclear centres around the world. For further information see http://www.PLSRNC.ru.

The 2003 DESY Theory Workshop on GUTs and Branes will take place at DESY, Hamburg, on 23–26 September. Topics will include strings and extra dimensions, supersymmetry and unified theories, and baryon and lepton number violation. For further information see http://www.desy.de/desy-th/workshop2003/.

The First International Meeting on Applied Physics, APHYS-2003, will be held in Badajoz, Spain, on 15–18 October. It will cover all branches of physics, in particular interdisciplinary research, including biomedical engineering, nanobiotechnology and imaging techniques. A special feature will be the promotion of existing and future european projects financed by, for example, the EU. For further details see http://www.formatex.org/aphys2003/aphys2003.htm.

The 2003 IEEE Conference, which includes the **Nuclear Science Symposium, Medical Imaging Conference, 13th International Workshop on Room-Temperature Semiconductor X-Ray and Gamma-Ray Detectors, and Symposium on Nuclear Power Systems**, is being held in Portland, Oregon, US, on 19–25 October. Further details, including deadlines for submission of abstracts and registration etc, are available at http://www.nss-mic.org/2003/.

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http://www.nss-mic.org/2003

Nuclear Science Symposium

Medical Imaging Conference

13th International Workshop on Room-Temperature Semiconductor X- and Gamma-Ray Detectors

2003

Radiation Detectors and Electronics:

Applications in Physics, Industry, Space, Biology, Genetics and Medicine

Physics, Engineering and Mathematical Aspects of Medical Imaging

- Plenary Sessions
- Oral Presentations
- Poster Sessions
- Satellite Workshops
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Abstract Submission Deadlines:

NSS & MIC: May 16, 2003

RTSD Workshop: June 27, 2003

October 19-25, 2003

Portland, Oregon, USA

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Sponsored by the Nuclear and Plasma Sciences Society of the Institute of Electrical and Electronics Engineers in cooperation with University of Wollongong (Australia), Vrije Universiteit Brussels (Belgium), Czech Technica University (Czech Republic), CEA Saclay (France), European Materials Research Society (France), IN2P3, (France), Bonn University (Germany), DESY (Germany), FZ Juelich (Germany), FZ Karlsruhe (Germany), Ludwig Maximilians-University Munich (Germany), RWTH Aachen (Germany), Technical University Munich (Germany), University of Freiburg (Germany), National Technical University of Athens (Greece), NIKHEF Amsterdam (Holland), INFN (Italy), University of Pisa (Italy), University of Napoli (Italy), KEK (Japan), Tokyo Metropolitan University (Japan), University of Ljubljana (Slovenia), University of Stockholm (Sweden), KTH-SCFAB Stockholm (Sweden), CERN, (Switzerland), Taiwan National University (Taiwan), Argonne National Lab (USA), Brookhaven National Lab (USA), Fermi National Accelerator Lab (USA), Thomas Jefferson National Accelerator Facility (USA) Lawrence Berkeley National Lab (USA), Los Alamos National Lab (USA), Lawrence Livermore National Lab (USA), National Aeronautics and Space Administration (USA), National Institute of Health (USA), Oak Ridge National Lab (USA), Sandia National Laboratories (USA), Stanford Linear Accelerator Center (USA), University of California, Davis (USA), University of Hawaii, University of Massachusetts (USA), University of Oregon, (USA), University of Pennsylvania (USA), University of Washington (USA), U.S. DOE (USA). Photograph courtesy of POVA.

RECRUITMENT

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RESEARCH FACULTY POSITION
ACCELERATOR PHYSICS
UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN

The Department of Physics invites applications for a full-time, non-tenure track research faculty position in accelerator physics/beam dynamics. The starting date will be August 2003, pending the approval of funding.

Candidates should have a Ph.D., two or more years of postdoctoral experience, expertise in accelerator physics theory, non-linear dynamics, programming in scientific languages, and familiarity with particle physics. Currently active research topics include muon cooling channels. Salary and rank will be competitive and commensurate with qualifications.

For full consideration, applications should be received before May 15, 2003. Applications will be accepted until the position is filled. Applicants should submit a letter describing their research interests and accomplishments, a curriculum vita, and the names and addresses of four references to:

Head (Accelerator Physics Search), Department of Physics, University of Illinois at Urbana-Champaign, 1110 W. Green Street, Urbana, Illinois 61801-3080, (217) 333-3760

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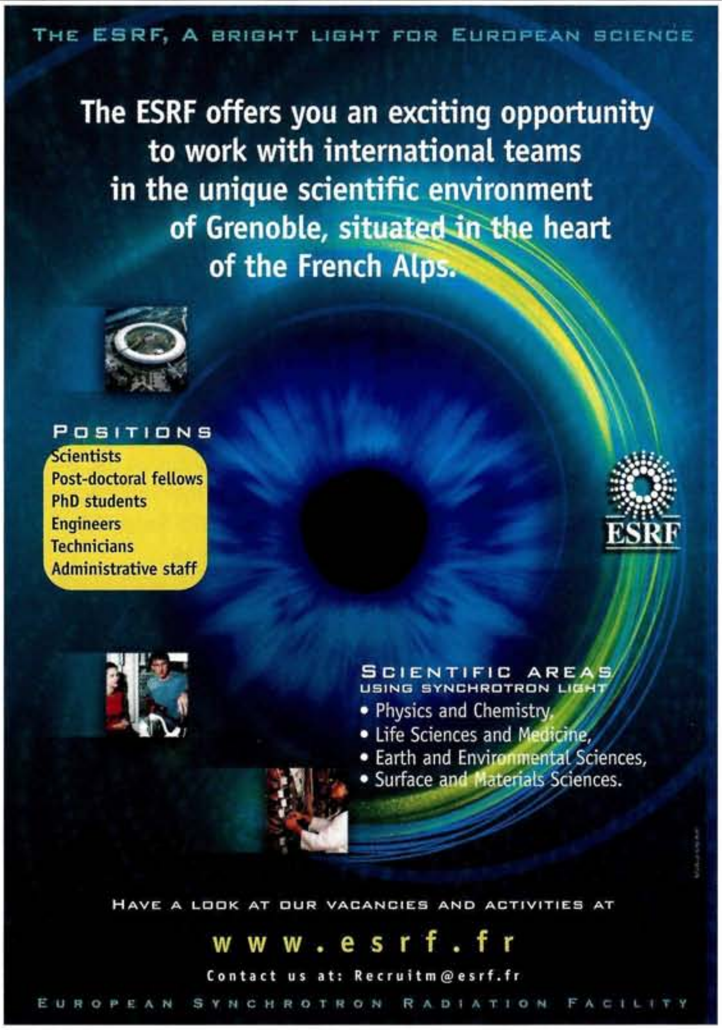

EDITORIAL POSITION, PHYSICAL REVIEW B AND PHYSICAL REVIEW LETTERS

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Joseph Ignacio, Director of Human Resources, American Physical Society, 1 Research Road, Box 9000, Ridge, NY 11961, email: edresumes@aps.org, fax: 631-591-4155.

Universität Karlsruhe (TH)

Am **Institut für Experimentelle Kernphysik** der Universität Karlsruhe (TH) ist eine

Professur (C3) für Teilchen-Astrophysik

baldmöglichst zu besetzen.

Bewerberinnen oder Bewerber sollten in einem der Fächer Teilchenastrophysik oder Elementarteilchenphysik ausgewiesen sein und Erfahrungen in der Entwicklung von Teilchendetektoren und Methoden der Datenanalyse besitzen. In enger Zusammenarbeit mit dem Forschungszentrum Karlsruhe bestehen ausgezeichnete Arbeitsmöglichkeiten in der Neutrinophysik (Experiment KATRIN) und der Physik kosmischer Strahlung bei sehr hohen Energien (Experimente KASCADE Grande, Pierre-Auger-Observatorium in Argentinien). Zu den Lehraufgaben gehört die Beteiligung an der Physikausbildung auch für Studierende anderer naturwissenschaftlicher und ingenieurwissenschaftlicher Fachrichtungen.

Habilitation oder gleichwertige Qualifikation wird vorausgesetzt. Bewerbungen mit den üblichen Unterlagen, Kopien der fünf wichtigsten Veröffentlichungen sowie einer Darstellung der bisherigen Forschungs- und Lehrtätigkeit sind bis zum **30. April 2003** an den **Dekan der Fakultät für Physik, Universität Karlsruhe (TH), Postfach 6980, 76128 Karlsruhe** zu richten.

Die Universität Karlsruhe ist bestrebt, den Anteil an Professorinnen zu erhöhen und begrüßt deshalb die Bewerbung entsprechend qualifizierter Frauen. Schwerbehinderte Bewerberinnen/Bewerber werden bei gleicher Eignung bevorzugt berücksichtigt.

Im Falle einer erstmaligen Berufung in ein Professorenamt wird das Dienstverhältnis zunächst grundsätzlich befristet; Ausnahmen von der Befristung sind möglich.

Stanford Linear Accelerator Center

Tenured Professorial Position in Accelerator Physics

The Stanford Linear Accelerator Center (SLAC) is seeking an outstanding individual for a tenured faculty position in Accelerator Physics. We are looking for candidates with significant accomplishments and promise for important future achievements. In particular, the candidates are expected to have demonstrated leadership in the design, construction, and/or operation of major accelerator facilities.

The successful candidate is expected to take a leadership role in developing present accelerator facilities, in developing new initiatives at SLAC and in creative scholarship. As a member of the Academic Council of Stanford University, there will be opportunities to teach and supervise undergraduate and graduate students.

Candidates should submit a curriculum vitae, publication list, a statement of research interests, and the names of four references to **Professor Burton Richter, SLAC–MS 80, 2575 Sand Hill Road, Menlo Park, CA 94025, or electronically to brichter@slac.stanford.edu**.

The deadline for receipt of applications is April 15, 2003.

SLAC is an equal opportunity employer and welcomes nominations of women and minority group members and applications from them.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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The Experimental Physics Division invites applications for a long term position of a

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Candidates are expected to have a PhD in particle physics and an excellent record of successful work with typically 5-10 years of post-doctoral experience in this field. Further requirements include: a high capacity for innovation and leadership; competence in detection techniques and in the use of on-line and off-line software; potential for making a significant medium to long-term contribution to the scientific programme of the Organization. Very good communication skills and an aptitude for team work.

The position is of a long-term nature and offers a competitive remuneration package and excellent career prospects.

The selected candidate will take a leading role in all aspects of particle physics experiments, involving the conception and design of experiments, the development and operation of detectors and the analysis of data. He/she will also coordinate or make important contributions to studies, projects or committee work and represent the Organization at conferences, workshops, or in other research laboratories and institutions.

Interested candidates are asked to send an application letter, a CV including the names of three referees and a brief description of research interests as well as a list of publications to Dr. D. Schlatter, EP Division Leader, CERN, CH 1211 Geneva 23, e-mail: Dieter.Schlatter@cern.ch, by 9 May 2003. Preference will be given to nationals of CERN Member States*.

This position is also published under reference EP-DI-2003-25-FT, which can be consulted at www.cern.ch/jobs/.

CERN is an equal opportunity employer and encourages both men and women with the relevant qualifications to apply.

*** AT, BE, BG, CH, CZ, DE, DK, ES, FI, FR, GR, HU, IT, NL, NO, PL, PT, SE, SK, UK**

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For the development of an additional dedicated synchrotron radiation source we are looking for

Physicists (PhD) m/f

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for the design and realization of a compact 600 MeV-electron storage ring for the radiometry of the Physikalisch-Technische Bundesanstalt. Work focuses are design and construction of beam transport elements, a 500 MHz-accelerating system, a high-precision beam position measurement, ultra-fast bunch-to-bunch feedback systems and scientific instrumentation.

The successful applicants will be expected to have profound knowledge in the field of accelerator physics. Experience with accelerators will be an advantage.

Work contracts conform to the framework of the Bundes-Angestelltentarifvertrag and are limited to the project duration of three years. Efforts are made for conversion into a permanent employment as operation of the facility starts.

Applications of qualified female candidates are particularly encouraged. Among equally qualified applicants, handicapped candidates will be given preference.

Applications should include CV and publication list as well as above key number and earliest possible starting date. Please send your application to:

Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H. (BESSY)
- Personalverwaltung -
Albert-Einstein-Str. 15, 12489 Berlin, Germany

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Publication date: 25 April

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PENNSTATE

LIGO Gravitational Wave Data Analysis

As a member of the LIGO Scientific Collaboration (LSC), the Penn State relativity group seeks one or more postdoctoral scholars with strong data analysis experience and skills to take part in the analysis and interpretation of observations from the Laser Interferometer Gravitational Wave Observatory (LIGO). The start date for the positions is September 2003; at least two years of funding are available for each position.

The Penn State LSC group is among the largest and most active in the collaboration. It plays a leading role in the analysis and interpretation of LIGO data, including analysis in collaboration with other gravitational wave detector experiments worldwide. It is also host to an International Virtual Data Grid Laboratory (iVDGL) University Regional Center for grid computing, whose primary focus is data analysis for LIGO. It is part of the larger Penn State relativity group, which is among the largest and most active in the country with five faculty, eleven postdocs, sixteen graduate students, nine undergraduate students engaged in research in all areas of gravity.

Penn State is also home to the Center for Gravitational Wave Physics (CGWP), funded by the National Science Foundation as part of its Physics Frontier Centers program. The mission of the CGWP is to help crystallize and develop the emerging discipline of gravitational wave phenomenology the astrophysics and fundamental physics that gravitational wave observations – in all wavebands – enable. The Center for Gravitational Wave Physics brings several major workshops and conferences addressing all areas of gravitational wave physics and astrophysics to Penn State every year.

Applicants with Ph.D. in hand should send a CV, statement of research interests and relevant experience, and arrange for three letters of recommendation to be sent to

LSC Postdoc Search,
Center for Gravitational Wave Physics,
104 Davey Laboratory
University Park, PA 16802.

Applications will be considered beginning 15 April. New applications will be considered until the position is filled. For more information see our website at **http://cgwp.gravity.psu.edu**

Penn State is committed to affirmative action, equal opportunity and the diversity of its workforce.

PhysicsJobs @physicsweb.org

Staff Associate Electrical Engineer

Columbia University Nevis Labs has an immediate opening for an electrical engineer to design instrumentation for high energy physics research. Typically this involves data readout of large scale detectors located at accelerator labs in the U.S. and Europe. Our electronics group currently consists of three engineers and three technicians. We do analog and digital circuit design using commercial components, ASIC's, standard cell, FPGA's and PCB's. Prototyping and testing is done in house and on site, while production is typically performed by outside vendors. The applicant should have at least two years of design experience in some of the above areas and some knowledge of Spice, HDL and PCB layout tools.

Please send resume and three letters of recommendation to:
Chief Engineer, Electronics Department,
Nevis Lab, POB 137, Irvington, NY 10533, USA.

Columbia University is an Equal Opportunity/Affirmative Action Employer, Women and minorities are encouraged to apply.

Imperial College London

Department of Physics

Research Associate Positions in High Energy Physics

Applications are invited for two Research Associate posts in the High Energy Physics group, Imperial College London. One post is to work on the electromagnetic calorimeter (ECAL) for the CMS experiment at the LHC and the other is to work on the group's Neutrino programme.

The group plays a leading role in the CMS experiment and is jointly responsible for the design, testing and construction of the ECAL end-cap. The successful candidate for this CMS ECAL post should have a background in experimental high energy physics and an appreciation of the physics goals of the CMS experiment. S/he will take responsibility for measurements made in the Crystal Laboratory at Imperial and should have the necessary background and ability to undertake the development of software for the experiment. The position will involve some travel to CERN. Further information may be obtained from Dr David Britton at d.britton@imperial.ac.uk

The group is also one of the leaders in the R & D programme designed to lead to a neutrino factory and is planning to participate in one of the proposed neutrino 'superbeam' experiments. The successful candidate will take a leading role in this programme, a major part of which will be the design, construction and commissioning of the International Muon Ionisation Cooling Experiment (MICE) at RAL. Further details of the group's neutrino programme and the MICE experiment may be obtained from Dr K Long, email: K.long@imperial.ac.uk

Additional information on the group's wide experimental programme can be found on http://www.imperial.ac.uk/research/hep

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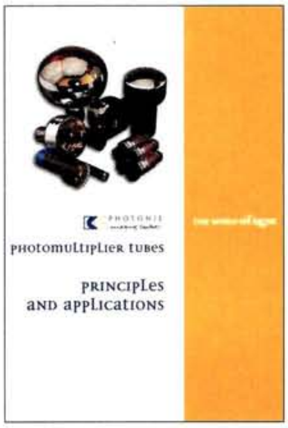

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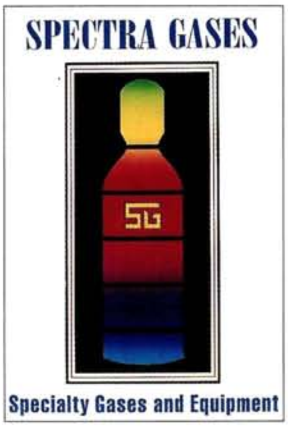

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BOOKSHELF

Hidden Worlds: Hunting for Quarks in Ordinary Matter by Timothy Paul Smith, Princeton University Press.
ISBN 0691057737, £17.95 ($24.95).

The world of subatomic particle physics is often portrayed to the non-specialist as solely the business of large "atom smashing" particle accelerators. But the mysterious quarks are very much the basis of familiar matter in the world about us, as Timothy Paul Smith explains in his book *Hidden Worlds*.

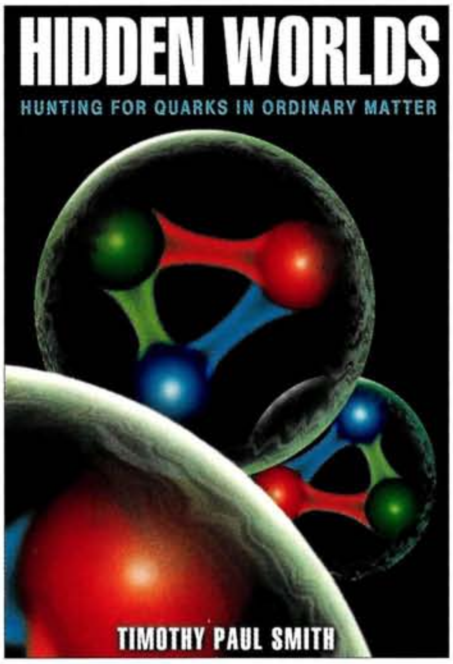
Smith, a research scientist at the Massachusetts Institute of Technology Bates Linear Accelerator Center and research professor at Dartmouth College, has produced a clear and concise journey through the wonders of subatomic physics for the student. His background as a teacher is soon apparent, as he uses common experiences to help relate the physical scale, details and concepts he wishes to convey. This skill makes the story and its comprehension easy for the lay reader.

Smith quickly introduces his target area and focuses on his quark story. The early pages lead us through the requirement for high-energy accelerators and for their ever-increasing power to explore smaller and smaller particles as the atom, nucleus and nucleons are unwrapped.

The regular comparison and relation of physics concepts to chemistry provides an additional base for the reader's understanding. The use of quick resumés at the start of each chapter also enables the reader to progress through the book with some certainty – and is helpful for those who cannot complete the book in one go.

Smith uses his own experiences at research laboratories to describe both the scientific method and research team challenge in technical and organizational arenas. His obvious excitement and dedication to the research challenge are very clear, and no high-school student should miss such an invitation to a career.

The book should give the reader confidence in the use of the concepts of – among others – the nucleus, nucleon, charge, spin, color, quark, antiquark and gluon. Smith's good use of analogies using everyday systems also means that the reader can quickly become confident with the constituent quark and quantum chromodynamics. However, this should not be misinterpreted as gaining a full understanding; this is a small book covering a wide subject area and simply gives an overview in preparation for more advanced work.



The chapter "Particle Taxonomy and Quark Soup" brings us into the Greek alphabet soup, which usually sinks lone attempts at the quark world. Smith's attitude appears to be that the reader should be exposed to this, but not overwhelmed. Patterns and overview are extracted and we proceed to further discoveries without exhaustion. However, Smith should have expanded more here, as this is the area in which readers are likely to be short of knowledge.

Next, Smith delves into the quark/gluon world, where there is a good use of clear text and diagrams. Having reviewed the quark's history and the current theories, Smith completes his story with some outstanding questions and current research proposals.

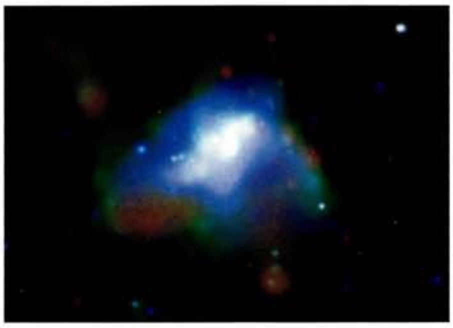
For those of you who flip through a book looking at the ratio of diagrams to text, Smith certainly passes the test, including Feynman diagrams, scale charts, quark and nucleon diagrams, accelerator exploded views and ample graphical charts. A glossary that gives an adequate description of technical terms is also provided, enabling easy reference without having to search through previous chapters.

In all, *Hidden Worlds* provides a short introduction and overview of the subject area. Students should use it as such and expect to follow up with a more rigorous technical book. It is written in an attractive and easy to read style, which gives the reader the confidence to attack this difficult subject. In my opinion, a copy should be placed in every public library.
John Cuckney, Oxford University Summer School for Adults.

Element Genesis, solving the mystery a video release by the RIKEN Institute, Japan. English version ¥3000 NTSC format, ¥4000 PAL/SECAM format.

A flapping butterfly, the songs of birds, the colours of flowers, mountains and oceans – all are relics of the stars, for the ashes of stars are the building blocks of all we can see and touch. On Earth, the ashes must have been recycled, because we can find nearly all the elements present. It is only half a century since we began to understand that the genesis of the elements lies in the stars. They are the factories and, depending on their fuel, mass and age, they produce their specific elements.

RIKEN, the Institute of Physical and Chemical Research in Japan, has taken the initiative to produce a video of the processes involved in the synthesis of elements in the stars. The film begins with a gentle introduction, but soon the audience must be alert as they will be informed about the basics of radioactivity and the structure of atomic nuclei, in subtle detail. The video continues with the synthesis of elements, first in a star like the Sun, then during the Big Bang,



Element factory: NGC 1569, a dwarf galaxy 7 million light-years from Earth, is pictured in X-rays by the Chandra Observatory, which found evidence for elements such as oxygen, neon, magnesium and silicon – the recycled "ashes" of dead stars. (NASA/CXC/UCSB/C Martin et al.)

and then in massive stars, and ends with the production of thorium and uranium in a supernova explosion. Back on Earth, RIKEN argues that its research using radioactive ion beams is important for unravelling the mysteries of element synthesis, with supporting statements from scientists from other countries.

The video lasts for 35 minutes and is a complete lesson in nuclear synthesis. It is excellent material for high-school and university students who already have a background knowledge of this subject matter. Despite the long duration ▷

of the film, it can be used to support lessons on this topic. However, there are also some cautionary remarks. As mentioned before, the information given within the first six minutes about the basics of radioactivity and the structure of atomic nuclei is so compact and detailed that even the most attentive students will be exhausted, especially as the information comes both from a voice-over and simultaneously from three or four different places in an animation. This could be simply avoided.

Fortunately, the movie then slows down and the alternation of the narrator with comments from Japanese scientists works very well. If the "man in the street" understands that thermal motion of two hydrogen nuclei by quantum-electrotunnelling through the barrier created by electric repulsion leads to fusion into deuterium, a positron and a neutrino, then the video would also be suitable for the general public. Otherwise, it would probably be better to make a special, more simplified version, which could give an overview of the birth and death of the (massive) stars that 5 billion years ago resulted in the birth of our solar system.

In summary, this is an attractive and interesting video on nuclear synthesis and nuclear structure, and could be useful for supporting lectures and classes. For further information on the video and its distribution, please see http://www.image-science.co.jp/element.

Jacques Visser, Public Relations, NIKHEF.

Books received

Introduction to Numerical Analysis by Michelle Schatzman, Oxford University Press. Paperback ISBN 0198508522, £24.95; hardback ISBN 0198502796, £49.95.

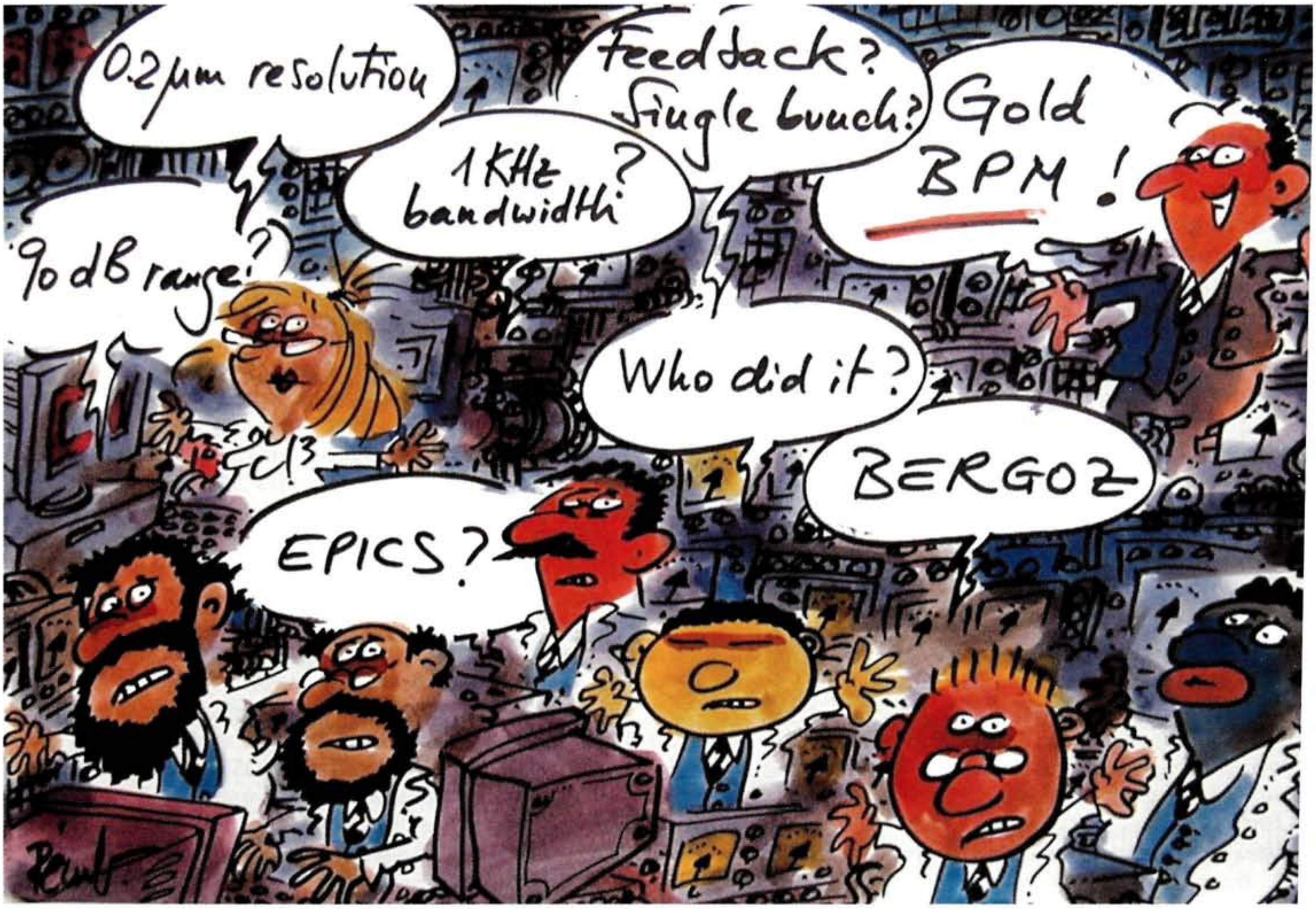
Written for advanced undergraduate mathematics students who are interested in the "spice and spirit" of numerical analysis, this is an English translation of an updated version of Schatzman's book, which first appeared in French in 1991.

Nonrelativistic Quantum Mechanics World Scientific. Paperback ISBN 981024651X, £33 ($48); hardback ISBN 981024634X, £53 ($78) and **Problems & Solution in Nonrelativistic Quantum Mechanics** by Anton Z Capri, World Scientific. Paperback ISBN 9810246501, £33 ($48); hardback ISBN 9810246331, £58 ($86).

Now in its third edition, Capri's textbook is suitable for advanced undergraduate students as well as graduate students. The new study guide, in its first edition, has grown out of popular demand. The problems, most of which have been tested on the author's students, vary in difficulty from very simple to research level.

Chaos and Time-Series Analysis by Julien Clinton Sprott, Oxford University Press. Paperback ISBN 0198508409, £24.95; hardback ISBN 0198508395, £49.95.

Aimed at students, scientists or engineers who want to use the ideas in a practical setting, this book introduces new developments in chaos and related topics in nonlinear dynamics. The emphasis is on physical concepts and useful results.



VIEWPOINT

Science, technology and the Third World

Abdus Salam believed that the gap between rich and poor nations is one of science and technology. His former student **Riazuddin** describes efforts to bridge that gap.

Abdus Salam, who died on 21 November 2001, would have been 77 on 29 January 2003. In remembering him on such occasions, one misses his sharp intellect and his passion for promoting science and technology in Third World countries. Few have discovered a universal law of nature, and still fewer have founded an Institute for the underprivileged. Salam accomplished both. In addition to seeking "unity in seemingly disparate forces of nature", he sought unity in mankind, and his crowning achievement was the creation in 1964 of the International Centre for Theoretical Physics at Trieste – now named after him – which has touched the lives of physicists and other scientists the world over.

Yet Salam failed in one of his lifelong goals, perhaps the one closest to his heart. Near the end of his life, he lamented: "Countries like Turkey, Egypt and my own country, Pakistan, have no science communities geared to development because we do not want such communities. We suffer from a lack of ambition towards acquiring science, a feeling of inferiority towards it, bordering sometimes even on hostility."

Passive tolerance of poverty in the Third World was of deep concern to Salam. The greatest failure of science and technology is their failure to act as a social equalizer, and the gap between rich and poor has increased, despite the fact that the wealth created by science and technology is sufficient to alleviate poverty. "Predictions that the 'poor might not always be with us' have not come true. In 1990, there were optimistic forecasts that the percentage of absolute poor in the world (those with income below US$1 a day) would drop to 18% by 2000. By 1998, the figure was at 24% and the trend-line had turned upward" (Mooney 1999).

This echoes what Salam said in 1988: "This globe of ours is inhabited by two distinct types of humans. According to the UNDP count of 1983, one-quarter of mankind – some 1.1 billion people – are developed. They inhabit two-fifths of the land area of the Earth and control 80% of the world's natural resources, while 3.6 billion developing humans – 'les miserables', the 'mustazeffin' – live on the remaining three-fifths of the globe. What distinguishes one type of human from the other is the ambition, the power, the elan which basically stems from their differing mastery and utilization of present-day science and technology. It is a political decision on the part of those (principally from the South) who decide on the destiny of developing humanity if they will take steps to let the less miserable create, master and utilize modern science and technology for their betterment."

Again he wrote: "Today the Third World is only slowly waking up to the realization that in the final analysis, creation, mastery and utilization of modern science and technology is basically what distinguishes the South from the North. On science and technology depend the standards of living of a nation. The widening gap in economics and influence between the nations of the South and the North is essentially the science and technology gap. Nothing else – neither differing cultural values, nor differing perceptions or religious thoughts, nor differing systems of economics or of governance – can explain why the North (to the exclusion of the South) can master this globe of ours and beyond."

Indeed, scientific knowledge and innovation are becoming leading factors of production and economic development around the world. There can be no high technology without first-rate science. Science develops new tools in laboratories for its progress, and trains students and technicians to build them. These tools find users outside, and some young people become entrepreneurs and launch their own companies, which then grow into large enterprises. However, such companies grow around big centres of scientific research, for example Silicon Valley around Stanford. But the Third World countries do not have big centres of research. So do they have a chance, or have they lost out for ever? I believe the answer lies in linkages with big science centres in developed countries. A fine example is CERN, where high technology and fundamental science reinforce each other.

Let me end by quoting from a paper by Salam, presented on 11 May 1983 in Bahrain: "We forget that an accelerator like the one at CERN develops sophisticated modern technology at its furthest limit. I am not advocating that we should build a CERN for Islamic countries. However, I cannot but feel envious that a relatively poor country like Greece has joined CERN, paying a subscription according to the standard GNP formula. I cannot rejoice that Turkey, or the Gulf countries, or Iran, or Pakistan seems to show no ambition to join this fount of science and get their men catapulted into the forefront of the latest technological expertise. Working with CERN accelerators brings at the least this reward to a nation, as Greece has had the perception to realize."

Since then, Pakistan and Iran have joined CERN collaborations and, if Salam were alive today, I am sure he would be delighted to see that aspects of his vision are at last being transformed into reality.

Further reading

P R Mooney 1999 *Development Dialogue* **1–2** 19.

Riazuddin, head of the National Centre for Physics, Quaid-i-Azam University, Islamabad.

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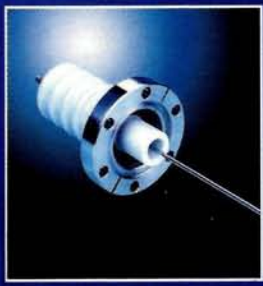
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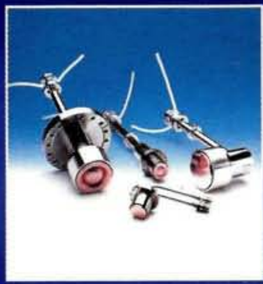
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