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CERN COURIER

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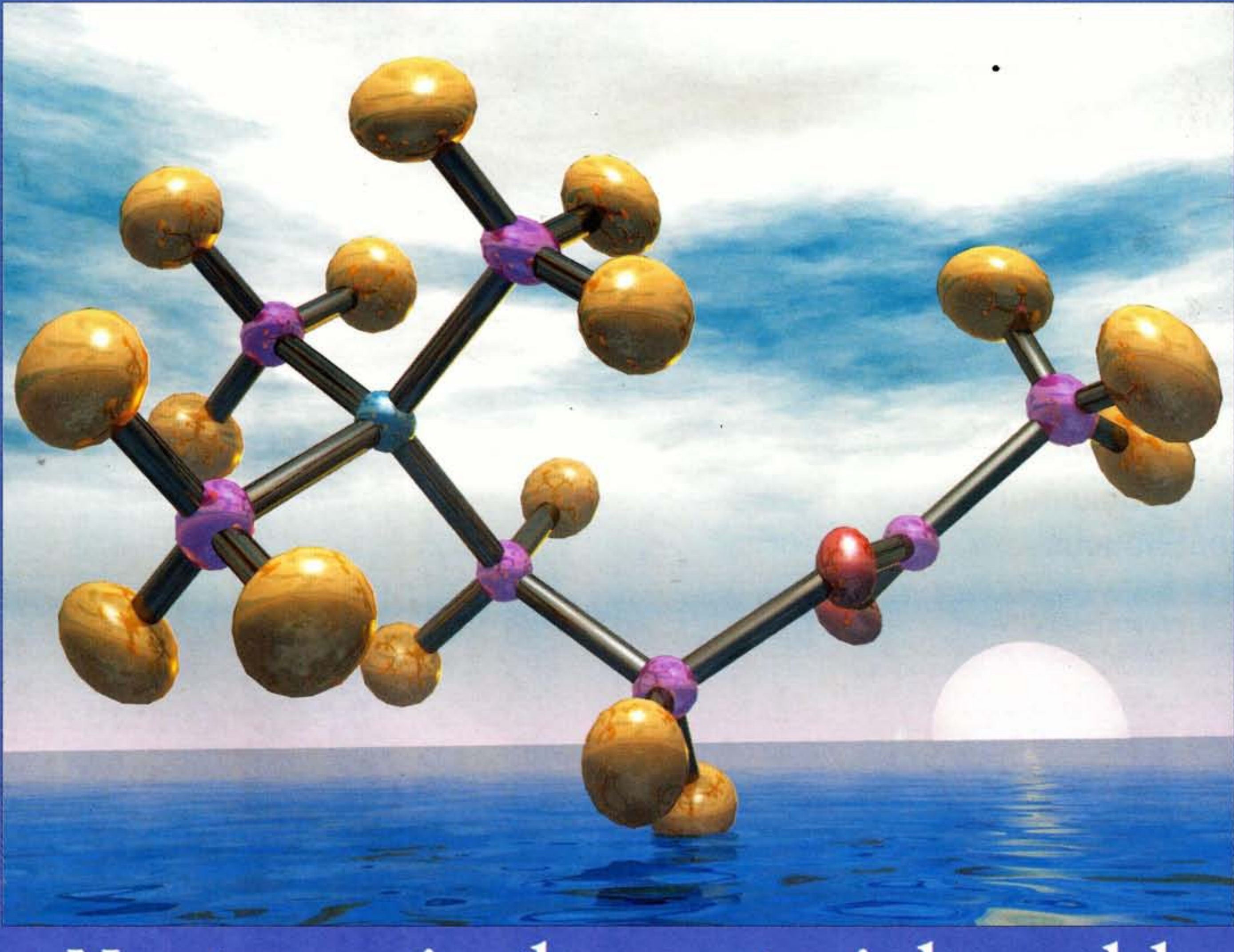

Neutrons in the material world

QUARK GLUON PLASMA
Nuclear beams point back to the Big Bang p13

NEUTRINO BEAMS
Out of stored muons will come forth abundant neutrinos p17

DOUBLY MAGIC NICKEL
A new isotope with stable proton and neutron shells p27

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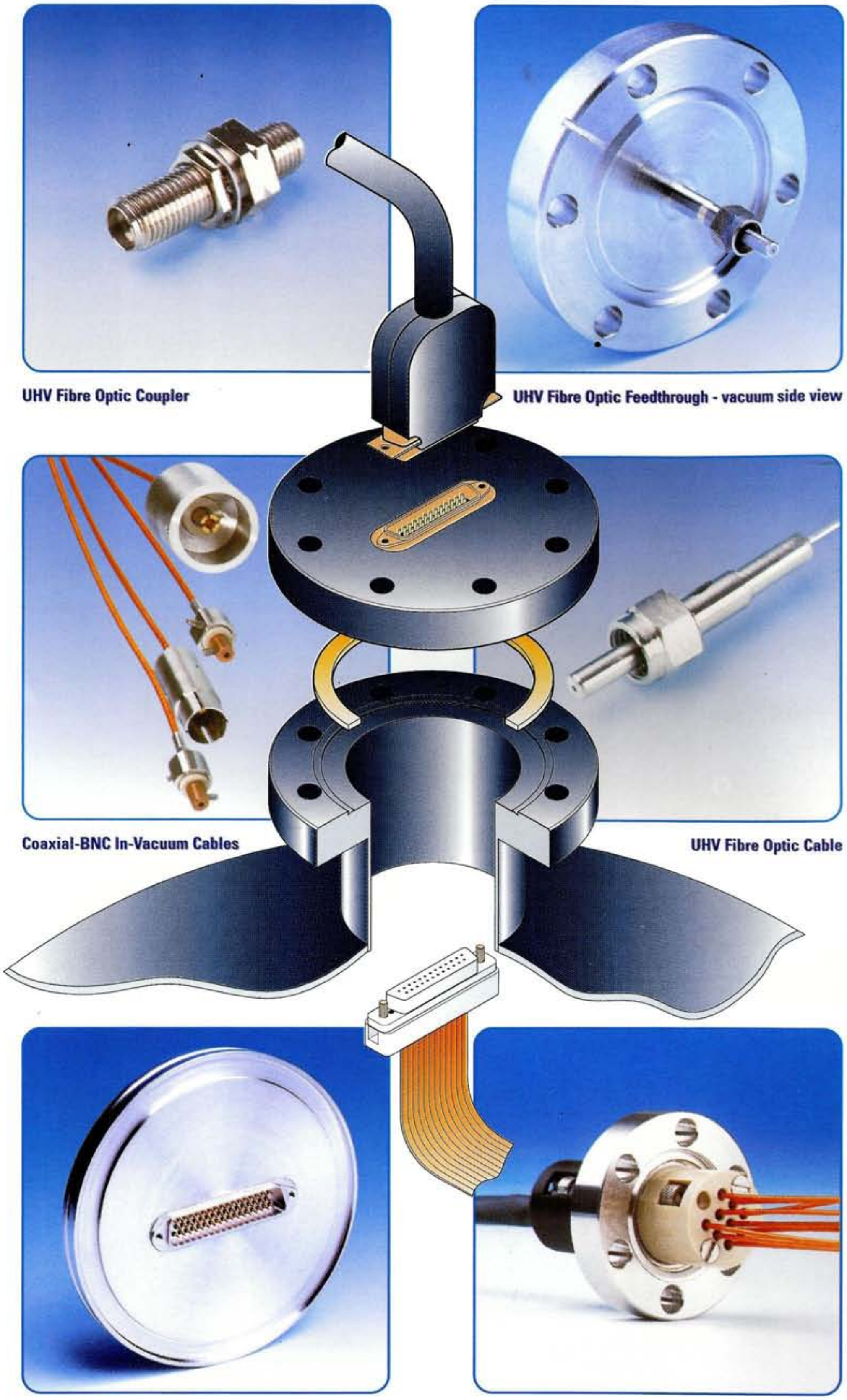

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UHV Fibre Optic Feedthrough - vacuum side view

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VOLUME 40 NUMBER 3 APRIL 2000

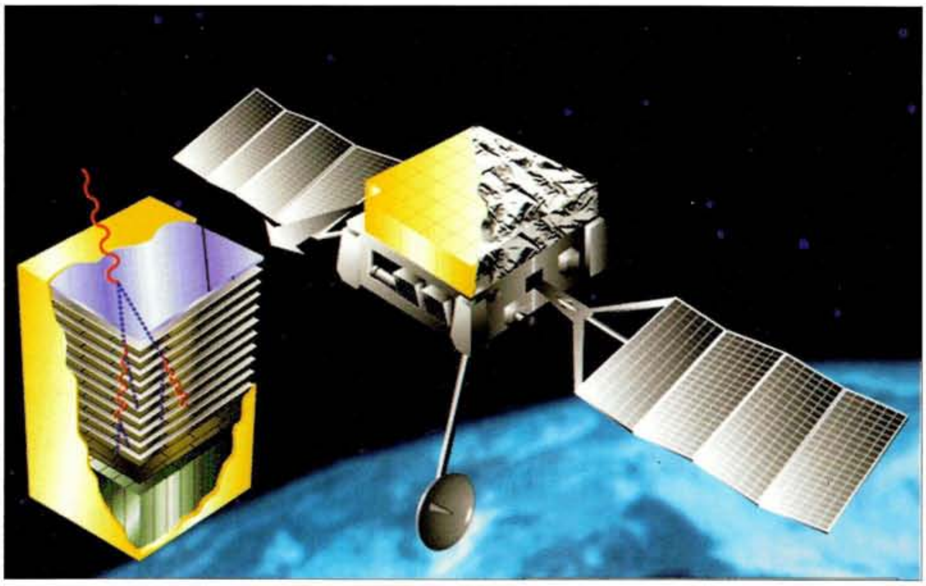

Ball lightning p9


GEM detector p20


New ESA chairmen p29

Cover: "*Nano-Dali*" – Acetylcholine is an important neurotransmitter, the crystal structure of which has been studied to great precision on the single-crystal diffractometer at the ISIS neutron source at the Rutherford Appleton Laboratory, UK. Vibration of individual atoms in the molecule is revealed via their thermal ellipsoids. In the body, acetylcholine acts in an aqueous environment, and its influence on the structure of water surrounding it has also been studied in detail on the SANDALS instrument (p20).

NASA to work with Stanford for major astrophysics project



Artist's impression of the Gamma-Ray Large Area Space Telescope, which is scheduled for launch in 2005. Particle physicists are making a major contribution.

In a move that underlines the growing requirement for sophisticated hardware for precision physics experiments in space, NASA has announced an award to Stanford University for the development of the GLAST space-based gamma-ray telescope.

GLAST (Gamma-Ray Large Area Space Telescope) will be built as a collaboration of NASA, the US Department of Energy and specialists in France, Germany, Italy and Japan. It will detect electrons and nuclear particles accelerated to ultrahigh energies beyond those attainable on Earth.

Management of the project will be centred at the Stanford Linear Accelerator Center. The launch is scheduled for 2005.

Expected to have a mission life of five years, GLAST will make great improvements over gamma-ray telescopes, such as EGRET, which is currently aboard the Compton Observatory. EGRET has operated successfully long past its design life and is about to stop. Compared with EGRET, GLAST will have a field of view and an effective area each about six times as large, sensitivity of some 50 times as good and energy of more than 10 times as high. Its wide field of view will enable scientists to probe extreme transient phenomena, such as active galactic nuclei and the mysterious gamma-ray bursts over a range of timescales.

The primary GLAST instrument is a matrix of towers composed of thin lead foil interleaved with thin silicon detectors to record the gamma-ray direction, followed by a matrix of scintillation crystals to measure the gamma-ray energy. Using about 100 sq. m of silicon strip detectors, GLAST will be by far the largest silicon-based detector to be launched into space.

For more information, see "http://www-glast.stanford.edu/" and "http://glast.gsfc.nasa.gov/".

B race hots up

The new generation of "B-factory" electron–positron colliders at SLAC, Stanford (PEP-II), and the Japanese KEK laboratory (KEKB) have both made good progress and exceeded luminosities (a measure of the collision rate) of $10^{33}/cm^2/s$ – previously uncharted territory for electron–positron colliders. PEP-II achieved this figure late last year and KEKB reached it in February.

PEP-II achieved its first collisions in July 1998, but the BaBar physics detector did not appear until May 1999. KEKB and its BELLE detector began operation last June. The aim of these colliders is to mass-produce B particles (containing the fifth "b" quark), and the new collision rates are good news for the physicists, who hope to see the first signs of CP violation in a B particle setting.

The previous world record electron–positron luminosity was 8×10^{32}, held by the valiant CESR ring at Cornell, which is still in the race. CERN's 27 km LEP collider is in a different league because of its size, and here the focus is on achieving maximum collision energy.

New laser light at DESY

On 22 February an international team at the DESY laboratory, Hamburg, succeeded in obtaining a 110 nm wavelength ultraviolet beam with a free electron laser (FEL) – the smallest wavelength produced with such an device. This is a significant extension in the range of wavelengths available via this technique and is a significant milestone en route to DESY's ultimate goal of a 33 km superconducting electron linear accelerator (TESLA) for particle research that would also drive several X-ray FELs (*CERN Courier* May 1999 p11).

For such small wavelengths, classical lasers using reflecting surfaces have to be replaced by alternative approaches – in this case the ▷

JINR–Russia agreement is ratified

Visiting the Joint Institute for Nuclear Research - JINR - Dubna, near Moscow, Chairman (Speaker) of the State Duma of the Russian Federation Gennady Seleznev inspects the superconducting Nuclotron.

Under a new ruling, the Joint Institute for Nuclear Research (JINR) in Dubna, near Moscow, has the same legal status of an international organization in Russia as CERN enjoys in its host countries.

"On Ratification of the Agreement between the Government of the Russian Federation and JINR on the Location and Terms of Activity of JINR in Russia" was approved by the Russian Parliament on 22 December and signed by the acting president of the Russian Federation Vladimir Putin on 2 January.

On the scientific front, milestones at JINR in 1999 included the first successful test of the beam slow extraction system of the superconducting Nuclotron and also the start up of the new methane cryogenic moderator for experiments with cold neutrons at the IBR-2 reactor.

JINR's prestigious Bruno Pontecorvo prize for 1999 was awarded to Raymond Davis of Brookhaven for his outstanding achievements in developing the chlorine–argon method for solar neutrino detection.

The prestigious Bruno Pontecorvo Prize of JINR, Dubna, was awarded for 1999 to Raymond Davis of Brookhaven for his outstanding achievements in developing the chlorine–argon method for solar neutrino detection. Left to right: Laureate Davis, JINR Director Vladimir Kadyshevsky and Dmitri Shirkov, Jury Chairman for the Prize and Honorary Director of JINR's Laboratory of Theoretical Physics.

SASE (self-amplified spontaneous emission concept first proposed in the 1980s; *CERN Courier* July 1999 p33) – that can produce infrared and optical wavelength beams.

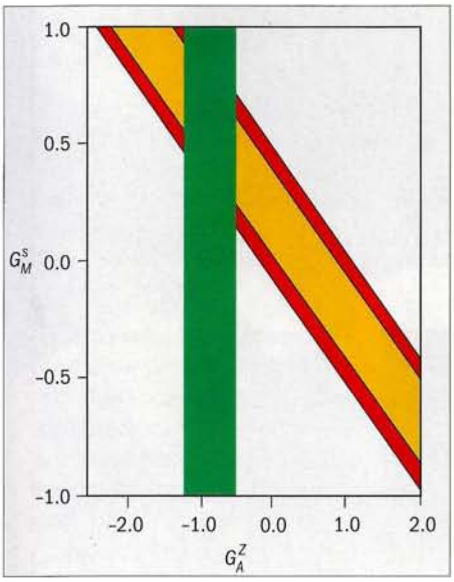
The latest DESY beam was produced by a 14 m magnetic "undulator" that could go on to form part of a 300 m FEL to attain 6 nm X-ray wavelengths and provide intense beams to precision probe cells, molecules and materials.

The 300 m FEL would also be a pilot installation for the bold TESLA scheme to supply electron and positron beams using a 33 km linear collider for collision energies from 500 GeV for a new generation of particle physics research. A decision on this ambitious scheme is expected in 2002/3, and construction would stretch over eight years.

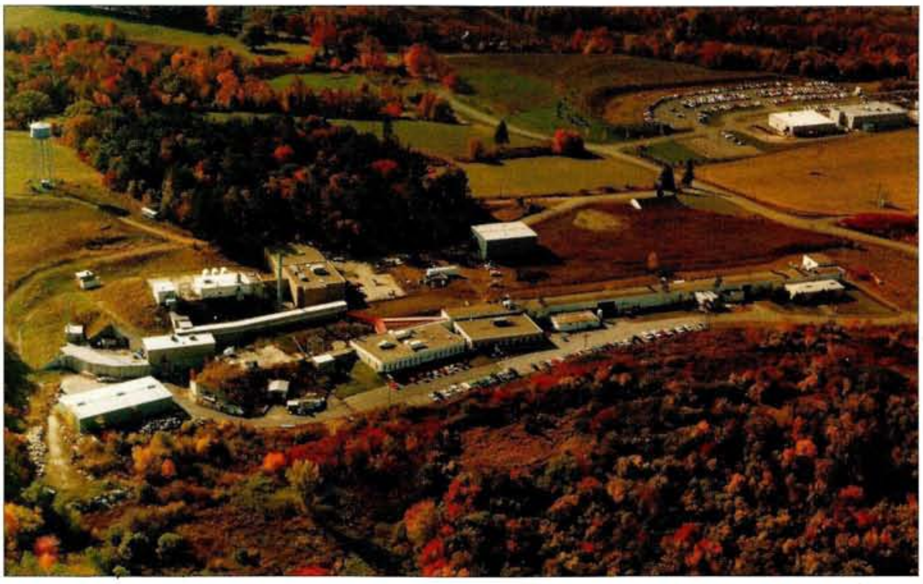
Construction of the 300 m project will be the focus of the Light for the New Millennium exhibition at DESY's EXPO 2000 show, which runs from 1 June to 31 October (see "http://www.desy.de/expo2000/").

The magnetic "undulator" at the heart of the new free electron laser at DESY has to shake transmitted electron beams with a precision of 20 μm.

Taking a new close look at the proton's weak magnetism



Results from the SAMPLE proton experiment. The magnetic moment due to strange quarks (vertical axis) is plotted as a function of of the weak axial vector current, as measured in parity-violating electron scattering. The blue band indicates the statistical uncertainty and the red band the systematic uncertainty. The vertical band is the theoretical estimate.



The MIT-Bates linear accelerator center in Middletown, Massachusetts.

Ever since Otto Stern surprised his colleagues in 1933 by announcing that the proton's magnetic moment was some three times as large as expected, physicists have puzzled over the origin of this effect. During the past two summers, the SAMPLE experiment at the MIT-Bates Linear Accelerator Center has shed new light on this question by measuring the proton's magnetism as seen by the weak, rather than the electromagnetic, interaction.

Although the weak interaction violates parity (left/right symmetry), it still tries to mimic electromagnetism, and this introduces a magnetic-like term, which was called "weak magnetism" by Gell-Mann in 1958.

The new measurement leads to the first direct information on how different quark "flavours" in the proton generate the magnetic moment. Because the electromagnetic and weak interactions are precisely related in the Standard Model, the new result can be combined with the proton's ordinary magnetic moment (and that of the neutron, the proton's iso-spin partner) to uncover the magnetic contributions of the separate quarks.

The experiment is an analogue of the classic electron-scattering experiments of Robert Hofstadter and his collaborators at Stanford in the 1950s. In the SAMPLE experiment, the electrons are polarized so that their spins are aligned either parallel or antiparallel to the beam direction. Scattering experiments with these two types of beam are sensitive to the mirror-symmetry (parity) violating nature of the weak interaction. However, the relative differences are only a few parts per million, presenting a significant experimental challenge.

An intense pulsed beam of polarized electrons from the Bates accelerator hits a liquid-hydrogen target. The backward-scattered electrons are detected with a large solid-angle air Cherenkov detector.

It is the strange quark contribution to the magnetic moment that is of the greatest interest, because such effects must come from the proton's "sea" of virtual quark-antiquark pairs.

In the first SAMPLE experiment, the parity-violating asymmetry of the proton was measured. Using a theoretical estimate for the contribution of the weak axial vector current, the portion of the magnetic moment due to strange quarks comes out to be significantly positive.

To check the axial current contribution, a second measurement was made last summer using a deuterium target, where the strange quark effects from the proton and neutron are expected largely to cancel. The analysis will reveal the strange quark contribution to the proton magnetic moment.

These experiments, plus new measurements from the Jefferson Lab (*CERN Courier* December 1999 p6), mark the beginning of a programme to determine the contributions of strange quarks to the proton's inner distributions of charge and magnetization.

SAMPLE is a collaboration between Caltech, Illinois, Louisiana Tech, Maryland, MIT, William and Mary, and Virginia Tech.

EPAC 2000 *Vienna*

7th European Particle Accelerator Conference
A Europhysics Conference

Austria Center Vienna
26 - 30 June 2000

The 7th European Particle Accelerator Conference will take place at the Austria Center, Vienna, from 26 to 30 June 2000. Previous conferences took place in Rome, Nice, Berlin, London, Sitges and Stockholm, with approximately 800 delegates participating each time. Lively poster sessions, an important industrial exhibition and a session organized with representatives of the industry in mind, complete the overall programme of the conference.

EPAC 2000 is a Europhysics Conference, organized by the Elected Board of the EPS Interdivisional Group on Accelerators. The Organizing Committee is chaired by Dr. S. Myers, CERN, Geneva. The Scientific Programme Committee is chaired by Dr. J.-L. Laclare, CEA, Paris. The Local Organizing Committee is chaired by Professor M. Regler, Institute of High Energy Physics of the Austrian Academy of Sciences, Vienna.

All information concerning the conference is published at the conference website at

http://www.cern.ch/epac/Vienna/General.html

Registration is possible via mail, fax, e-mail, and the WWW.

Edited by Alison Wright

Except where otherwise stated, these news items are taken from the Institute of Physics Publishing's news service, which is available at "http://physicsweb.org".

Bose–Einstein condensate goes molecular

Researchers in Texas, US, have reported the first observation of molecules formed in a Bose-Einstein condensate of rubidium atoms.

Confined in a magnetic trap, the atoms were cooled first by lasers, then using evaporation, until the condensate formed. Using laser-absorption imaging, the team measured the gas temperature to be below 130 nK and it determined that 80% of the atoms had settled into the condensate.

The team then fired lasers into the gas, which, at the right frequency, stimulated Raman transitions, and a dip in the measured number of atoms was seen as molecules were formed.

The linewidth for the transition in the condensate was less than a 10 000th the width of previous experiments using laser-cooled gases, because Doppler broadening and the kinetic energy spread of the colliding atoms are negligible in the condensate.

The precise shape and position of the resonance depended on the density of the condensate, indicating that there was sensitivity to the interactions between the molecules and the condensate atoms.

The researchers predict that this technique will allow molecular binding energies to be determined with unprecedented accuracy and that it will provide extremely precise information on long-range atomic interactions.

SQUIDs give support to symmetry with d-waves

In low-temperature superconductors, Cooper pairs of electrons (or holes) are essentially spherical and are said to have "s-wave" symmetry. However, in high-temperature superconductors the symmetry is believed to be a "d-wave", resembling a four-leaved clover, and with a π phase change between neighbouring leaves of the clover in the quantum wave function of the Cooper pair.

Evidence to support this has now been revealed by a group of German physicists with its fabrication of a "π-SQUID". A SQUID (superconducting quantum interference device) is a superconducting loop, interrupted by two thin insulating junctions, through which Cooper pairs tunnel. The researchers produced a SQUID in a 100 nm thick film of $YBa_2Cu_3O_7$ grown on a $SrTiO_3$ tetracrystal.

The SQUID was designed to exploit the expected "d-wave" symmetry and to introduce a π phase change over one of the two 9 μm diameter junctions. Exactly this behaviour was seen in tests up to 77 K, supporting the theory of "d-wave" symmetry in high-temperature superconductors. These devices could also find application as superconducting "qubits" in a quantum computer. *AIP*

Silicon particles make great balls of fire

Since the Middle Ages, eyewitnesses have reported ball lightning during thunderstorms. This extraordinary natural phenomenon of a football-sized sphere of light, floating just above the ground for anything from 2 to 50 s, has defied explanation.

Now, two New Zealand researchers have proposed a model that offers the most comprehensive explanation yet. They realized that in soil with a carbon to silica ($C:SiO_2$) ratio of 1:2, a lightning strike creates a sufficiently high temperature (approximately 3000 K) to extract pure silicon – exactly the chemistry exploited by the integrated-circuit industry.

Fast cooling following the strike causes the silicon to clump into chains of nanometre-sized particles. Then tangled chains of silicon could float through the air, as gradual oxidization releases thermal energy as heat and light.

The scientists exposed soil to a lightning-like 10–20 kV DC discharge, transferring up to 3.4 C of charge. Under an electron microscope, deposits from the air close to the discharge revealed chains of nanoparticles, 5–70 nm in diameter, exactly as predicted, but no ball lightning.

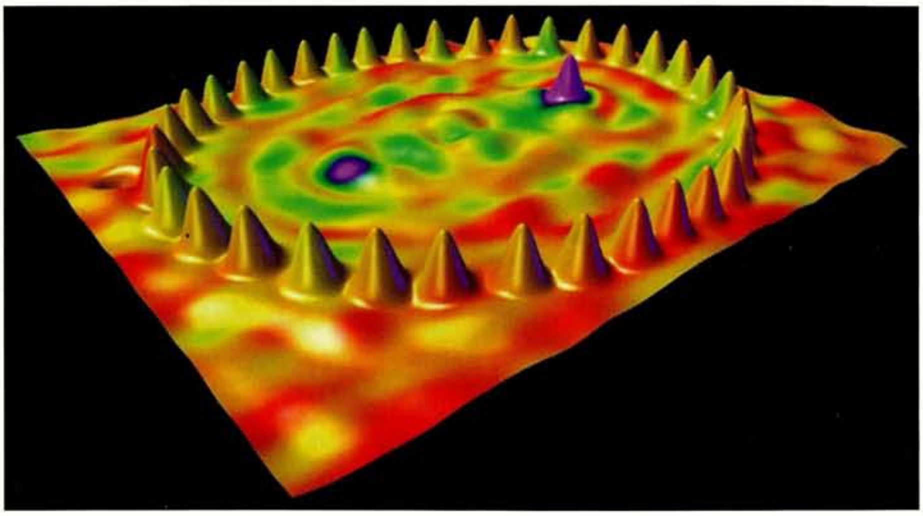
However, such is the attractiveness of this model in getting right so many features of ball lightning (size, motion, duration, luminosity and extinction), that the researchers are confident that more work on the lightning-soil interaction will allow them to home in on exactly the right ingredients to make ball lightning in the laboratory.

The spectacular phenomenon of ball lightning, seen here in a photograph taken in Austria in 1978, might be due to the oxidization of silicon particles released from the ground by a lightning strike.

Cobalt magnetic resonance forms quantum mirage

Classical image projection by lenses or resonant cavities is familiar in the bending of light in the atmosphere to form mirages, and the focusing of sound in whispering galleries. Researchers at IBM, California, have now uncovered an analogous phenomenon in condensed matter systems that they call a "quantum mirage".

The researchers arranged cobalt atoms in an ellipse of a few angstroms' breadth on the surface of a copper crystal and an extra cobalt atom was placed at the focus of the ellipse. Cobalt has a magnetic moment and, at low temperatures, exhibits a "Kondo resonance": the conduction electrons in the copper surface around the cobalt atom align their spins to screen the magnetic moment of the atom. The resonance is seen as a rise in resistance as the magnetic atom, surrounded by the spin-aligned electron cloud, becomes a more effective scatterer of conduction electrons.



Cobalt atoms, positioned on a copper surface, form an elliptical "quantum corral". When an additional cobalt atom is placed at one of the foci of the ellipse, a "mirage" of another cobalt atom appears at the other focus.

To measure the Kondo resonance, the researchers bombarded the cobalt atom at one focus of the ellipse with electrons from the tip of a scanning tunnelling microscope and saw a "ghost" cobalt atom appear at the other focus of the ellipse. Electron partial waves in the copper surface had been scattered by the cobalt atom and reflected (though not 100%) by the surrounding ellipse of atoms, to add coherently at the second focus. This quantum mirage is a surprisingly faithful spectroscopic replica of the real atom and opens the way for many "spectroscopy-at-a-distance" experiments. *AIP*

Edited by Emma Sanders

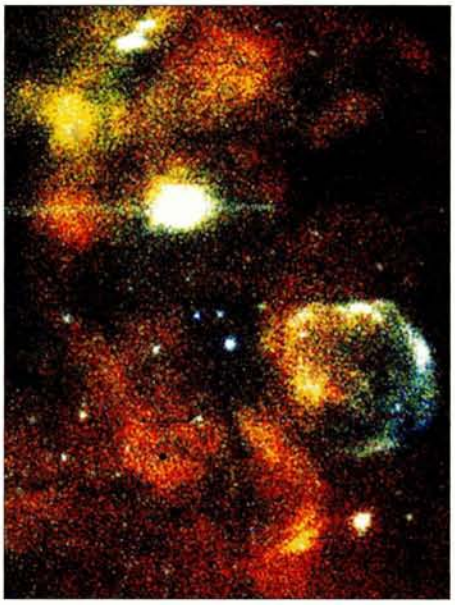
XMM Newton reveals first images

The first images have been captured using the new X-ray Multi-Mirror (XMM) space telescope, now called the Newton observatory. The telescope was successfully launched last December (*CERN Courier* January 2000 p13). Mission controllers say that the spacecraft is stable and that the instruments are working as expected. It is costliest science project ever undertaken by the European Space Agency.

The subject of the first observations was the Tarantula Nebula, part of the neighbouring galaxy the Large Magellanic Cloud. At temperatures of more than 1 million degrees, the Tarantula Nebula is a region of intense star formation with supernova explosions blasting material out into the surrounding medium. The expanding hot gas produces X-ray emissions as it collides with the interstellar medium.

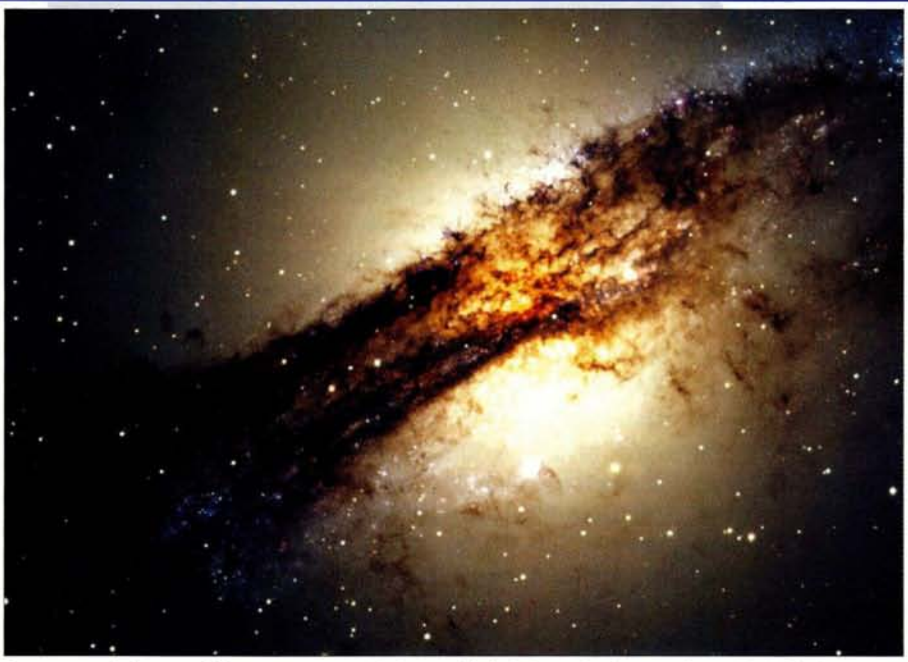
XMM Newton joins the US Chandra project (*CERN Courier* September 1999 p15) in studying the hottest, most active parts of the universe, such as gamma-ray bursts, quasars and the X-ray background radiation.

Another X-ray mission was not so lucky. The launch of the Japanese-American Astro-E spacecraft in February was unsuccessful, with the satellite not attaining the necessary altitude for a proper orbit.



XMM Newton reveals new structures in the Tarantula Nebula. Blue denotes the hottest regions, imaged for the first time. (ESA.)

Picture of the month



Centaurus A is one of the most extensively studied objects in the southern sky. This image shows the thick dust layers that almost completely obscure the galaxy's centre at optical wavelengths. It was captured using the KUEYEN telescope, one of the four 8 m telescopes of the European Southern Observatory's optical interferometer, the Very Large Telescope in Chile. Centaurus A has an active nucleus that emits strongly at radio wavelengths. It is the smallest known extragalactic radio source – only 10 light-days across. Radio and X-ray images show a jet of high-energy particles shooting outwards from the core, which is thought to contain a supermassive black hole with a mass of 100 million suns. (ESO.)

Workshop stresses potential of space technology

April sees a joint workshop on fundamental physics in space held at CERN and organized jointly by CERN and the European Space Agency (ESA). Interest in fundamental physics missions is at its greatest, and the last few years have seen major space agencies make policy moves to encourage the generation of new ideas (*CERN Courier* July 1999 p16).

The aim of the workshop is to highlight the possibilities offered by space technology: fundamental physics experiments such as tests of general relativity and the equivalence principle; measurements of cosmological parameters; the study of gamma-ray bursts and high-energy cosmic rays; and the search for dark matter candidates, to name but a few.

On 5–6 April there will be a series of specialized sessions for invited participants, followed by an open session on 7 April in the CERN auditorium with summary talks by the seven special session conveners. The European Physical Society and the European Astronomical Society are also sponsoring the event. See "http://www.cern.ch/Physics/Events/Conferences/2000/0405CERNESA/".

Cracow establishes a tradition

Neutrinos were the subject of an annual conference held in Poland in January.

Jack Steinberger (right) in discussion with Harald Fritzsch during this year's Cracow Epiphany Conference.

Marek Jeżabek (left), main organizer of the Cracow Epiphany Conferences, with Ferruccio Feruglio.

Neutrinos always provide compelling physics. An example of this occurred earlier this year on 7-9 January, just after the Epiphany holiday, when more than 150 high-energy and nuclear physicists and astrophysicists from many countries met in Cracow, Poland, for the Epiphany Conference on Neutrinos in Physics and Astrophysics, which is organized jointly by the Institute of Nuclear Physics and the Jagellonian University of Cracow. First held in 1995, these January Cracow meetings have now become an established feature of the international physics calendar.

Never lacking anyway, neutrino interest has been boosted by new evidence for neutrino oscillations - neutrino species (electron, muon and tau), long thought to be distinct and immutable, transform into each other. As well as surveying the experiments that led to this realization, the conference looked forward to new and planned experiments to investigate this new phenomenon further.

Of special interest are the long-baseline studies, in which neutrinos produced by an accelerator beam are observed by detectors installed at a distant point, typically several hundred kilometres away, for a direct measurement of neutrino oscillations. These manifest themselves either by the disappearance of the neutrino species produced at the accelerator site or by the appearance of a different neutrino species, depending on the capabilities of the detector installed.

One such project, K2K in Japan, which uses the neutrino beam produced at KEK and detectors of the Super-Kamiokande neutrino observatory (*CERN Courier* October 1999 p5), has just started operation. The status of this experiment and recent data on solar and atmospheric neutrinos from Super-Kamiokande were presented in Cracow by Danuta Kiełczewska (Warsaw). Results on the neutrino masses and mixing from other ongoing experiments were discussed by Jochen Bonn (Mainz), Yves Declais (Annecy) and Jonny Kleinfeller (Karlsruhe).

Two planned experiments, designed to use neutrinos produced at CERN and the detectors installed in the Grand Sasso tunnel in Italy, the ICANOE and the OPERA projects (*CERN Courier* January 2000 p1), were described by Andre Rubbia (Zurich) and Stavros Katsanevas (Lyon) respectively. Adam Para (Fermilab) summarized US neutrino experiments including the MINOS project, the 730 km baseline experiment using neutrinos from Fermilab (*CERN Courier* October 1999 p6), while Rob Edgecock (Rutherford Appleton) discussed the potential use of future muon colliders for super-long-baseline neutrino experiments (p17).

Theoretical aspects were covered by Harald Fritzsch (Munich), who discussed potential connections between quark and neutrino mixings, Ferruccio Feruglio (Padova), who reviewed existing theories, and Marek Zrałek (Katowice), who discussed the experimental constraints for Dirac neutrinos. The theory of unification and evolution of the neutrino masses was discussed by Stefan Pokorski (Warsaw) and Smaragda Lola (CERN).

On the subject of neutrinos in astrophysics, Wojciech Dziembowski (Warsaw) discussed the tests of the Standard Solar Model and production of solar neutrinos, Edwin Kolbe (Basel) talked about neutrino-nucleus interactions in stars, Henryk Wilczyński (Cracow) presented the neutrino aspect of the Pierre Auger cosmic-ray experiment and Anna Staśto (Cracow) discussed the penetration through the Earth of super-high-energy neutrinos.

The conference was summarized by 1988 Nobel laureate Jack Steinberger (CERN), who recalled the milestones of neutrino physics.

The first Cracow Epiphany Conference, in January 1995, was dedicated to Kacper Zalewski, one of the most creative and influential Cracow theoretical particle physicists, in honour of his 60th birthday. The subject was the physics of heavy quarks, one of Zalewski's main fields of research. The success of that meeting encouraged Marek Jeżabek, longtime Zalewski collaborator and (since last year) his successor as Head of Particle Theory Department of the Institute of Nuclear Physics in Cracow, to start a tradition. The idea was to change the subject of the conference every year and to attract the whole community of Cracow particle physicists working at the Jagellonian University, at the Institute of Nuclear Physics and at the Technical University of Mining and Metallurgy.

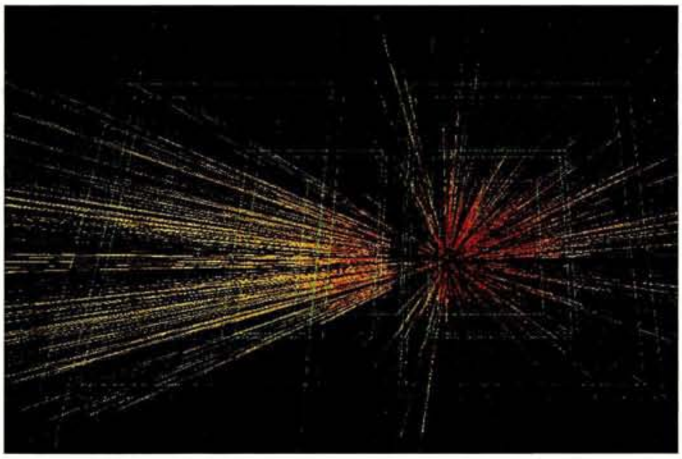
In 1996 the conference topic was proton structure, followed by W boson physics in 1997, the spin effects in particle physics in 1998 and electron-positron colliders in 1999.

The next Cracow Epiphany Conference, to be held on 5-7 January 2001, will cover b physics and CP violation. Further information is available from "epiphany@ifj.edu.pl".

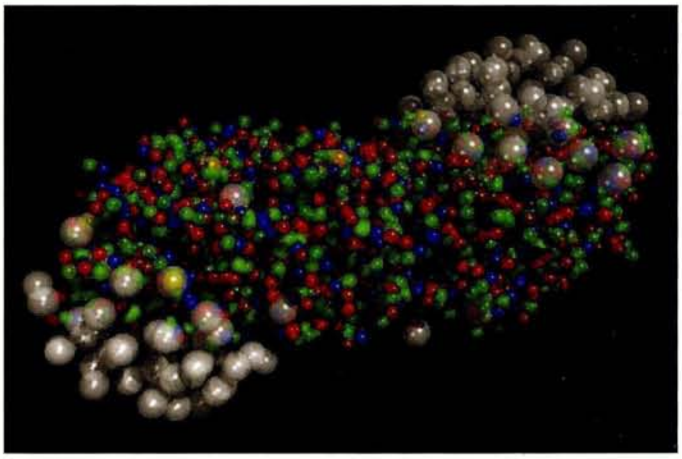
Jan Czyżewski, *Jagellonian University, Cracow.*

Heavy implications for the first second

After a decade of running, the results from CERN's research programme with high-energy nuclear beams provide tantalizing glimpses of mechanisms that shaped our universe.



Recreating the Big Bang – a "Little Bang" as seen by the NA49 experiment at CERN. The image shows a display of the tracks emanating from the Little Bang created in a central collision of lead projectile with a lead nucleus.



Fusion of two high-energy nuclei to form a core of plasma of quarks and gluons – the kind of matter produced a few microseconds after the Big Bang to set the stage for the production of nuclear particles.

About a microsecond after the Big Bang, the universe was a seething soup of quarks and gluons. As this soup cooled, it "froze" into protons and neutrons, supplying the raw material for the nuclei that appeared on the scene a few minutes later.

To check if this imagined scenario is correct, since 1986 experiments at CERN have been accelerating beams of nuclear particles to the highest possible energies and piling them into dense nuclear targets. Recreating what happened in the first microsecond of creation has so far taken many years of careful and painstaking work.

The goal has been to use the energy supplied by the nuclear beams to recreate tiny pockets of primordial quark-gluon plasma about the size of a big nucleus and watch them behave as "Little Bangs". Theorists using simulation tools predict that this soup/plasma should be formed at a temperature of about 170 MeV (about 10^{11} degrees, or 100 000 times the temperature at the centre of the Sun) with an energy concentration of about 1 GeV per cubic femtometre – seven times that of ordinary nuclear matter.

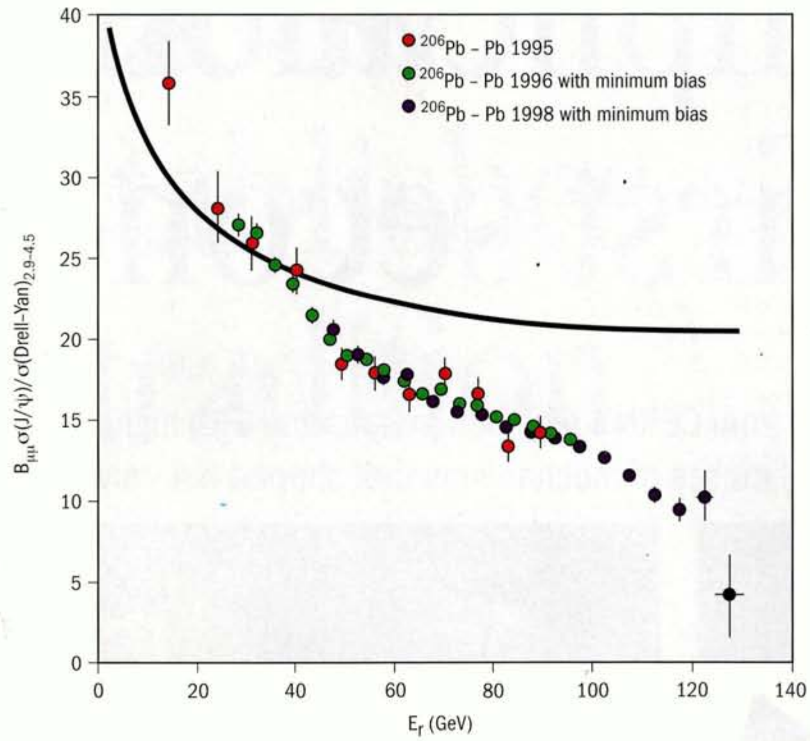
The milestones of the early universe, separated by only fractions of a second, nevertheless stretched over immense energy gaps as the Big Bang temperature plummeted. The Little Bang experiments too have to contend with vast swings of temperature/energy.

The experiments take snapshots of the particle patterns emerging from these Little Bangs, but these patterns, although embedded in the particle behaviour, are quickly masked by the surrounding nuclear debris. The challenge is to peer through this debris to glimpse the signature of the Little Bangs.

Ion beam experiments

The ion beams at CERN serve several large experiments, codenamed NA44, NA45, NA49, NA50, NA52, WA97/NA57 and WA98. Some of these studies use existing multipurpose detectors to investigate the fruit of the heavy-ion collisions. Others are special dedicated experiments to detect rare signatures.

On both the machine and the physics sides, the programme is an excellent example of collaboration in physics research. Scientists from institutes in more than 20 countries, including Italy, Japan, Germany, France, Portugal, Russia, Finland, India, Poland, Greece, Switzerland, the UK and the US, have participated in the ▷



Fingerprint of quark–gluon plasma: compared to predictions (solid curve), production of the J/psi particle in lead–lead nuclear collisions, as measured by the NA50 experiment, is strongly suppressed (right) when the nuclei hit head-on.

At a seminar on CERN's heavy-ion programme, Johanna Stachel of Heidelberg looked at the role of photons emerging from fireballs.

experiments. The programme has also allowed a new productive partnership to develop between high-energy physicists and nuclear physicists, and it has considerably extended the number of scientists using CERN as a research base, with new research centres, some of them from far afield, joining the CERN research programme.

Estimates of the energy density established when the colliding nuclei coalesce point to several giga-electron-volts per cubic femtometre (*CERN Courier* November 1999 p8), suggesting that the theoretically expected critical energy threshold has been crossed.

One important quark signature is the J/psi particle, which is made of a charm quark and its antiquark. J/psis are rare because charm quarks are heavy. However, theorists suspected that the production of J/psis would be suppressed by the screening of the quark "colour" charge by the surrounding quark–gluon matter. A strong reduction in the number of J/psis leaving the fireball would suggest that hot quark-gluon plasma was initially present. This is exactly what the NA50 experiment saw (*CERN Courier* May 1999 p8).

Other particles - phi, rho and omega mesons - are composed of lighter quarks and antiquarks bound together. These mesons can be seen through the surrounding fog of dense matter via their decay into pairs of weakly interacting particles - for example, electron–positron pairs - which pierce through the surrounding strongly interacting material. In a quark–gluon plasma, the quarks and antiquarks find it difficult to lock onto each other and therefore their signals get smeared out, as seen in the NA45 experiment.

Another encouraging sign seen quite early in CERN's heavy-ion experiments was the increased production of particles containing strange quarks. The ion projectiles only contain up and down quarks - no strange quarks. High-energy proton–proton or electron–positron collisions provide enough energy to synthesize strange quark–antiquark pairs, but for the nucleus–nucleus collisions the fraction seen by the WA97 experiment was markedly higher. The greater the strangeness content of the emerging particles, the more their production levels were increased. For example, the yield of Omega baryons containing three strange quarks was 15 times normal.

In principle the cleanest quark signals are the electromagnetic ones, and WA98 has seen some preliminary signs of an increased yield of single photons radiated by quarks.

Quark chemistry

The particles leaving the fireball retain signatures of their past, pointing back in time. In elastic scattering when particles "bounce" off each other, only their momentum changes. As the fireball expands, the energy density decreases until the hadrons no longer interact - their momenta "freeze out". The momentum distribution of the particles leaving the fireball gives a snapshot of when this freeze-out occurred, at a temperature of about 100 MeV.

What happened if the fireball was much hotter and denser, when quark chemistry was operating? Once the resulting subnuclear particles emerged, their composition reflected what happened when the quarks froze. These particle distributions serve to reveal the chemical freeze-out temperature when quarks became subnuclear particles - around 180 MeV, which agrees with the critical temperature predicted by theory.

Another experimental technique, based on interferometry, is a development of the pioneering astronomical work of Hanbury, Brown and Twiss and adapted for particle physics by Giuseppe Cocconi at CERN in 1974. Looking at correlated pairs of particles, this technique measures sizes. The rate of expansion of the system is known, so size information can be extrapolated backwards to reveal the original energy density and to disentangle thermal motion from collective flow.

Heavy ions at CERN

The CERN results obtained with lead beams are the culmination of a long programme. A proposal in 1982 from heavy-ion enthusiasts suggested that the CERN machines could be used to accelerate beams of oxygen ions to extend interesting heavy-ion results obtained earlier at Darmstadt's Unilac and Berkeley's Bevalac.

Despite CERN's crowded programme (the SPS proton–antiproton collider was then in full swing) and commitments to new projects such as LEP, development work for heavy-ion beams began at CERN through a Berkeley/CERN/Darmstadt collaboration. An important element was CERN's Linac 1 injector, which had already learned how to handle deuterons and alpha particles. This was fitted with an electron cyclotron resonance ion source from Grenoble and a radiofrequency quadrupole from Berkeley.

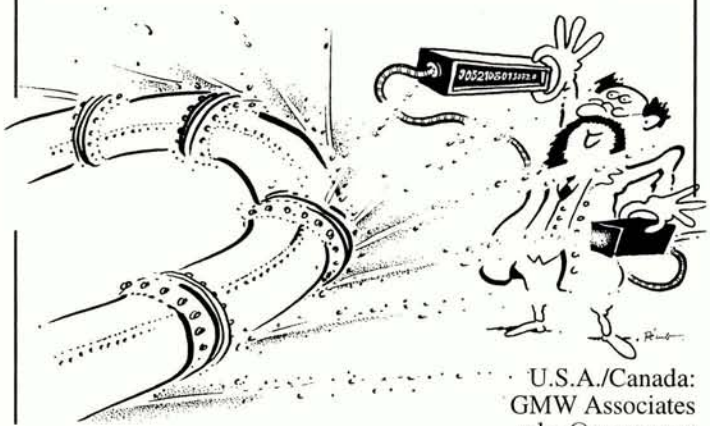
In the mid-1980s, at the same time as CERN's big machines were learning how to handle electrons and positrons in preparation for LEP, an experimental programme got under way at CERN's SPS synchrotron using 200 GeV/nucleon oxygen ions. Complementary data came from a programme at Brookhaven's AGS synchrotron with beams of 14.6 GeV/nucleon.

CERN soon extended the range of its experimental programme by supplying sulphur beams at 200 GeV/nucleon. From 1993, equipped with the new Linac 3 injector and its ion source, and in a collaboration between CERN and institutes in the Czech Republic, France, India, Italy, Germany, Sweden and Switzerland, the reach of the experiments was considerably extended using the much heavier lead projectiles.

The future

These results, announced on 10 February at CERN, resulted in a blaze of media hype. However, they are not definitive and have to be followed up. While all of the pieces of the puzzle seem to fit a quark–gluon plasma explanation, it is essential to study further this new form of matter to characterize its properties fully and confirm the quark-gluon plasma interpretation. Where exactly is the energy threshold for the new state of matter? What are the critical sizes of the produced fireballs? What is the actual transition? In a succinct analogy from theorist Maurice Jacob, "We have seen boiling water but we do not yet know what steam looks like, nor how the boiling goes."

Although the ion beam experiments at CERN continue, the focus of heavy-ion research now shifts to the Relativistic Heavy Ion Collider at Brookhaven, which starts experiments this year. Due to start in 2005, CERN's Large Hadron Collider experimental programme will include a dedicated heavy-ion experiment, ALICE. □



Second Announcement

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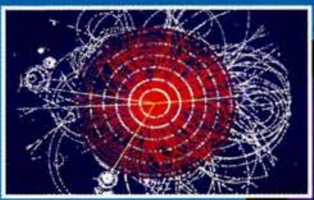

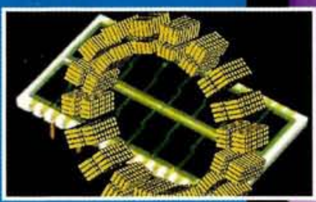

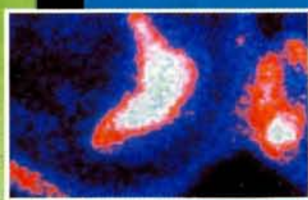

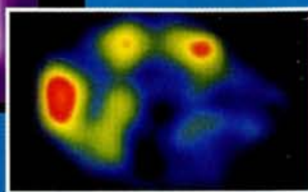

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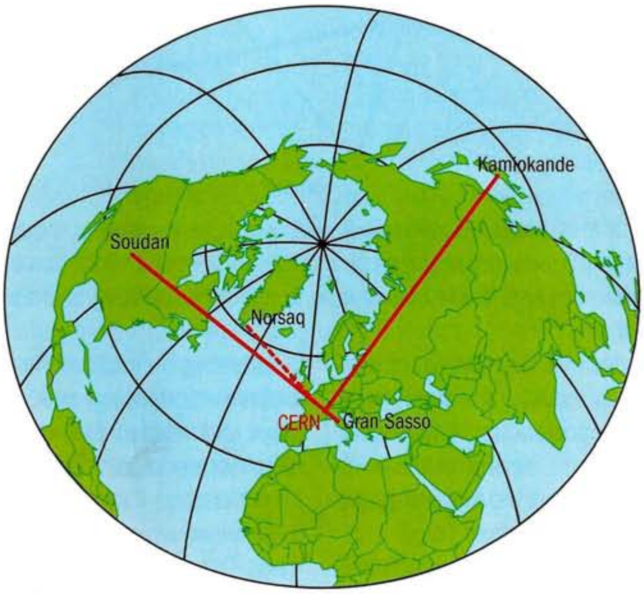
Making muon rings round neutrino factories

A new way of making neutrino beams has caught the attention of physicists worldwide.

Almost every day, fresh results steadily fuel the progress of science. Less frequently, major breakthroughs in experimental techniques revolutionize the way in which this research is done. Examples of such breakthroughs in particle physics include the development of accelerators in the 1950s, and of colliding rings in the late 1960s, finally culminating with CERN's proton–antiproton collider, using beam-cooling techniques and opening up a new energy regime.

Although there is still a long research and development road to be negotiated, the first major breakthrough in particle physics experimental techniques for the 21st century looks to be the advent of a new type of machine – the muon storage ring – and using it to provide neutrino beams.



A world machine – intercontinental neutrino beams.

Making accelerators with muons seems crazy at first. Machine builders so far have had the wisdom to store and accelerate particles that are abundant – like the protons and electrons naturally found in matter – or, if not abundant, that at least have the good taste to be stable, like positrons and antiprotons.

It takes at least 30 min to fill CERN's LEP collider and accelerate its beams of electrons and positrons. How could one do such a thing with unstable muons, with their combined inconveniences of being rare and having a lifetime of a mere 2.2 μs?

Progress in accelerator techniques has made this challenge at least conceivable, to the extent that there has been discussion of muon collider rings (*CERN Courier* December 1997 p1) as a serious future option in the US and at CERN.

When, following the inspiration of the US muon collider collaboration, European physicists started looking at this new route, the obstacles appeared overwhelming, with many new problems to solve simultaneously.

A breakthrough came with the realization that muon decay could be turned into an advantage – muon storage rings would be an abundant source of neutrinos. Coming at the same time as the new awareness of neutrino oscillations (*CERN Courier* September 1998 p1), this step forward met with a thunderclap of enthusiasm.

The muon storage ring as neutrino source, nicknamed "neutrino factory", requires a much lower density of particles and should thus be easier to build than a muon collider. The decay of muons into electrons provides the only known source of high-energy electron-type neutrinos – a unique and powerful new physics tool.

This led the prospective study group mandated by the European Committee for Future Accelerators (ECFA) to propose a three-step approach to muon storage rings, the first being the construction of a neutrino factory (Autin, Blondel and Ellis 1999). This has led to a series of international workshops – Lyon in July 1999 and Monterey, California, in May 2000. Neutrino-factory research and development is now a well recognized and supported project at CERN and further afield, with ECFA-supported study groups investigating the very rich physics opportunities.

Beams from rings

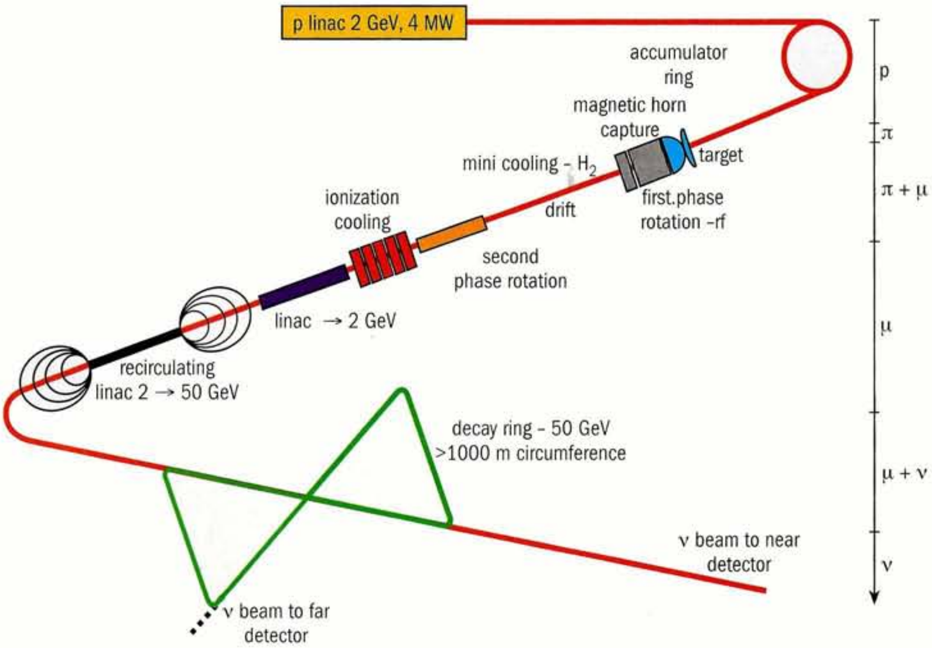
The key requirement is a very intense proton accelerator, delivering several megawatts of beam power. These protons will be used to create pions, which will be magnetically collected. Designing a target to withstand so much power more than once is beyond what has been achieved so far and will require either a liquid jet target or a very large rotating wheel to dissipate the heat.

Pion collection is optimized for rather low momentum – about 300 MeV/c. These pions rapidly decay into muons of similar momentum. At this point the "beam" is about 1 m across and the haphazard momentum spread 100% – more like a big, hot potato than a beam. ▷

The design challenge is to shrink the momentum spread to 5% and the beam size to a few centimetres within a few microseconds to shape the muons into an acceptable beam.

This requires two crucial elements. The first, "phase rotation" ("monochromatization"), uses variable longitudinal electric fields of a few million volts per metre to slow down the fastest particles and accelerate the slow ones. This needs either high-gradient, low-frequency radiofrequency cavities or an induction linac, with considerably improved performance compared with what has been achieved so far.

The second crucial beam element is cooling. Beam cooling was a key feature of CERN's antiproton project, converting the largest possible number of rare particles produced from a target into a smooth beam. While antiprotons are stable and can be stored almost indefinitely, muons need fast action. However, as muons choose not to interact strongly with nuclear matter, one can use cooling via ionization energy loss, reducing the momentum in three dimensions. Followed up by reacceleration in the beam direction via a longitudinal electric field, the net result will be a decrease of transverse momentum. Simulations are promising, but this technique has yet to be demonstrated in practice.



A possible layout for a neutrino factory, showing the complex chain of upstream machines required. In this case the decay "ring" has a bow-tie shape to point neutrino beams in several directions. Many other designs are possible.

This initial conditioning is followed by a series of fast accelerators to take the muon beam to high energy. If well designed, the system spares enough muons after decays or acceptance losses so that, from the original 10^{16} protons per second, 10^{14} high-energy muons per second can be injected into a storage ring, where during a few hundred turns, positively charged muons, for example, will decay into electrons, accompanied by electron-type neutrinos and muon-type antineutrinos.

Storage ring geometry

The intentionally long, straight sections of the storage "ring" generate a large flux of collimated neutrinos, particularly electron-type ones, with properties very different to those of traditional laboratory neutrino beams (which are mainly composed of muon-type neutrinos). The geometry of the storage ring is left to the designer's imagination. Bow-tie, triangular and trombone ring configurations have been proposed.

Whatever the geometry, very intense neutrino beams would be available right next to the storage ring, opening a new era of neutrino physics. However, what has made everyone really excited is the prospect of firing neutrino beams through the Earth, serving several underground experiments in several continents and providing different neutrino flight paths – "baselines" – for the study of neutrino oscillations.

For a long time the three neutrino types (electron-, muon- and tau-) were considered massless, and thus immutable.

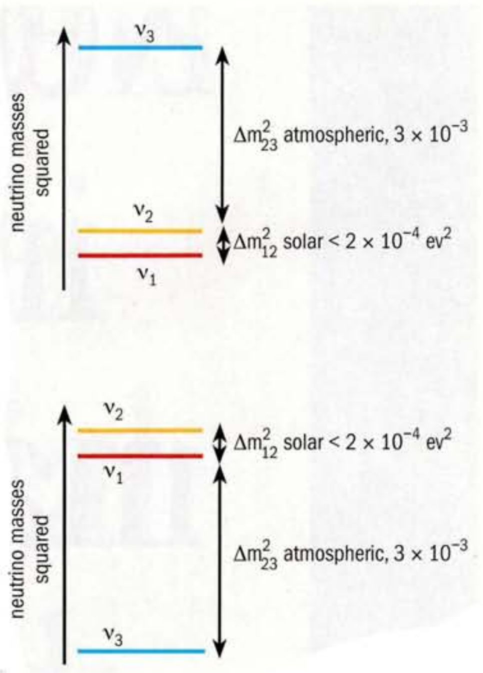
Following indications from solar neutrinos as early as 1975, experiments studying neutrinos produced by the decay of cosmic-ray pions and muons in the atmosphere finally confirmed in 1998 that neutrinos undergo transmutations. The observed signals can only be understood if neutrinos starting out as muon-type in the upper atmosphere change into another type in transit – probably tau neutrinos. This neutrino "oscillation" can only be understood if the particles have a mass.

Although these masses are probably tiny – a fraction of an electron volt – the consequences are considerable. As neutrinos are one of the most common particles in the universe, their total mass could provide a significant fraction of the whole mass of creation. From the particle physicists' point of view, neutrinos are very interesting. Since they do not feel electromagnetic or strong forces, one hopes they could provide cleaner clues to the origin of mass.

In quantum mechanical language, neutrinos produced in a weak decay or interacting via weak interaction are well defined – the well known electron, muon and tau neutrino "flavours". However, if they have mass, neutrinos also feel the mysterious "Higgs" force that generates masses, and the neutrino states emerging with well defined masses need not be the same as those with well defined flavours.

The three flavour neutrinos are therefore mixtures of the three mass neutrinos, and a matrix of parameters connects the two triplets. Moreover, as usual in quantum mechanics, this mixing has time-dependent phases, so that any one neutrino flavour turns into another as time passes – as one type of neutrino disappears, another "appears" to take its place. This is what is meant by neutrino oscillations.

Information on these oscillations is still scanty, but atmospheric neutrino experiments tells us that a muon neutrino of 1 GeV probably turns into a tau neutrino after about 500 km. Experiments with



Possible (squared) mass spectra of neutrinos. So far the experiments have only been able to measure the differences between (squared) masses. A neutrino factory would be capable of distinguishing unambiguously between these alternative scenarios.

electron neutrinos from nuclear reactors show that these particles are reluctant to oscillate on this timescale. The disappearance of solar neutrinos, which set out as electron-type, shows that these particles have a much longer oscillation timescale. However, solar neutrinos are somewhat ambiguous, since neutrinos produced deep in the stellar interior have to travel through the Sun before emerging into the vacuum of space, and one does not know where the oscillation takes place.

New "long baseline" experiments, firing neutrino beams at detectors hundreds of kilometres distant, are setting out to explore these oscillations in more detail (*CERN Courier* January p1). However, these experiments are based on conventional synthetic neutrino beams, composed mainly of muon-type particles, and are expected to validate and sharpen the pattern derived from the combined findings of atmospheric neutrino experiments and reactor neutrino experiments, although surprises cannot be excluded.

Crucial information should come from new reactor and solar neutrino experiments – Kamland (*CERN Courier* April 1999 p22), Borexino(*CERN Courier* October 1998 p12) and SNO (*CERN Courier* July 1998 p1) – sensitive to the disappearance of electron neutrinos suggested by the solar neutrino experiments.

New neutrino physics

With the neutrino factory, and as new results from solar, reactor and accelerator experiments become available, physicists can plan a much more systematic investigation of neutrino mass differences and mixings. The key is the high-intensity flux of electron neutrinos from a neutrino factory. With this, any appearance of muon neutrinos from oscillation of the electron neutrinos would give an immediately recognizable neutrino interaction signature, producing a muon of opposite sign to that of the original muon beam.

Comparing results using beams of positively and negatively charged muons would contrast the behaviour of electron neutrinos and their antineutrinos. As neutrinos pass through matter, they encounter atomic electrons. The interactions of electron neutrinos and antineutrinos with these electrons are different, and would lead to a matter-induced asymmetry.

Depending on whether the transmutation into muon neutrinos of electron neutrinos and antineutrinos are enhanced or suppressed by matter, one would be able to distinguish between the two mass scenarios shown in the figure.

CP violation with neutrinos

Comparing oscillation rates for electron neutrinos and antineutrinos would open another possibility, which until recently had been almost unthinkable. By comparing the transformations of, say, electron-neutrinos into muon-neutrinos with the process in the reverse direction, and with the corresponding rates for antineutrino transformations, physicists could for the first time be able to investigate delicate CP and time symmetry violations for the neutrino sector.

Such effects have been well explored in the quark sector, using the neutral kaon system. CP violation unambiguously differentiates particles and antiparticles, implying that what is called matter and what is called antimatter is not a heads-or-tails call. This is one of the necessary ingredients to explain how a matter-dominated universe evolved from a Big Bang that supposedly produced equal amounts of matter and antimatter.

CP violation is deeply connected to the violation of time reversal symmetry, when a "film" of a particle interaction run backwards would look different.

World machine

Neutrino physicists are very excited at these prospects. However, such experiments would require very long baselines (in excess of 3000 km) and preferably two different baselines to unravel different processes. This leads to a vision of a truly world machine with intercontinental beams.

These new neutrino sources are of world-wide interest and a whole network of detailed working groups has been set up to attack the problems. A crash study at Fermilab will shortly make its recommendations, while a wider study involves other US laboratories.

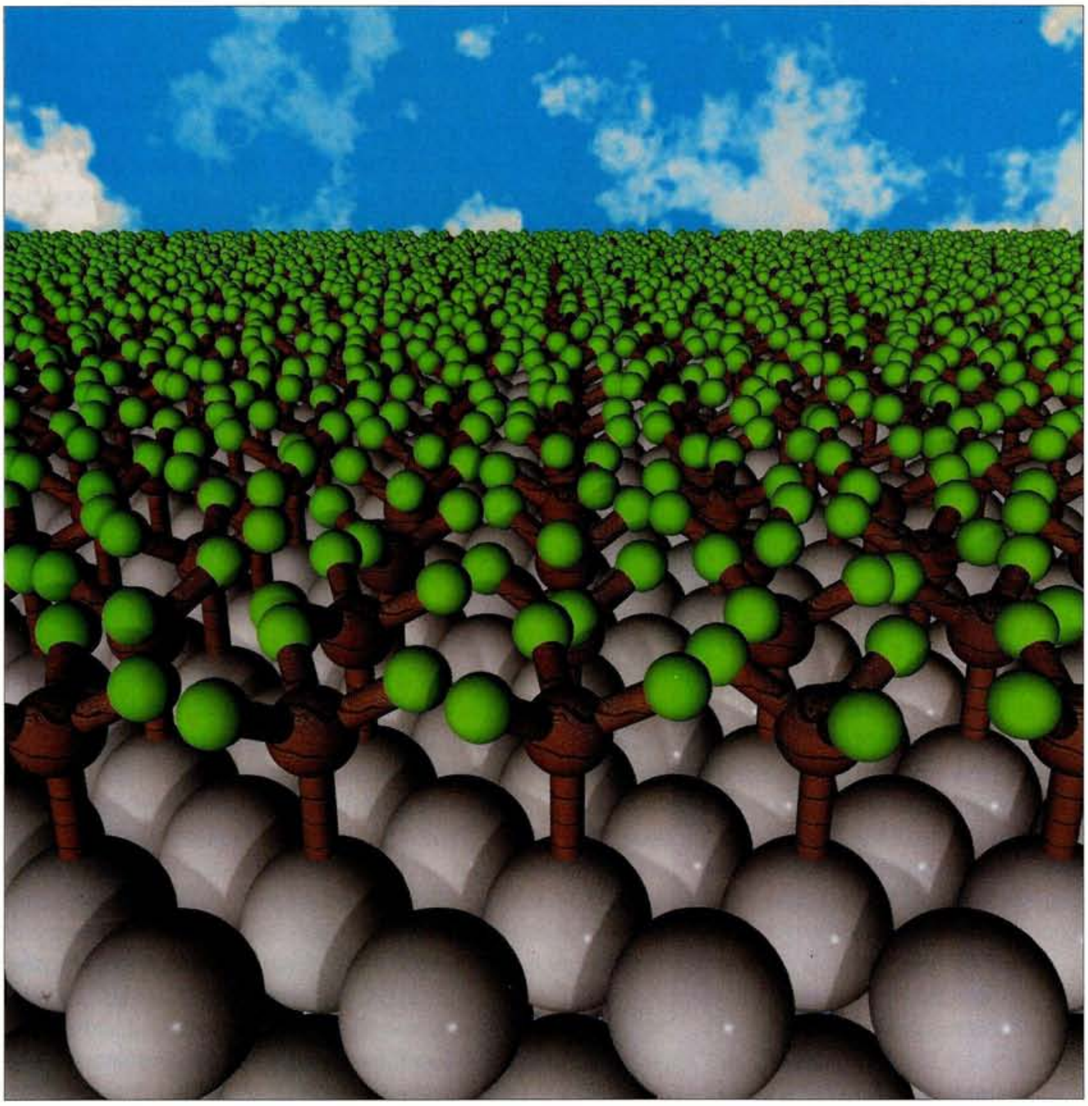
In Europe, CERN has set up a neutrino factory study group with specialized subgroups looking at specific machine components (proton driver, targets, accumulator rings, etc). Other groups, under the sponsorship of the ECFA, look at physics objectives. These studies involve specialists from many European laboratories.

By the time this year's Neutrino Factory meeting in Monterey takes place in May, these plans should have progressed significantly and hopefully give insight on how difficult the construction of a neutrino factory will be, on how long it would take to design and build. A similar effort is necessary to understand what detectors could be built to best take advantage of these fascinating beams. This is certainly a line of physics that will take us well into this century!

Further reading

B Autin, A Blondel and J Ellis, *Prospective Study of Muon Storage Rings at CERN*, CERN 99-02, ECFA 99-197.

Alain Blondel, *University of Geneva, and* **Gordon Fraser**, *CERN.*



"Forest": catalyst deactivation is a major financial burden on the chemical industry and understanding how it happens is the key to preventing it. Using vibrational neutron spectroscopy on the TOSCA instrument at the ISIS neutron source, it was shown in one crucial industrial process that methyl (CH_3) groups had covered the surface of a commercial palladium metal catalyst. As shown here, the CH_3 groups prevent the reactants from reaching the surface, stopping the reaction.

Neut in t mat wo

Some 15 years ago, ar a neutron source o accelerator came to fr detector and data ac continue to play an i ISIS at the forefro

ISIS, the major facility at the Rutherford Appleton Laboratory (RAL) in Oxfordshire, UK, is the world's most powerful pulsed spallation neutron source. Since 1984 it has provided beams of neutrons and muons that have enabled the structure and dynamics of condensed matter to be probed on a microscopic scale ranging from the subatomic to the macromolecular, from a proton wavefunction to a protein structure.

Neutron production

Construction of the source was approved in 1977, following a proposal by UK scientists who saw an opportunity to build a world-leading neutron facility replacing the aging NIMROD proton accelerator at the then Rutherford Laboratory. In contrast with the traditional means of neutron production by nuclear fission, which involves the production of a continuous stream of neutrons, ISIS was to be a pulsed neutron source, similar to but much more intense than the existing IPNS source at Argonne National Laboratory in Illinois, US.

First, H^- ions would be accelerated in a pre-injector column to 665 keV, then passed into a linear accelerator consisting of four accelerating RF cavities, reaching an energy of 70 MeV. At the point of injection into the final acceleration stage (a 52 m diameter proton synchrotron), the electrons would be stripped from the H^- ions by a 0.25 μm alumina foil, to produce a circulating beam of protons.

At full intensity, 2.5×10^{13} protons per pulse would be accelerated to 800 MeV, before being extracted and sent to a heavy metal target, producing a burst of neutrons by spallation. This whole process would then be

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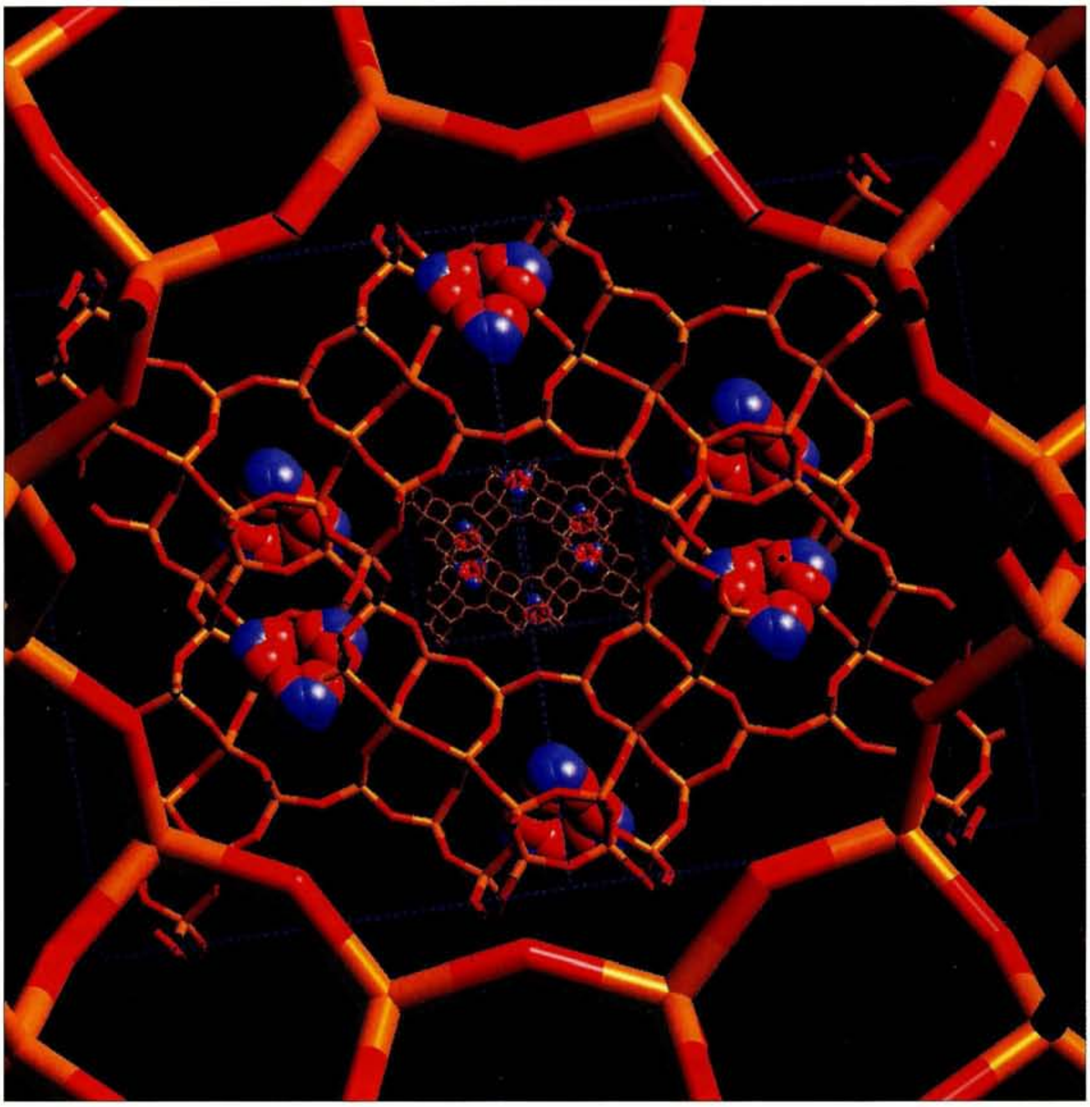


"Trapped": the microporous structure of Zeolite Y is the cage within which NO molecules are imprisoned. Recent neutron powder diffraction experiments on the HRPD instrument at the ISIS neutron source have detected the way in which NO molecules bind onto the zeolite Y framework structure. These experiments help us to understand the catalytic and exchange processes in which these materials are involved. Of particular relevance here is their role in cleaning up fuel emissions.

repeated 50 times per second.

As a result of the low duty cycle of the ISIS accelerator, the time-averaged heat production in the ISIS target would be a modest 160 kW, but, in the pulse, the neutron brightness would exceed that of the most advanced steady-state sources. In addition, the structure of the neutron pulse would be exploited using time-of-flight measurement techniques and white neutron beams, thereby providing a direct determination of the energy and wavelength of each neutron detected. The duty cycle of the accelerator would also ensure good signal-to-noise levels.

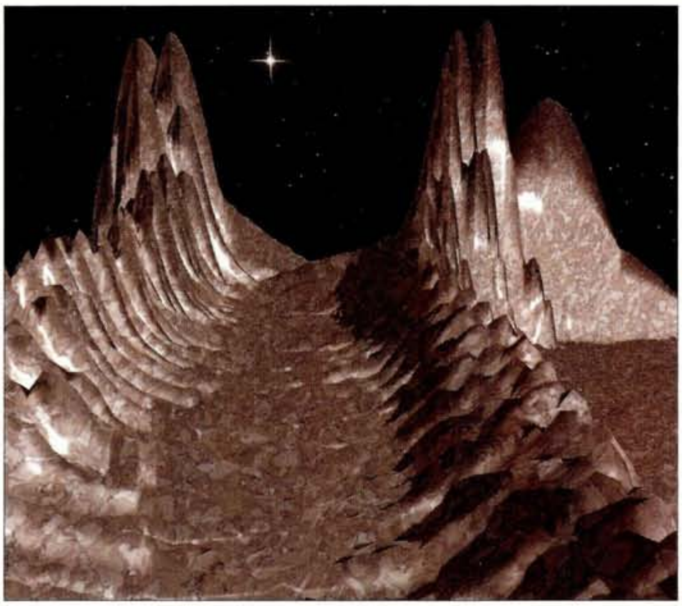
The major GEM detector at ISIS: a view of the diffractometer during construction, looking down the beamline towards the neutron source. The large detector banks can be seen on either side of the person standing at the sample position.

The first neutrons were produced in late 1984 and ISIS was officially inaugurated in October 1985. The facility reached its design specification of delivering 200 μA pulses to the target station in 1993, and it has run more or less consistently at this level since then.

Leading edge science

Over the past 15 years, ISIS has attracted substantial international investment and has developed into a major international force in condensed matter research. It has seen its complement of instruments rise from 6 to more than 20 and its user base from 200 to more than 2000. This popularity reflects the fact that the neutron is in many ways the ideal probe for the study of solids and liquids.

The citation for the 1994 Nobel Prize for Physics to Brockhouse and Schull for their pioneering work in neutron scattering put this point succinctly – neutrons simultaneously probe the structure and dynamics of matter, bringing insight at an atomic and molecular level about where atoms "are" and what atoms "do".



"Moonscape": the ISIS synchrotron is used to accelerate a 200 μA proton beam to 800 MeV using an RF system that captures and accelerates the beam in "buckets". This shows the beam density of a small diagnostic beam in a single bucket during its acceleration, with the mountain peaks representing the beam bunching at the bucket edges.

Structural and dynamical studies at ISIS have had a major impact at the cutting-edge of materials development at both the fundamental and the applied levels. ISIS has been heavily involved in many of the most exciting stories of recent years, including the physics "Woodstock" of high T_c superconductors and the discovery of a new form of carbon, C_{60} (Buckminsterfullerene). On the applied side, work at ISIS underpins the development of materials such as batteries, detergents, catalysts, pharmaceuticals and polymers.

More data faster

Over the past 15 years the problems tackled at ISIS have become ever more diverse and challenging. The desire to collect more data faster has become irresistible, as areas such as *in situ* and time-resolved studies on increasingly complex systems become more important. To handle this trend, detector arrays have expanded enormously from those originally installed, employing "spin-off" technology borrowed from high-energy physics techniques.

Next-generation instruments at ISIS, such as the new MAPS spectrometer and the GEM diffractometer, now include detector arrays with areas as large as 16 m^2 – orders of magnitude larger than those available in 1984 and containing more than 50 million data points per measurement. Much of the development of these new neutron detectors, both in terms of front-end construction and signal encoding, has been undertaken at RAL.

In tandem with these large detector arrays, the data acquisition and storage systems at ISIS must also be state of the art to handle the huge volumes of data generated. ISIS instruments operate to a common data acquisition framework based on the RAL-developed electronics. The ability to develop, build and support such advanced systems in house has again relied a great deal on experience gained from RAL's historical and continuing involvement in other aspects of high-energy and particle physics.

Looking to the future

While the trend towards massive detector arrays is one way of increasing the number of neutrons utilized in an experiment, developments in the synchrotron ring are taking place that will increase the current that can be delivered to the target to 300 μA.

This involves the addition of a second harmonic to the existing accelerating RF waveform, achieved by the insertion of four new RF cavities into the existing ring. As well as benefiting all of the instruments clustered round the existing target station via increased neutron production, this enhanced current can be shared with a second target station optimized for the production of longer-wavelength cold neutrons, opening up new research opportunities in fields such as complex macromolecular assemblies, magnetism, colloid and surface chemistry, high-resolution diffraction and the biological sciences. Furthermore, the enhanced current will be essential if the SIRIUS project, which aims to utilize the spallation source as a method of producing radioactive nuclei for post-acceleration, is to become a reality.

Tony Csoka, **Kenneth Shankland** *(Data Analysis Group)*, **Chick Wilson** *(head of Crystallography) and* **Andrew Taylor** *(director), ISIS Facility, Rutherford Appleton Laboratory.*

Honouring Burton Richter

Winner of a Nobel Prize for physics, a longtime laboratory director and a leading figure in international science – Burton Richter's contributions range wide. A recent celebration at the Stanford Linear Accelerator Center paid tribute.

Haim Harari from the Weizmann Institute in Israel said it best: "On occasions like the celebration honouring Burton Richter, the talks require a formula: 30% physics, 30% nostalgia, 30% entertainment and 10% admiration."

Other speakers at the day-long celebration held at the Stanford Linear Accelerator Center (SLAC) in January varied a great deal in these percentages. The day was, in turns, serious, funny and sentimental. When the balance shifted to the sweet side, Richter, now emeritus director of SLAC, commented: "You can get sick on too much sugar."

Burton Richter – acquiring memorabilia.

Harari's presentation reviewed the November Revolution of 1974. He recalled mailing a letter home to Israel on 8 November of that year, saying that things were rather boring at SLAC and that he wished that he were at Fermilab. Two days later, the psi peak was discovered at the SPEAR electron-positron collider and Harari realized his good fortune in being at SLAC on such a momentous occasion.

Weighing in heavily on the admiration end of the scale, both Martha Krebs, former director of the Office of Science at the Department of Energy (DOE), and John O'Fallon, head of the high-energy physics programme at the DOE, praised Richter for his candour and his mentoring of the young (and "not-so-young", according to Krebs). "Richter is a strong and ardent advocate for science," said O'Fallon. Known for having the last word in every situation, Richter shot back: "If I'm so good, how come I didn't get bigger budgets?"

Recognizing Martha Krebs' six-and-a-half years with the DOE in Washington, Richter added a surprise event to the day's agenda. After Krebs' speech, he presented her with a coveted award given only to SLAC retirees – a beam tree. "After all, you're a retiree now," he remarked.

SLAC director Jonathan Dorfan's welcome to the crowd of 300 people roasted his old boss with gentle jibes about Richter's trainers, the trademark New Balance shoes that he habitually wears, almost regardless of the occasion. (Let the record show that Richter did wear leather shoes for his celebration.) Dorfan showed pictures of Richter in sneakers from 1970 to the present, with university presidents and royalty. Richter's golf hats also came in for some ribaldry. Later on at the after-dinner speech, Sidney Drell admonished Dorfan on this topic. "Dorfan is a good scientist but a lousy historian. I lost my hair long before Burt, and I started the trend to golf hats at SLAC, and I want to set the record straight," said Drell emphatically.

Others continued to roast Richter while praising his wife Laurose. SLAC emeritus director W K H (Pief) Panofsky complimented Richter on his good judgement. "He stole my secretary and married her," he said, referring to Laurose. MIT's Lou Osborne recalled the early days with Richter at MIT, but made sure that he added "that one of the best things about Burt is Laurose: her hospitality, her good sense and wisdom that rivals her husband's."

Nan Phinney stuck to the science of the SLC/SLD for her talk. Artie Bienenstock, now at the Office of Science and Technology Policy, flew in from Washington, DC, to his old home at SLAC. He made some political remarks, which, he assured the participants, "do not represent the President, the White House, the Congress or OSTP," adding that he was sure to offend someone, since that's what happens once a person moves to Washington.

That sentence gave Stanford University president Gerhard Casper just the opening he needed. "Artie, rest assured that you have offended at least one president in the audience," he joked. A masterful speaker, Casper included erudite allusions and ad libs, fact and fiction. "One needs true genius to achieve praxis, the ability to combine theory and practice," he said. "Richter bridges the conceptual, practical and political to get results." Casper noted that Richter was lab director for 15 years, and in that time there were seven Secretaries of Energy. "Why so many? They were all worn down by Burt," said Casper. "Politicians come and go, but like the Energizer Bunny, Richter keeps going and going."

CERN's Luciano Maiani, in paying tribute to Richter's international science connections, was grateful for the arrival of a C-4 cargo plane in Italy. "It carried the BaBar coil back to America and allowed us in Italy to say the project was on time!" ▷

At the celebration honouring Burton Richter at the Stanford Linear Accelerator Center. Left to right: after-dinner speaker Sidney Drell; former Department of Energy Office of Science director Martha Krebs; Stanford University president Gerhard Casper; and Burton Richter. (SLAC.)

John Rees spoke about Richter's role in building SPEAR and how they struggled to design something cheap enough to get funding. "When we realized that we had spent too much the first year, like any good project managers, we decided to cut the construction time and we finished SPEAR sooner," said Rees. Gus Voss traced the roots of the design for the next linear collider from SLAC projects in the past to the grand designs for the future generation machine.

At the evening's dinner party, Sidney Drell brought the day's events to an eloquent and pithy close, even though Richter still had the last word. "Physicists are not normal," Drell said, "so we don't have to follow Shakespeare's seven stages of man." Instead, Drell (the theorist) theorized on the stages of the physicist's life: student, problem solver, builder, mentor, advisor, statesman. "Richter may choose at some point to answer to a higher authority and become a theorist himself."

Richter came back with his own stages, having written them on his dinner napkin. "Monomaniacal physicist – that lasts up until about age 40," he proposed. "Then in the 50s one becomes mature. I got a little concerned about turning 60, then I decided that was the age of wisdom. But in a few years I'll turn 70, and I am looking forward to the next stage, whatever that might be."

The next stage may well be rearranging his office to display all the plaques, pictures and memorabilia he acquired at his celebration. That is, if Richter takes the time away from his role as president of IUPAP, champion of the Next Linear Collider, advisor to Washington, and statesman for high energy physics.

P A Moore, *SLAC.*

Bogolyubov conference caravan takes in Moscow, Dubna and Kiev

Last year the 90th anniversary of the birth of Russian scientific polymath Nikolai Nikolaevich Bogolyubov was marked by an international conference, which travelled through the three cities where he worked.

Moscow – Joint Institute for Nuclear Research director Vladimir Kadyshevsky addresses the opening of the International Bogolyubov Conference at Moscow State University. The conference subsequently adjourned to Dubna and then to Kiev.

Last year marked the 90th anniversary of the birth of an outstanding Russian scientist in the field of mathematics, mechanics and physics: academician Nikolai Nikolaevich Bogolyubov (1909–92). An international conference, Problems of Theoretical and Mathematical Physics, dedicated to his memory, took place on 27 September – 6 October. The scientific and memorial sessions were held in Moscow, Dubna and then Kiev – the cities in Russia and Ukraine where Bogolyubov left his remarkable heritage as a teacher and a founder of new scientific schools and research directions.

The conference covered those fields to which Bogolyubov made fundamental contributions and initiated new lines of research: mathematics and nonlinear mechanics; quantum field theory; elementary particle physics; statistical physics and kinetics; and nuclear physics. More than 200 scientists from many countries attended. The conference was organized by the Russian Academy of Sciences (RAS), the National Academy of Sciences of Ukraine (NASU) and the Joint Institute for Nuclear Research (JINR), with the support of UNESCO, INTAS, the International Mathematical Union, the Ministry of Science and Technology of the Russian Federation, the Ministry of Education of the Russian Federation, Moscow State University (MSU), the Russian Foundation for Basic Research, the State Committee of Ukraine for Science and Intellectual Property and the Heisenberg–Landau and Bogolyubov–Infeld Programmes.

Awards ceremony

During the opening at MSU on 27 September, the participants were addressed by the president of the RAS, Yu S Osipov; the rector of MSU, V A Sadovnichy; and the director of the JINR, V G Kadyshevsky. The first day saw the award of prizes: the N N Bogolyubov Gold Medal of the Russian Academy of Sciences for 1999 went to academician V S Vladimirov; and the N N Bogolyubov Prize of the Joint Institute for Nuclear Research for 1999 was awarded to Prof. I R Progogine, Nobel Prize winner and director of the Solvay Institute (Brussels), and to academician V G Bar'yakhtar (Kiev).

At the plenary session, talks were presented by V S Vladimirov, Yu A Mitropol'sky and V G Bar'yakhtar. I R Progogine spoke about causality, irreversibility and non-locality. CERN director-general Luciano Maiani reviewed research on particle physics conducted and planned at CERN. Talks on mathematics and nonlinear mechanics; quantum field theory; and statistical physics and kinetics, ▷

given at parallel sessions, completed the first day's proceedings.

On the following day the conference continued at the Steklov Mathematical Institute of the RAS, where plenary talks were delivered by D V Shirkov (Dubna), L D Faddeev (St Petersburg), G I Marchuk (Moscow), N N Bogolyubov Jr (Moscow), W Thirring (Vienna) and J Devreese (Antwerp).

On 29 September, participants paid tribute to Bogolyubov by laying flowers on his tomb in Moscow's Novodevichy Cemetery. Participants then moved to Dubna, where sessions were continued at the Bogolyubov Laboratory of Theoretical Physics until 2 October. Of great interest were the reminiscences by N N Bogolyubov's brothers, A N Bogolyubov (Kiev) and M N Bogolyubov (St Petersburg).

The Dubna part of the conference included more than 60 talks by well known physicists, including K Nishijima (Tokyo), V A Matveev (Moscow), A N Tavkhelidze (Tbilisi), A M Baldin (Dubna), H Araki (Tokyo), A A Logunov (Protvino), J Zinn-Justin (Saclay), I A Savin (Dubna), A A Slavnov (Moscow), A N Sissakian (Dubna), V A Moskalenko (Dubna) and Yu Ts Oganessian (Dubna).

The Kiev part of the conference opened on 4 October in the Main Conference Hall of the NASU. The participants were welcomed by B E Paton, president of the NASU; A G Sitenko, director of the Bogolyubov Institute of Theoretical Physics; and V G Kadyshevsky, director of the JINR. Academicians V G Bar'yakhtar (Kiev) and Yu A Mitropol'sky (Kiev) emphasized Bogolyubov's role in developing new ideas and directions in statistical physics, kinetics and nonlinear mechanics. Plenary talks were presented by D V Shirkov (Dubna), P N Bogolyubov (Dubna) and O S Parasuyk (Kiev).

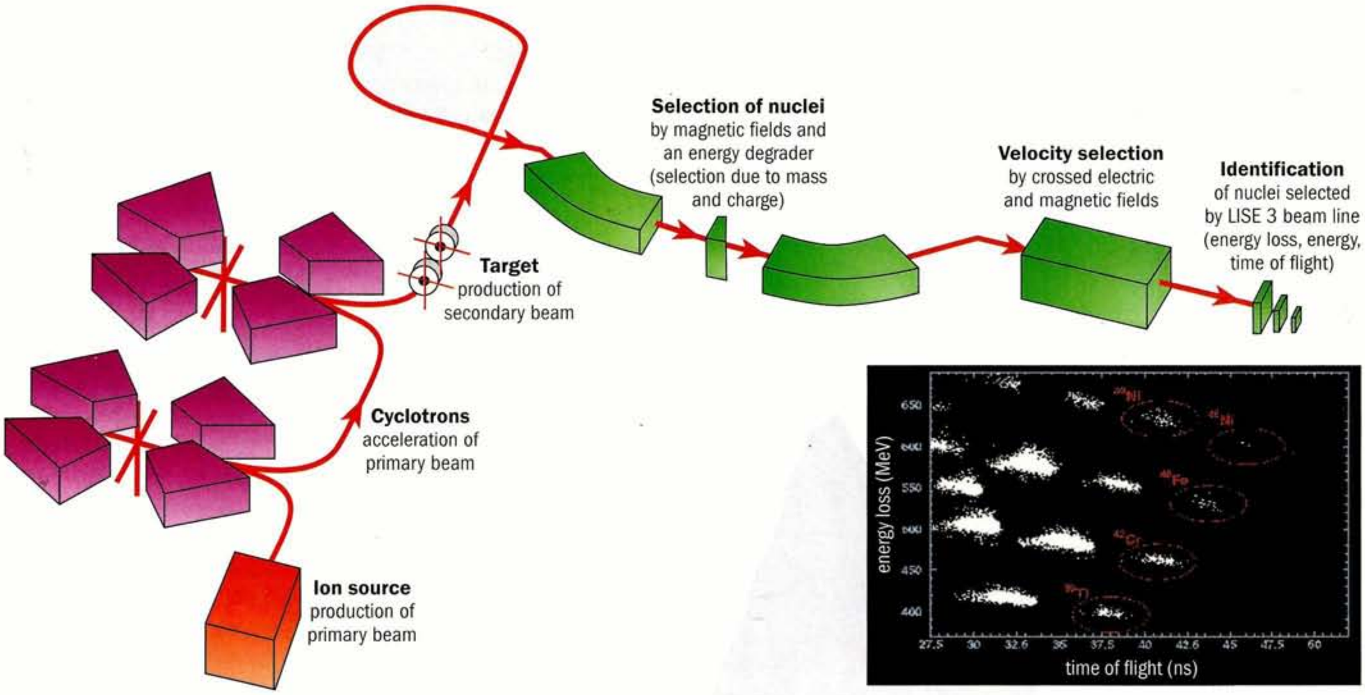
CERN director-general Luciano Maiani at a plenary session of the Bogolyubov Conference.

On 5 and 6 October, sessions continued at the Bogolyubov Institute for Theoretical Physics of the NASU and the Institute of Mathematics of the NASU with more than 70 talks. V G Kadyshevsky presented new ideas on the extension of the Standard Model, based on geometric reasoning. Problems of "ghost" singularities in quantum field theory were examined by D V Shirkov. N N Bogolyubov Jr suggested a development of polaron models. Plenary sessions included talks by R Jackiw (Cambridge, MA), I P Yukhnovski (Lvov), J Wess (Munich), D Ya Petrina (Kiev), W Manfliet (Antwerp), Yu L Klimontovich (Moscow), S P Peletminskii (Kharkov) and W Ebeling (Berlin). In the programme of parallel sessions on mathematics and physics, ample time was allotted to representatives of the Kiev School of Theoretical Physics, established by Bogolyubov.

The conference, including 42 plenary talks and more than 150 contributions at parallel sessions, closed on 6 October in Kiev. □

Discovery of doubly magic nickel

An experiment at the French GANIL laboratory has recently discovered a new "doubly magic" nucleus – only the tenth such isotope known to science.



A schematic layout of the GANIL devices used for the production of nickel-48 – the ECR ion source, the cyclotrons, the target in the SISSI device and the ALPHA and the LISE3 separators. The spectrum shows an energy loss/time-of-flight plot with two of the four nickel-48 events.

Just as in the atom, where the electrons fill different energy levels or "shells", the nucleons (neutrons and protons) in an atomic nucleus are also arranged in similar shells. Each time a shell has the maximum number of particles it can accommodate, the nucleus, like the atom, is particularly stable.

These "magic numbers" (2, 8, 20, 28, 50, 82 and 126) were discovered in the 1940s and soon explained by the nuclear shell model. Unlike the atom, the atomic nucleus consists of two different types of particle – the protons and the neutrons. A nucleus with completely filled shells for protons and for neutrons is called "doubly magic".

Of the roughly 2500 different nuclear isotopes known to date, only nine had a doubly magic shell structure. Nickel-48, with 28 protons and 20 neutrons, becomes number 10 in this list, and probably, at least for quite a while, the last one.

Beyond the importance of nickel-48, owing to its doubly magic properties, this nucleus is also of particular interest because it is at the extreme limit of nuclear stability, where the nuclear forces are no longer able to bind all protons and neutrons together.

At the "drip lines", nuclei decay by the emission of excess protons or neutrons. All commonly used models for atomic nuclei predict that nickel-48 is already beyond this proton drip line and is thus unstable with respect to the strong interaction, which means that this nucleus is only held together briefly owing to electrical forces between the protons.

Therefore, a possible decay mode of nickel-48 is the emission of two protons forming a helium-2 nucleus, analogous to alpha decay, where a helium-4 nucleus is emitted. This former type of radioactivity has never been observed. In addition, nickel-48 is the only ▷

doubly magic nucleus with a bound mirror nucleus, which will allow for interesting mirror symmetry studies.

In September 1999 a collaboration of French, Polish and Romanian physicists began an experiment at the Grand Accélérateur National d'Ions Lourds (GANIL) in Caen, France, to search for nickel-48, the last doubly magic nucleus accessible with present methods.

A primary beam of nickel-58 with an average intensity of 10^{12} ions per second and an energy of 95 MeV per nucleon hit a natural nickel target in the superconducting solenoids of the SISSI device.

The proton-rich projectile fragments were selected by the LISE3 separator and finally identified by their time of flight, their energy loss and their total energy in a detection set-up consisting of a microchannel plate detector and a stack of five silicon detectors. This allowed the measurement of 10 independent parameters to identify each fragment arriving at the focal plane.

Features of GANIL

The success of the present experiment is a result of the combination of specific and powerful features available at GANIL:

- a primary beam intensity never reached before was achieved through an intense ion-source development programme: a new technique allowed nickel to be treated as a gas in the ion source, yielding a gain of a factor of 20 compared with past experiments;
- the transmission of the GANIL cyclotrons was optimized to accelerate a high-intensity primary beam;
- the efficient production and collection of projectile fragments by the SISSI superconducting device;
- the powerful separation and identification by the LISE3 separator with its velocity filter and an efficient detection set-up.

The experiment ran for about 10 days, revealing for the first time four production "events" of this new nucleus. Although optimized for the transmission of nickel-48, it also produced other exotic proton-rich nuclei in the vicinity – about 100 events of nickel-49, 50 of iron-45 and 290 of chromium-42. This confirms a similar experiment conducted about three years ago at the GSI laboratory, Darmstadt, where 5, 3 and 12 events, respectively, of these latter isotopes were reported for the first time.

The new observation gives a lower limit for the half-life of nickel-48 of about 0.5 μs. This contradicts a number of models that predicted nickel-48 to be highly unstable, with half-lives of far less than 1 μs, the typical flight time of the projectile fragments between the production target in the SISSI device and the detection set-up at the end of the LISE3 separator.

However, the few events observed at GANIL do not allow a detailed comparison with nuclear models. To do this requires higher-statistics experiments to determine, for example, the exact half-life of this nucleus. Such experiments should be possible in the near future at GSI as well as at GANIL, where continuous improvements in source development and the acceleration process should yield even higher production rates. □

Lise Meitner Prize

Ilka Brunner – Lise Meitner Prize.

Since 1998, Berlin's Humboldt University has awarded a Lise Meitner Prize for outstanding PhD thesis work in physics. The prize is awarded by the Association of Friends of the Institute of Physics. For 1998 and 1999 it was sponsored by the Jewish community of Berlin and for the coming years it will be sponsored by the W E Heraeus Foundation.

In 1998 the prize went to Sibylle Petrak for her PhD thesis "Measurements of lifetimes of bottom hadrons in Z decays". Born in Weimar, Germany, Sibylle Petrak studied at the Technical University of Dresden, at the Free University of Berlin and at the Humboldt University. She now holds a postdoctoral position at SLAC, Stanford.

The 1999 prize went to Ilka Brunner for her thesis "On the interplay between string theory and field theory". Ilka Brunner was born in Pittsburgh, studied at Bonn and at the Humboldt University, Berlin, and now holds a postdoctoral position at Rutgers.

Tom Himel is the new leader of SLAC's Research Division, succeeding David Leith, who held the position for the past nine years.

For 2000, three new chairmen are appointed for the European Space Agency's advisory structure. Left to right: **Sandro Vitale** for the Fundamental Physics Advisory Group (replacing Maurice Jacob), **Michael Ward** for the Astronomy Working Group (replacing Reinhard Genzel) and **Yves Langevin** for the Solar System Working Group (replacing Risto Pellinen).

Canadian Ambassador to the UN in Geneva, **Sergio Marchi** (third from right), at the Opal experiment at CERN, with (left to right) Canadian physicists **John White** (Carleton), **Robert McPherson** (TRIUMF/Victoria), **Jim Pinfold** (Alberta), **Brigitte Vachon** (TRIUMF/Victoria) and **Isabelle Trigger** (McGill).

AWARDS

Rolf-Dieter Felst of the H1 experiment at DESY's HERA electron-proton receives this year's Max Born Prize, which is awarded jointly by the German Physical Society and the UK Institute of Physics, for his leading role in electron-positron physics at PETRA employing the JADE detector, and in addition for his continual support of UK scientists in their work at DESY.

Another DESY scientist, **Martin Lüscher**, receives the Max Planck Medal of the German Physical Society for his significant contributions to particle theory, in particular for his outstanding contributions to lattice gauge theory.

Michel Spiro of Saclay and chairman of CERN's LEP Experiments Committee is awarded the French Physical Society's 1999 Félix Robin Prize for his major role in several significant particle physics experiments.

Head of CERN Scientific Information Service **Corrado Pettenati** has been elected Science & Technology International Librarian for 1999 by the influential Special Libraries Association (SLA). The award will be presented at the 2000 SLA Annual Conference in Philadelphia, Pennsylvania, on 10–15 June.

CERN director-general **Luciano Maiani** (centre) recently paid an official visit to Poland. On his left is **Jan Krzysztof Frackowiak**, Under Secretary of State and Secretary of the State Committee for Scientific Research. On his right is minister **Jerzy Niewodniczanski**, president of the National Atomic Energy Agency. Polish physicists participate extensively in CERN's research programme, including all major LHC experiments, and are proud of a tradition that dates back to the 1953 discovery of hypernuclei by Danysz and Pniewski.

In Germany, this year is "Das Jahr der Physik", the year of physics, with a series of major events planned throughout. The programme got under way in January at Berlin's Urania Centre. Left to right: German Minister for Education and Research **Edelgard Bulmahn**, German science TV personality and particle physicist **Ranga Yogeshwar** and German Physical Society president **Alexander Bradshaw**. For additional information about "Das Jahr der Physik", see the Web site at "http://www.physik-2000.de/". (Ilka Flegel.)

MEETINGS

The 4th European Conference on Lasers and Electro-Optics (CLEO/Europe) and the **International Quantum Electronics Conference (IQEC 2000)** will be held on 12-14 September in Nice, France. The CLEO/Europe-IQEC 2000 exhibition and conference is the principal event in Europe this year to provide visitors and delegates with the opportunity to review the latest innovations and advances in optics, photonics, lasers, optoelectronics,imaging and electro-optics. For further information, visit "http://www.cleoeurope.com". For the exhibition, contact Laurence Devereux, Mobilex Exhibitions Limited, Unit 2, Downside Farm, Cobham Park Road, Cobham KT11 3NE, UK, tel. +44 1932 866766, fax +44 1932 866189, e-mail "cleo.mobilex@zetnet.co.uk". For the conference, contact Christine Bastion, EPS Conferences BP 2136, 68060 Mulhouse Cedex, France, tel. +33 389 32 94 42, fax +33 389 32 94 49, e-mail "eps.conf@univ-mulhouse.fr".

The VII International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT 2000, formerly AIHENP) will be held on 16-20 October at Fermilab, sponsored by Fermilab and the US Department of Energy. The workshop will cover artificial intelligence, innovative software engineering, computer-aided symbolic algebra and very large-scale computing. The co-chairs are Pushpalatha C Bhat and Matthias Kasemann. E-mail "acat2000@fnal.gov". Further information at "http://conferences.fnal.gov/acat2000/".

A NATO Advanced Study Institute Meeting on Recent Developments on Particle Physics and Cosmology will be held in Cascais, Portugal, on 26 June - 7 July. More information and registration are available at "http://cfif.ist.utl.pt/~nato2000/".

The IEEE Nuclear Science Symposium and Medical Imaging Conference (MIC) will be held this year in Lyon in October, the first time that this important meeting will come to Europe. In addition to the usual scientific papers, the organizing committee anticipates increased interest from exhibitors of a highly technical nature, and a number of short courses aimed at PhD student/postdoctoral level in topics of current interest in image reconstruction and multimodality imaging. These would also serve as a useful introduction to an experienced scientist or engineer in high-energy physics who might have an interest in applications in medicine. See "http://NSS2000.in2p3.fr". Deadline for submission of papers is 30 April.

The University of Minnesota Theoretical Physics Institute is organizing a symposium on 13-15 October celebrating Thirty Years of Supersymmetry. Immediately following the symposium, a workshop on supersymmetry will run on 27 October, co-chaired by Keith Olive and Mikhail Shifman. The meeting marks the 30th anniversary of the work of Golfand and Likhtman. Many of the pioneers of supersymmetry, including V Akulov, P Fayet, S Ferrara, J L Gervais, M Green, J Iliopoulos, E Likhtman, A Neveu, J Polchinski, P Ramond, B Sakita, J Schwarz, V Soroka, J Wess and B Zumino, have agreed to participate and are expected to present historically flavoured reviews from their own perspectives. N Koretz-Golfand (Y Golfand's widow) is also expected to attend and present recollections of her husband. Recent developments will be covered by M Dine, P Nilles, S Dimopoulos, J Ellis, and P Argyres. More details are available from "http://www.tpi.umn.edu/susy30.html".

Michael Marinov 1939–2000

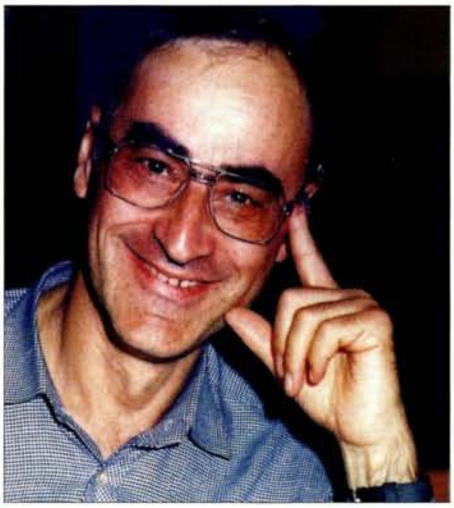
Michael Marinov, from the Technion-Israel Institute of Technology, passed away on 17 January after a courageous fight with cancer.

Born in Moscow in 1939, Marinov studied at Moscow University and completed his PhD on spinning particles in 1966 at the Institute of Theoretical and Experimental Physics (ITEP), where he worked until 1979. He achieved global recognition for his work in mathematical physics and field theory. His passion was the path integral approach. His famous work with Berezin in 1977 resulted in a novel description of spin by Grassmann variables. With Terentev he applied path integrals to quantum dynamics on group manifolds. Quantization on manifolds with nontrivial geometry and quantum tunnelling became the focus of his studies for many years, both at ITEP and then at the Technion.

In 1979 Marinov resigned from ITEP to apply for permission to emigrate to Israel, his long-lived dream, but his application was denied. With his wife Lilia and daughters Masha and Dina he passed more than seven difficult years as an unemployed "refusnik", earning an income as a translator and even as a construction worker, while continuing his research at home.

It takes a special person with integrity and courage to endure such suffering. From this period of his life, Marinov had warm memories of his friends' support and encouragement from visiting physicists from the West.

Marinov joined the Technion in 1988 and gained rapid command of Hebrew. He was an excellent and conscientious teacher and thesis advisor who was adored by his students. For scientists and students from the former Soviet Union, he was their Technion contact person.



Michael Marinov 1939–2000.

Misha Marinov will be remembered as a brilliant physicist, an extraordinary person of outstanding integrity and courage, a friend of great warmth and a source of great knowledge and wisdom.

Roland Barloutaud 1925–2000

Roland Barloutaud, who devoted his career to physics, passed away on 23 January.

Having graduated from the Sorbonne, Barloutaud entered the Nuclear Physics department of the Commissariat à l'Énergie Atomique, newly founded by Frédéric Joliot-Curie, in 1948. He began his career at Fort de Châtillon, working on measurements of weakly radioactive materials, before moving on to Saclay's 3 MeV Van De Graaff accelerator in 1951, focusing on Coulomb excitation, the subject of his thesis in 1958.

In 1960, after spending a period at the University of Houston, Barloutaud joined André Berthelot, who had just founded the High Energy Physics Laboratory at Saclay. Here he studied pion-nucleon interactions using the 3 GeV proton-synchrotron Saturne and 35, 50 and 80 cm hydrogen and deuterium bubble chambers. From 1962 he took part in many collaborations using CERN's 80 cm and 2 m bubble chambers, notably a large preliminary experiment with incoming kaons between 400 and 1400 MeV/c (CHS) and two full experiments with kaons, one at 3 GeV and the other at 14 GeV.

In around 1977, pursuing his interest in ever-higher energies, he led the analysis of photographs from the Mirabelle bubble chamber at the 70 GeV Serpukhov proton synchrotron, as part of a CERN-France-Soviet Union collaboration.

In the early 1980s Barloutaud turned his attention to the famous Fréjus experiment, designed to measure the lifetime of the proton in the Modane Underground Laboratory, of which he was the first director.

The numerous cosmological by-products of this experiment sparked his interest in particle astrophysics, especially neutrinos of all types and dark matter – subjects that fascinated him until the end of his life.

Roland Barloutaud 1925–2000.

Roland Barloutaud's numerous friends and colleagues from Saclay, many of whom were his students, will remember him as an engaging personality, whose feeling for physics, critical mind and encyclopaedic knowledge, often hidden by extreme kindness and a shy nature, lit up the laboratory for more than half a century.

RECRUITMENT

For advertising enquiries contact *CERN Courier* recruitment/classified, IOP Publishing Ltd, Dirac House, Temple Back, Bristol BS1 6BE, UK.
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The appointment will be indefinite with a salary according to the German civil services tariff BAT-O Ib.

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DESY Zeuthen, Personalabteilung
Platanenallee 6, D-15738 Zeuthen
by April 15, 2000

Handicapped applicants will be given preference to other applicants with the same qualification. Women are especially encouraged to apply.

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Laboratory of Nuclear Studies

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DSM - DAPNIA

CEA Saclay, Department of Astrophysics, Particle Physics, Nuclear Physics and Associated Instrumentation

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Contact: François DARNIEAUD CEA - Saclay, DSM / DAPNIA / SEI
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e-mail: darnieaud@dapnia.cea.fr

BRUNEL UNIVERSITY

RESEARCH FELLOW AND POSTGRADUATE STUDENT POSITIONS

The Sensors, Instrumentation and Radiation Effects group has a position for an Experimental Particle Physicist (RA1A) to work on a PPARC Opportunity project. This project involves the modelling and measurement of Wakefields and studies of Machine Background Sources at a future linear collider. A Ph.D in experimental particle physics is required. The project will require the Fellow to be based at Stanford Linear Accelerator Center. **Informal enquiries to Dr Adrian McKemey on: mckemey@SLAC.Stanford.EDU Ref. No. R11171. Closing date: 1 MAY 2000**

The European TMR Network on Defect Engineering of Advanced Semiconductor Devices has several postdoctoral positions available at institutions throughout Europe. This project is studying radiation effects in silicon for detectors at the LHC and due to ion-implantation. The Network works on many topics including defect analysis, defect modelling, radiation damage measurements and radiation hard detector development. Research fellow and possibly postgraduate student positions are available. Further details may be found on the TMR Webpage at
http://www.brunel.ac.uk/research/ENDEASD/
Ref. No. R07251.

Research Fellows at Brunel University are employed on the RA1A scale. The salary is currently in the range £16286 to £24479 plus a London Weighting of £1462 per annum and will be dependent on age and experience.

Enquiries to Prof. Steve Watts at the Department of Electronic and Computer Engineering +44 1895 203356 or by email to ecehod@brunel.ac.uk

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VACANCY ANNOUNCEMENT NUMBER: ETR 00-EXC-50-002

The U.S. Department of Energy is seeking applicants for the Excepted Service position of Senior Technical Advisor for High Performance Computing within the Office of High Energy and Nuclear Physics in the Office of Science. The incumbent provides expert scientific advice and detailed technical analyses to the Associate Director for the evaluation of research programs, facility operations, and their associated resources to attain a planned course of action for the overall High Energy and Nuclear Physics, High Performance Computing mission. The scope of the incumbent's advisory responsibilities includes providing scientific judgment, program and strategic planning, policy development, budget formulation, and the measurement of program performance by peer review and other metrics. The incumbent serves as the recognized authority and expert in DOE in diverse areas of High Energy and Nuclear Physics, High Performance Computing.

Please refer to DOE Vacancy Announcement ETR 00-EXC-50-002 which can be accessed via the Internet at

http://www.hr.doe.gov/pers/doejobs.htm

for specific instructions on how to apply for this position. Applicants must comply with the instructions that are in the vacancy announcement in order to be eligible for consideration. Announcements can be mailed to you by calling 301-903-1577.

Applications must be postmarked no later than May 8, 2000, and should be sent to the U.S. Department of Energy, Executive Resources Division, Room 4E-084, 1000 Independence Avenue, SW, Washington, DC 20585.

The Department of Energy is an equal opportunity employer.

Five Year Fellowship in Experimental High Energy Nuclear Physics

The Lawrence Berkeley National Laboratory's Nuclear Science Division is seeking a person with outstanding promise and creative ability in the field of experimental high energy nuclear physics. The appointment will be as Divisional Fellow for a term of five years with the expectation of promotion to Senior Scientist, upon successful review. The successful candidate will have several years of experience beyond the Ph.D. in nuclear or particle physics and is expected to assume a leadership role in the Relativistic Nuclear Collisions (RNC) Program at LBNL.

The RNC group has a leading role in the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The group currently has a strong physics program in nucleus-nucleus collisions at RHIC. Candidates having an interest in all aspects of RHIC physics, including spin, are encouraged to apply.

Applicants are requested to e-mail (our preferred method) a CV, list of publications, statement of research interests, and the names of at least four references to: **employment@lbl.gov** (no attachments, please), no later than May 31, 2000. Reference job number **NS011700/JCERN** in your cover letter. Or mail to: **Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 937-0600, Berkeley, CA 94720.** Or fax: **(510) 486-5870**. Visit our website at: **www.lbl.gov**. Berkeley Lab is an AA/EEO employer.

BERKELEY LAB

POSITIONS IN ACCELERATOR PHYSICS at

MICHIGAN STATE UNIVERSITY

The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University is seeking several highly qualified accelerator physicists or engineers to join the Accelerator Physics Group. We seek to strengthen specific areas related to high-intensity beam dynamics and superconducting rf technology.

The NSCL is presently upgrading its facility to increase the intensity of primary heavy-ion beams in the 10-200 MeV/nucleon energy range by several orders of magnitude and produce world-unique secondary beams of rare isotopes for research in nuclear physics and nuclear astrophysics with scheduled completion mid-2001. A design effort for an accelerator system of an advanced rare isotope accelerator facility capable of producing high intensity (>100 kW) primary beams from hydrogen to uranium with energies per nucleon up to at least 400 MeV will be the primary emphasis in the near term.

Accelerator physicists and engineers with specific and extensive experience in the general areas of particle beam dynamics and superconducting rf accelerating systems are sought. Priority is given to applicants with experience in one or several of the following areas: space-charge dominated beams; RFQ design; linac dynamics particularly for heavy ions; superconducting accelerating cavity characterization, design, and fabrication; superconducting accelerating cavity rf system design and implementation including appropriate stabilizing rf feedback systems.

Depending on the successful applicants' qualifications, appointments will be made at any of three ranks in the NSCL Continuing Appointment System that approximately parallels the university tenure stream faculty system (see CA Handbook at http://www.msu.edu/unit/facrecds/policy/nscl01.htm). Interested individuals should send a CV and arrange for three letters of reference to be sent directly to:

Professor Richard York,
National Superconducting Cyclotron Laboratory, Michigan State University
East Lansing, MI 48824-1321.
For more information, see our website at http://www.nscl.msu.edu.

MSU is an equal opportunity/ affirmative action institution.

UNIVERSITY OF OXFORD

Physics Department

Post-doctoral Research Positions

The physics department at the University of Oxford invites applications for four post-doctoral research positions in the areas of particle physics and particle astrophysics:

Post RA-01: The Sudbury Neutrino Observatory is a large, heavy water detector based in Canada which is currently taking data expected to solve the longstanding solar neutrino problem. Key to this is the understanding and supression of radioactive backgrounds and ability to detect neutrons produced by neutral current interactions. We seek an individual to perform and further develop radiochemical assay techniques for the water system and to take responsibility for implementing the initial neutral current detection method, involving the introduction of highly purified salt to the detector. The candidate would be expected to spend at least 30% of their time on site in Sudbury, Ontario. A PhD in either physics or chemistry is required. Preference will be given to individuals with experience in measurement of low-level radioactivity and/or radiochemical techniques.

Post RA-02: An experiment is being undertaken to measure the flux of muons at high altitudes using a small detector to be flown on commercial aircraft.
The measurements will be essential input to new calculations (also being undertaken in this department) of the neutrino fluxes used to extract neutrino mixing parameters from the results of underground experiments such as Soudan 2 and SuperK. The successful applicant will have a strong interest and proven ability in experimental hardware and electronics. Initially he or she would be expected to work on the design and construction of the apparatus but will have the opportunity to participate in all aspects of the measurements.
The candidate should have, or be about to obtain, a PhD in Particle Physics or related field.

Post RA-03: MINOS is a long-baseline neutrino oscillation experiment using two detectors: one at Fermilab and one based in northern Minnesota. The candidate is expected to contribute to the development, implementation and maintenance of the MINOS off-line system. They should also have demonstrated excellence in physics analysis, as they are expected to lead the Oxford efforts towards the analysis of MINOS data. The exact role would depend on the candidates interest and experience and could also include working on the MINOS test beam program or electronics. Some contribution to detector installation is expected. A PhD in particle physics or a related field is required.

Post RA-04: LHCb is an experiment to study CP violation in the B system at the LHC. It will probe the parameters of the unitarity triangle to test the Standard Model and search for new physics beyond. The successful candidate will be expected to work primarily on the development of the LHCb Ring Imaging Cherenkov detectors. Responsibilities are expected to include development of RICH counter single photon detection techniques at LHC readout speed and the associated data acquisition, the optimization of the RICH detectors, and the development of the RICH reconstruction software. In addition, the successful candidate will be expected to take a leading role in the preparation of CP violation physics. The candidate should have, or will shortly be about to obtain, a PhD in elementary particle physics.

Starting salaries are in the range £16,286 - £24,479 p.a., depending on experience. These posts are funded by PPARC for a period of two years in the first instance. Further particulars for all posts may be obtained at http://www.physics.ox.ac.uk/jobs/ or from Mrs S Geddes, Nuclear & Astrophysics Laboratory, Keble Road, Oxford OX1 3RH, fax: +44 (1865) 273418, e-mail: S.Geddes1@physics.ox.ac.uk. Letters of application, including a description of research experience, a statement of interest, Curriculum Vitae and the names of three referees should be sent to the above address. Applicants should ask their referees to send references directly to Mrs Geddes by the closing date 30th April 2000.

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RWTH

RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN

In der Fakultät für Mathematik, Informatik und Naturwissenschaften/Fachbereich 1, ist eine

Universitätsprofessur (C3 BBesG) für Physik (Theoretische Elementarteilchenphysik)

(Nachfolge G. Roepstorff)

zu besetzen.

Bewerberinnen oder Bewerber sollen im Bereich
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arbeiten und dieses Fach in Forschung und Lehre vertreten.

Eine Zusammenarbeit mit bestehenden theoretischen und experimentellen Gruppen der Elementarteilchenphysik ist erwünscht.

Zu den Lehrverpflichtungen gehört die Beteiligung an der Ausbildung in der theoretischen Physik.

Einstellungsvoraussetzungen sind Habilitation oder gleichwertige wissenschaftliche Leistungen sowie pädagogische Fähigkeiten.

Die Bewerbung von Schwerbehinderten ist erwünscht

Die RWTH strebt eine Erhöhung des Anteils der Frauen in Forschung und Lehre an. Bewerberinnen und Bewerber werden gebeten, sich mit den üblichen Unterlagen (Lebenslauf, Darstellung des wissenschaftlichen bzw beruflichen Werdegangs, Schriftenverzeichnis) bis zum

15. Mai 2000 an den Dekan der Fakultät für Mathematik, Informatik und Naturwissenschaften der RWTH, Templergraben 64, D-52056 Aachen, zu wenden.

MAX-PLANCK-INSTITUT FÜR PHYSIK (Werner-Heisenberg-Institut) München

The Max Planck Institute for Physics in Munich is seeking

Three Scientific Members / Members of the Directorate

with main scientific interests and activities in one of the following areas:

Theoretical Particle Physics – Phenomenology
Experimental Elementary Particle Physics – High Energy Physics
Experimental Astroparticle Physics.

The research program of the Institute comprises at present the following fields:

Experimental physics: high energy physics experiments at CERN, DESY and BNL; preparations for the ATLAS experiment at CERN-LHC; high energy cosmic rays; dark matter search, low energy astroparticle physics. Theoretical physics: phenomenology of the Standard Model and its extensions; lattice gauge theory; mathematical methods of field theory; gravitation and quantum theory; astroparticle physics and cosmology; foundations of quantum mechanics.

The new Scientific Members are expected to take a leading role in the Institute's research program and in shaping its future direction.

Including the 3 new appointments the Institute has 6 Scientific Members. These jointly form the Directorate, one of whose members is elected as chairman (managing director) for one or two terms of 3 years.

There are about 200 staff positions at the Institute, including 60 for scientists. It has a lively visitors' program and co-operates with the local universities in teaching and training diploma and PhD students (presently 40 PhD students).

The experimental activities of the Institute are supported by strong technical groups. A laboratory for the development of semiconductor detectors is operated jointly with the Max-Planck-Institut für extraterrestrische Physik.

The conditions of appointment are equivalent to those of a full professor at a German University (C4).

Applications, including a curriculum vitae, list of publications and a covering letter outlining the current research activities and future plans should be submitted before
May 15, 2000 to:

The Chairman of the Search Committee, Professor Dr. Arndt Simon, Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1 70569, Stuttgart, Germany

Proposals for candidates are also welcome. The Max Planck Society especially encourages women to apply.
Further information may be found on the website: **http://www.mppmu.mpg.de**

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Temperature Measurement and Control catalogue

A new Temperature Measurement and Control catalogue is available from Lake Shore Cryotronics Inc. Comprehensive details are provided for cryogenic temperature sensors, current sources, temperature transmitters, accessories controllers and monitors. The catalogue contains a comprehensive product section and a useful and detailed reference guide. Several temperature sensors are new to this year's catalogue, as are a temperature controller and a temperature monitor.

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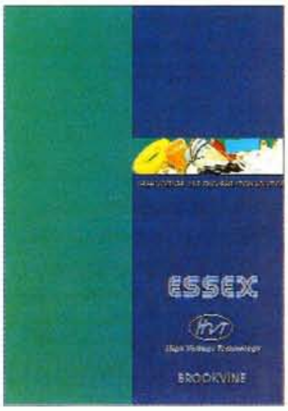

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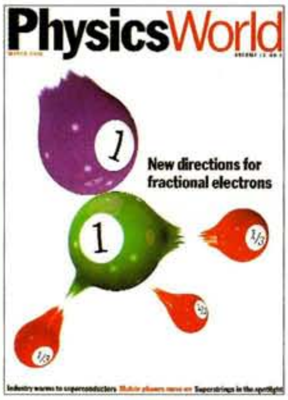

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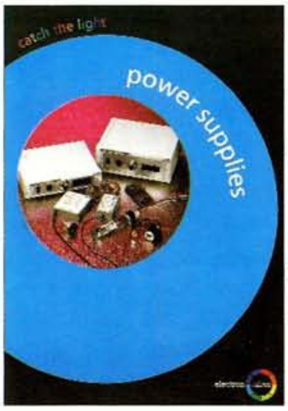

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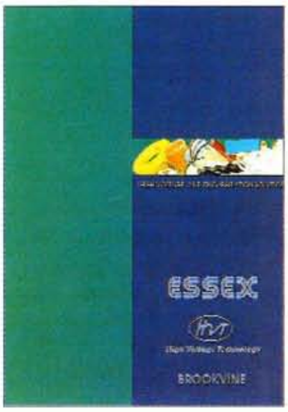

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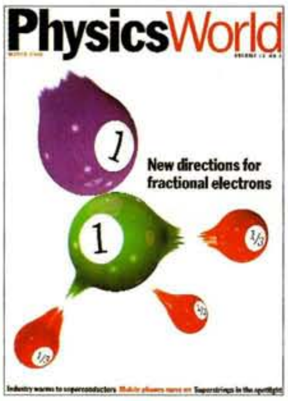

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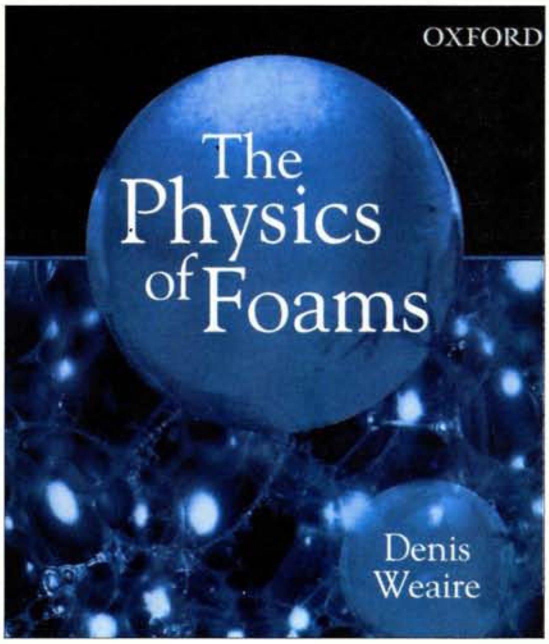
BOOKSHELF

The Physics of Foams by Denis Weare and Stefan Hutzler, Oxford University Press, ISBN 0 19 850551 5 (£47.50, 250 pages).

This is a specialized but wonderful monograph that begins: "Pour a bottle of beer. Restraining your thirst for one moment, admire its lively performance (see figure 1.1)." This book is also a lively performance – its authors, from Dublin's Trinity College, evidently have a knowledge for thirst!



The Physics of Foams – a knowledge for thirst.

Quantum Processes in Semiconductors by B K Ridley, Oxford Science Publications (4th edn), ISBN 0 19 850580 9 (pbk £27.50 435 pages).

First published in 1982, this work provides a useful overview of semiconductor physics without indulging in extraneous solid-state matters. The idea seems to have found a niche and the book has been repeatedly updated. In view of new developments in quantum entanglement and the interest in quantum computing, the latest edition includes new chapters on charge transport.

Particle Astrophysics by H V Klapdor-Kleingrothaus and K Zuber, revised edition, Institute of Physics Publishing, ISBN 0 75 030549 5 (pbk £34.99/$59.99, , 470 pages).

This is a revised and updated edition, in paperback, of a book that, when it first appeared a few years ago (Bookshelf, Summer 1998), merited the comment "more than just a graduate level textbook...it is also a sign of the times".

Defect and Microstructure Analysis by Diffraction by R Snyder, J Fiala and H J Bunge, Oxford Science Publications, ISBN 0 19 850189 7 (£95, 780 pages).

In the International Union of Crystallography series of monographs, this comprehensive compilation of 31 chapters from different authors looks at the latest developments in X-ray diffraction techniques.

Dynamics and Relativity by W D McComb, Oxford University Press, ISBN 0 19 850112 9 (pbk).

This a comprehensive textbook sets out to introduce special relativity to mathematicians, mathematical physicists and physicists in a natural way and avoid all "gee-whizz". There are ample exercises and an introduction to general relativity.

Introductory Statistical Mechanics by Roger Bowley and Mariana Sanchez, Oxford University Press (2nd edn), ISBN 0 19 8505760 (pbk, £21.99).

This text offers an introduction to the theory of condensed matter and first appeared in 1996. This edition includes three additional chapters on phase transitions and more examples.

Dynamics of Heavy Electrons by Y Kuramoto and Y Kitaoka, Oxford University Press, ISBN 0 19 851767 X (hbk £75)

In this context "heavy electrons" means electrons in rare-earth and actinide metals that acquire very large effective masses owing to strong local correlations.

LETTERS

CERN Courier welcomes feedback but reserves the right to edit letters. Please e-mail "cern.courier@cern.ch".

Opening SESAME

I read about SESAME – Synchrotron Light for Experimental Science and Applications in the Middle East – in recent issues of *CERN Courier* (March 2000 p17). It is worth pointing out that the Pakistani-born Physics Nobel Laureate Abdus Salam had visualized and worked towards science and technology in the Middle East – a vision that included a synchrotron laboratory as part of a larger scheme.

At a symposium entitled Future Outlook of the Arabian Gulf University on 11 May 1983 in Bahrain, he said: "I have mentioned an international laboratory in material sciences for Bahrain, with specialization in microelectronics and modern electronic communications, including space satellite communication, to help also with the banking communications needed at Bahrain.

"Such a laboratory was in fact proposed for the University of Jeddah. The idea was to emphasize science transfer in addition to technology transfer and to create international laboratories in the fields of materials sciences, including surface physics and a laboratory with a synchrotron radiation light source.

The facilities created would have been of the highest possible international order; the laboratories would have been opened to teams of international researchers, who would congregate and work at Jeddah, just as they congregate now at the great laboratories in Hamburg or Geneva" (Abdus Salam, *Renaissance of Sciences in Islamic Countries*, edited by H R Dalafi and M H A Hassan, World Scientific, Singapore 1994).

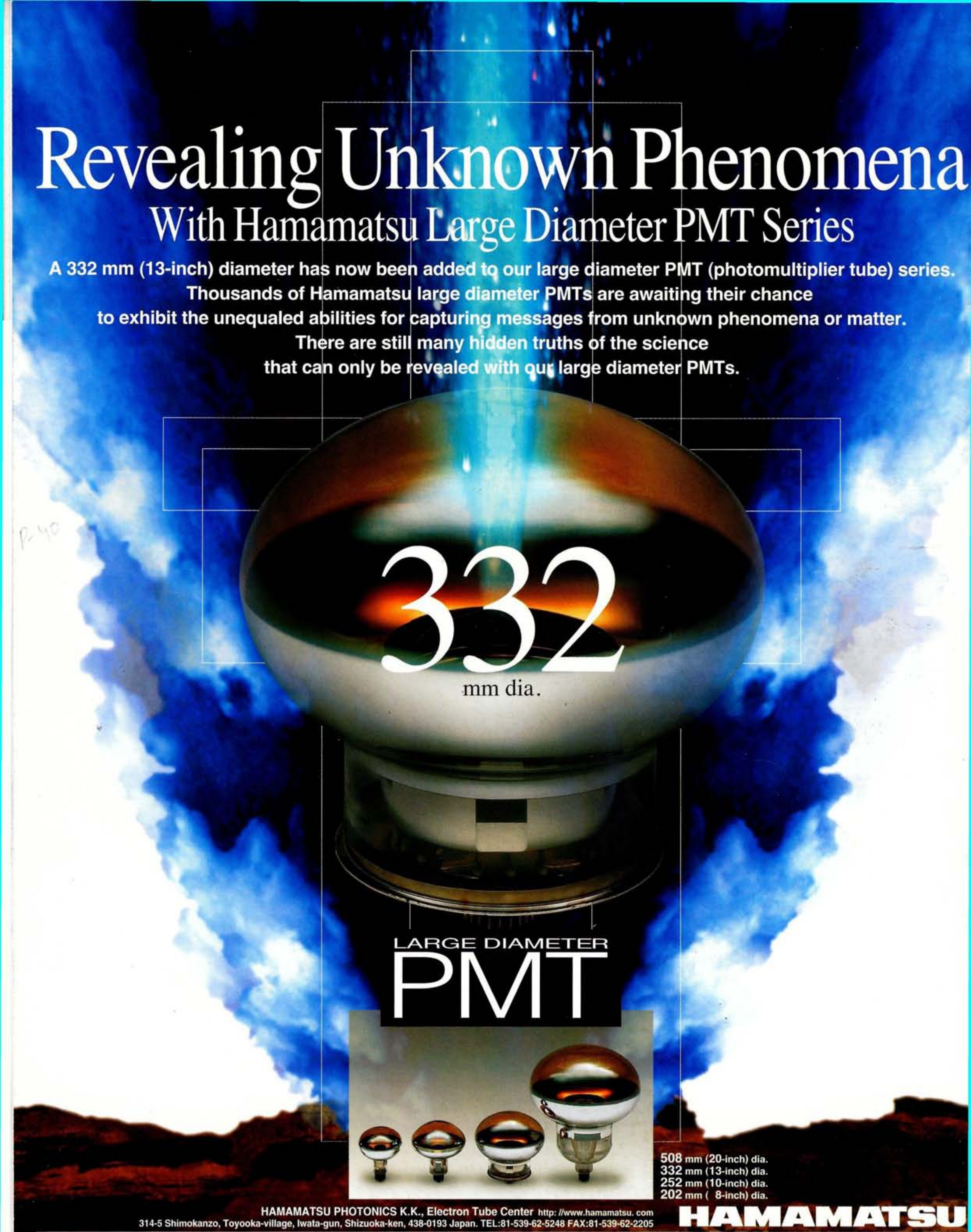
Another point is the immediate need for a series of schools on synchrotron radiation and related fields. These would, first, provide training for the potential users and, more important, enhance ongoing efforts for the Middle East Synchrotron.

Sameen Ahmed Khan, INFN-Padova,
"khan@pd.infn.it".

SESAME replies:

Other nations are welcome to join the SESAME project! In the meantime there will be a restricted meeting of the Interim Council in April at CERN. Director-general Luciano Maiani has agreed to welcome the council and explain how an international organization works.

Herwig Schopper, Chairman, SESAME International Interim Council.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