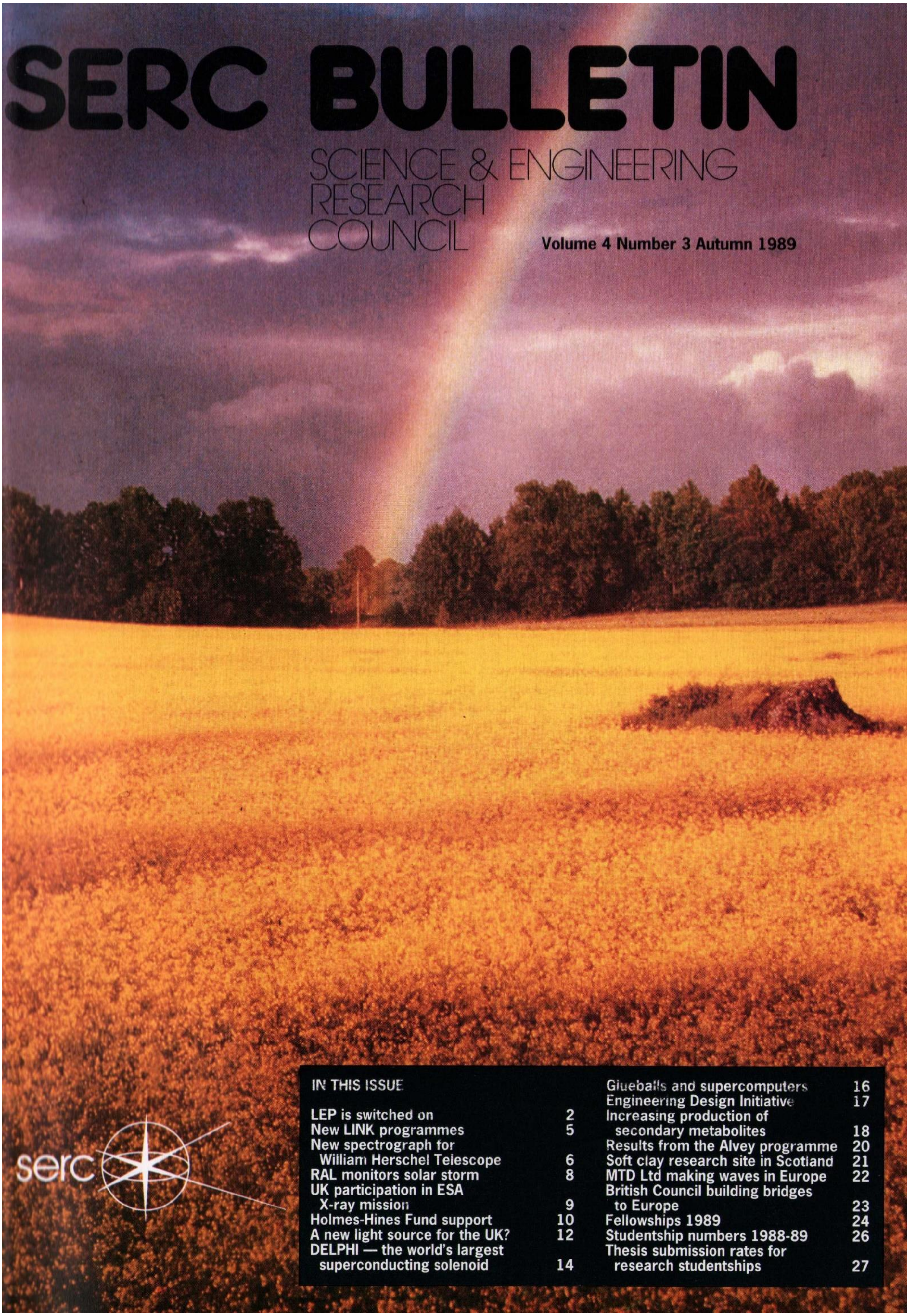

SERC BULLETIN

SCIENCE & ENGINEERING RESEARCH COUNCIL

Volume 4 Number 3 Autumn 1989

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IN THIS ISSUE

The Science and Engineering Research Council is one of five research councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through the provision of grants and studentships and by the facilities which its own establishments provide for academic research.

Establishments of the Science and Engineering Research Council

SERC Swindon Office
Polaris House, North Star Avenue
Swindon SN2 1ET
Telephone Swindon (0793) 411000
(or 41 + extension number).

SERC London Office
22 Henrietta Street
London WC2E 8NA
Telephone 01-836 6676

Rutherford Appleton Laboratory (RAL)
Chilton, Didcot, Oxon OX11 0QX
Director Dr P R Williams.
Telephone Abingdon (0235) 21900

Daresbury Laboratory
Daresbury, Warrington
Cheshire WA4 4AD
Director Professor A J Leadbetter
Telephone Warrington (0925) 603000

Royal Greenwich Observatory (RGO)
Herstmonceux Castle
Hailsham, East Sussex BN27 1RP
Director Professor A Boksenberg FRS
Telephone Herstmonceux (0323) 833171

Royal Observatory, Edinburgh (ROE)
Blackford Hill, Edinburgh EH9 3HJ
Astronomer Royal for Scotland and
Director Professor M S Longair
Telephone 031-668 8100

SERC *Annual Report* (available from PRU, SERC Swindon Office; price £6.00) gives a full statement of current Council policies together with appendices on grants, awards, membership of committees and financial expenditure. ***SERC Bulletin***, which is normally published three times a year, summarises the Council's policies, programmes and reports.

Published by:
SERC
Polaris House, North Star Avenue
Swindon SN2 1ET

Editor: Juliet Russell

ISSN 0262-7671

Front cover picture

***Pot of gold at the end of the rainbow? Biotechnology to improve oil seed rape** — see page 5.*

LEP is switched on

The first bunches of positrons were successfully circulated round the world's largest scientific instrument — the Large Electron Positron collider (LEP) at the European Laboratory for Particle Physics (CERN) in Geneva — on 14 July and the first experiments were carried out in early August.

Built at a capital cost of one billion Swiss Francs, LEP is housed in a 27-kilometre circumference tunnel under the French and Swiss countryside — about the circumference of the Circle Line on London's Underground system. LEP is designed specifically to study the massive Z and W particles which are associated with the weak force, one of Nature's four fundamental forces.

UK involvement

The UK was one of the founding members of CERN and the current UK subscription (£47 million) is paid on behalf of the UK Government by SERC. UK academic groups, supported by SERC, are heavily involved in three out of four LEP detector arrays, code named ALEPH, DELPHI and OPAL. This support has been through research grants and through its Rutherford Appleton Laboratory which has supplied engineering, design, computational and theoretical physics expertise, including the construction of the world's largest superconducting solenoid (see page 14). SERC support has cost about £50 million over the last eight years.

Council visitors to Swindon

Members of the Council were given detailed presentations on the work of four departments and met staff members when they toured Swindon Office before their Council meeting on 19 July. They visited the Biological Sciences and Electro Mechanical Engineering Committee Secretariats, the Postgraduate Training Support Section and the Management Services Group. The visitors said they were impressed by the work that they inspected and by the high quality of the presentations. They said they hoped to visit other sections in the future.

Carol Dent explains the work of her Electro Mechanical Engineering Committee Secretariat to Council Members (left to right) C A P Foxell CBE FEng, Professor Sir Michael Atiyah FRS and Professor B E F Fender CMG.

Congratulations to ..

Professor John M Thomas (Council member), Director of the Royal Institution: awarded the Royal Society of Chemistry's Faraday Medal for distinguished work in physical chemistry; Dr Jocelyn Bell Burnell, Head of the James Clerk Maxwell Telescope Section at the Royal Observatory, Edinburgh: awarded the Royal Astronomical Society's Herschel Medal for her contribution to modern astrophysics through her role in the discovery of pulsars.

Council commentary

Morris Report

At its June meeting, the Council reviewed issues raised by the report, sponsored by the Advisory Board for the Research Councils (ABRC), on the review of Research Councils' responsibilities for the Biological Sciences, by a working party chaired by Mr J R S Morris.

The Council regretted the errors of fact and misleading statements about SERC in the report. It thought that the report was largely irrelevant to the continuing problems faced by the science base and that the interface problems were exaggerated. However, if all Research Councils were prepared to join a National Research Council, SERC would be willing to examine a detailed structure. A full summary of the Council's views on the report were presented to the July meeting of ABRC.

Resource Management Study

Following completion of a Research Councils' Resource Management Study earlier this year, an agreement between SERC, the Department of Education and Science and the Treasury has been reached which considerably extends the Council's autonomy. This allows for up to 2% of recurrent expenditure to be carried forward between years, and Council investment projects up to £50 million will not normally require DES approval. A DES control mechanism by sample 'dipstick' testing will be introduced.

£1 million for new telescope 'searcher'

The Council agreed a £1.1 million project to construct new equipment for the James Clerk Maxwell Telescope in Hawaii. Called SCUBA (Sub-millimetre Common User Bolometer Array), it will fully exploit the telescope's capacity for detecting continuum sources.

SCUBA is an ideal instrument for discovering protostars — the 'holy grail' of infrared and sub-millimetre astronomy — and other applications include the mapping of new star formations in external galaxies and the search for primeval galaxies in the infrared spectral region.

Boost for Nuclear Structure Facility

Two major new instruments worth £4.1 million were approved, to make use of the recently boosted capabilities of the Nuclear Structure Facility (NSF) at Daresbury Laboratory. The instruments — the GAMIC gamma-ray microscope and the SUSAN spectrometer — will exploit the increased capabilities which will boost the energy of light ion beams on the NSF by some 40% and increase the range of useful ion beams that can be provided, opening up a number of new areas for research, such as the precise measurement of deep inelastic reactions and the detailed spectroscopy of exotic nuclei far from stability. Development will be by Liverpool, Manchester, Birmingham and York Universities, and Daresbury Laboratory.

Visiting Committees

Last year the Council set up Visiting Committees to examine the managerial effectiveness of the SERC establishments and Swindon Office. The first report to be received was that from the Observatories Visiting Committee, chaired by Professor Arnold Wolfendale FRS. The report was generally favourable but made a number of suggestions for consideration, for example on the presentation of project control information. Some of the suggestions have already been implemented and the Council referred others to the Director Laboratories, Dr Tony Hughes.

The Observatories Visiting Committee had also visited the overseas sites and examined their operations and relations with home bases. The Committee was complimentary about these arrangements but warned that the number of staff on the island sites was barely sufficient for the tasks in hand or projected.

Studentships

Following a meeting of the Advisory Board for the Research Councils on 18 July, the Council agreed improvements to the basic maintenance allowances of all SERC students from October 1989. In addition to cash increases of about £600, the practice of reducing allowances because of other income of the student or spouse is to be abolished.

Future finance

The Council continues to be uncertain about its future financial position. It has been given no indication whether sufficient funds will be received in 1990-91 to cover the increases associated with the academic salary awards. The total cost of conservatively estimated under-indexation is that £11 million of scientific and engineering programmes will have to be cancelled in 1990-91, if no response is made to SERC's bid for funding. The Council considers that it should not be cutting back science and engineering research at this time when so many projects (75%) cannot be funded.

Major new grants

Astronomy and Planetary Science: The Council approved £7.2 million worth of new research grants for a package of nine projects in astronomy and planetary science. The largest of these is for £2.8 million to Manchester University for supporting MERLIN, the Multi-Element Radio-Linked Interferometer at Jodrell Bank. A research grant of £504,400 to the Open University will support research on primitive matter in the solar system.

Nuclear Physics: The Council approved new consolidated grants worth £4.3 million for research in nuclear structure experimental physics. These were awarded to Birmingham, Edinburgh, Glasgow, Liverpool, Manchester and Oxford Universities.

Engineering: New research grants totalling £3.76 million were agreed for engineering research at Edinburgh University on the use of computational and mathematical tools in the processing industries, and University College London to further research in biochemical engineering and related biotechnology.

Science: Six new grants for science research, worth around £4.8 million in total, were approved. The largest of these, at Strathclyde University, worth £1.1 million and funded jointly by SERC, the Ministry of Defence and industry, is to overcome the serious shortfall in the supply of high quality non-linear optical samples. Other grants are in the physical chemistry of proteins and their interactions (Leicester University), the theory of condensed matter (Cambridge University), a molecular beam epitaxy facility for depositing magnetic multilayers and amorphous alloys (Leeds University), a project for a dense Z-Pinch of plasmas (Imperial College, London) and the development of microelectronic biosensors (Cambridge University).

Information Technology: A grant with a new commitment of £1.5 million to Surrey University was approved for the University's ion beam facility for microelectronics.

Materials: New grants approved in the materials science area were:

- Surface engineering (Hull University, Newcastle Polytechnic and Sheffield Polytechnic), totalling £900,000.
- Processing properties and engineering aspects of metal matrix composites (Oxford University): £541,000.

Four grants for research under the Low Dimensional Structures and Devices programme were also approved, with total funding of £2.1 million.

International gathering at Abingdon

Enjoying the sunshine at the Cosener's House in Abingdon in May was an influential group from some of the world's leading research bodies.

The occasion was the annual meeting of the Presidents or Chairmen of the science and engineering research agencies of Europe, Japan and the USA, hosted this year by the UK's Science and Engineering Research Council (SERC). Previous meetings were held in Venice and Washington, and next year's meeting will be held in Munich, West Germany.

The purpose of the meeting was to hold informal discussions on matters of mutual interest, and topics included:

- ***Research support for universities and interdisciplinary research***
- ***International collaborations not centred on big facilities***
- ***Public perception of chemistry***
- ***International collaboration in ground-based astronomy***
- ***Update on scientific discussion in each country of global environmental issues.***

After their day and a half of business sessions, the group had the opportunity to tour Rutherford Appleton Laboratory, at nearby Chilton. A dinner at Wadham College, Oxford, was attended by the Presidents, Directors of all SERC establishments and Science Minister Robert Jackson MP. The following evening the party attended the Royal Society Soiree at the kind invitation of Sir George Porter PRS.

Pictured are, from left to right, back row, Dr Sakata and Dr Michio Okamoto, Japan; Dr Bernard Gingras, Canada; Professor François Kourilsky, France; Professor Dr Hubert Markl, West Germany; Professor Luigi Rossi Bernardi, Italy; Dr John Moore, USA; Professor H A Staab, West Germany; and Dr Wakabayashi, Japan. Front Row: Dr Erich Bloch, USA; Mrs Birgit Erngren, Sweden; Professor William Mitchell, UK; and Professor Claude Frejaques, France.

Dr Sakharov visits RAL

Dr Andrei Sakharov, the Soviet human rights campaigner and parliamentarian, visited the Rutherford Appleton Laboratory on 22 June. The 68-year-old physicist was welcomed to RAL by the Director Dr Paul Williams (right in picture), and heard about current particle physics and science research from some of the Laboratory's senior scientists including Associate Directors David Gray OBE and Professor George Kalmus.

Dr Sakharov's visit was one of several engagements during his seven days in the UK, including receiving honorary degrees from Sussex and Oxford Universities and talks with the Prime Minister Mrs Thatcher.

New LINK programmes

Four new LINK programmes were announced during the Summer, bringing the total number of approved programmes under the LINK Initiative to 19. The LINK Initiative aims to encourage strategic research of medium-term industrial significance and, by strengthening the links between industry and the science base, improve the transfer of new technology into industry. LINK operates by supporting pre-competitive collaborative research projects involving industry and the scientific community, with up to 50% of the cost of these projects available from Government. Brief details of the new programmes are given here.

Optoelectronic systems

Optoelectronics is a cross-disciplinary technology, using optical and electronic methods for the manipulation, storage and transmission of information. This £30 million programme, funded by SERC, the Department of Trade and Industry (DTI) and industry, will build on materials and devices work undertaken under other schemes, such as the Joint Optoelectronics Research Scheme (JOERS). It focuses on optoelectronic systems and subsystems and complements the related Advanced Semiconductor Materials and the Molecular Electronics LINK programmes. Primary topics include optoelectronic communications systems for a variety of applications (such as telecommunications, aerospace, local networking), and optical information processing (for example, high speed data capture).

For further information contact Dr Maggie Wilson (SERC Swindon Office, telephone 0793 411479) or the LINK Optoelectronics Systems Programme Secretariat (Roy Landeryou, DTI, Kingsgate House, 66-74 Victoria Street, London SW1E 6SW; telephone 01-215 2770).

New catalysts and catalytic processes

This programme aims to encourage joint industrial/academic research into industrially relevant catalysts and catalytic processes and to strengthen the interactions between chemists and chemical engineers in this important area. Funding of £5 million is available from SERC, DTI and industry for this purpose. Primary topics will include C1 chemistry, hydrocarbon processing, environmental control, electrocatalytic technology, photocatalysis, polymerisation, and enabling technologies, such as catalyst support, characterisation and regeneration.

For further information contact Ms Anita Longley (telephone 0793 411476) or the LINK New Catalysts and Catalytic Processes Programme Secretariat (telephone 0793 411160) at SERC Swindon Office.

Control of plant metabolism

A greater understanding of the metabolic processes involved in plant growth will lead to improved crop yields, better varieties and new herbicides. This £3 million programme, funded by SERC, DTI, the Agriculture and Food Research Council (AFRC) and industry, aims to develop such understanding. The main thrust of the programme is biochemical, and principal themes include pathways for conversion of products of primary assimilation to products of economic importance, pathways of intermediary metabolism and the biochemistry of plant development.

For further information contact Nigel Birch (telephone 0793 411466) or the LINK Control of Plant Metabolism Programme Secretariat (telephone 0793 411310)at SERC Swindon Office.

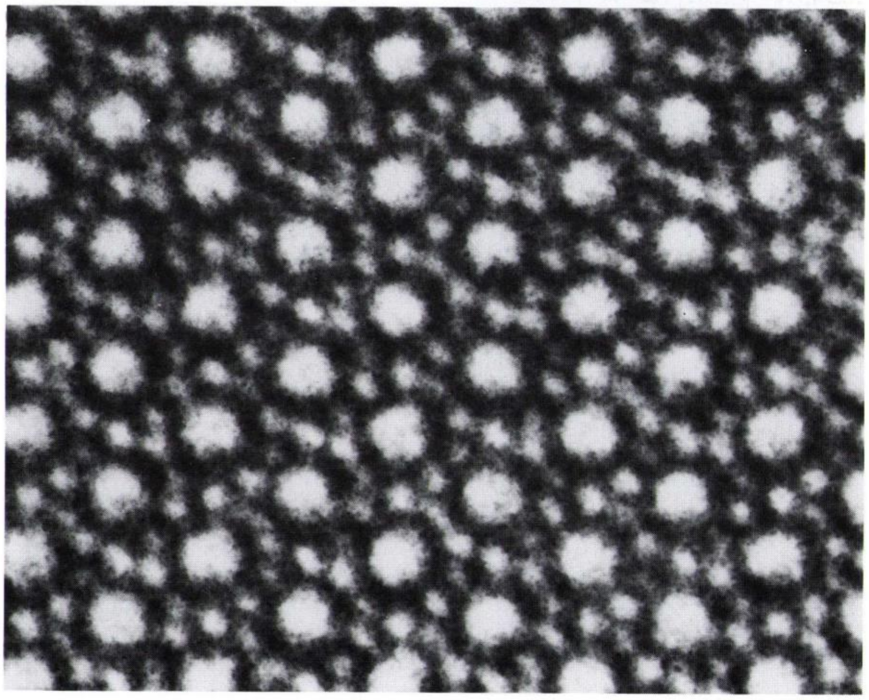
Power electronic devices and derived systems

This £14 million programme, which is funded by SERC, DTI and industry, is based on the use of solid state power devices and aims to encourage their wider application within engineering. Primary topics will include drive systems; non-drive power conversion, conditioning and control; uninterruptible power supplies; packaging, mounting and cooling of power devices and control circuits.

For further information contact Charles Whitlock (telephone 0793 411350) or the LINK PDDS Programme Secretariat (DTI, Ashdown House, 123 Victoria Street, London SW1E 6RB; telephone 01-215 6756/7).

For further general information regarding the LINK Initiative contact:

Stuart Ward
LINK Coordinator
(telephone 0793 411173)
Paul Tomsen
LINK Unit
(telephone 0793 411162)
SERC Swindon Office



High-resolution electron micrograph (magnification about 7 million) of a zeolitic catalyst. Each large white patch is the aperture (about 5 Å in diameter) of channels through which molecules migrate. (Royal Institution and Cambridge University).

New spectrograph for William Herschel Telescope

ISIS is the name given to the double spectrograph designed to be used at the Cassegrain focus of the 4.2-metre William Herschel Telescope (WHT) on La Palma. The acronym stands for Intermediate-dispersion Spectroscopic and Imaging System. It was designed and built at the Royal Greenwich Observatory (RGO) and originated from a collaboration with Oxford University during the design stage. This major new instrumentation is described here by Dr Keith Tritton of RGO.

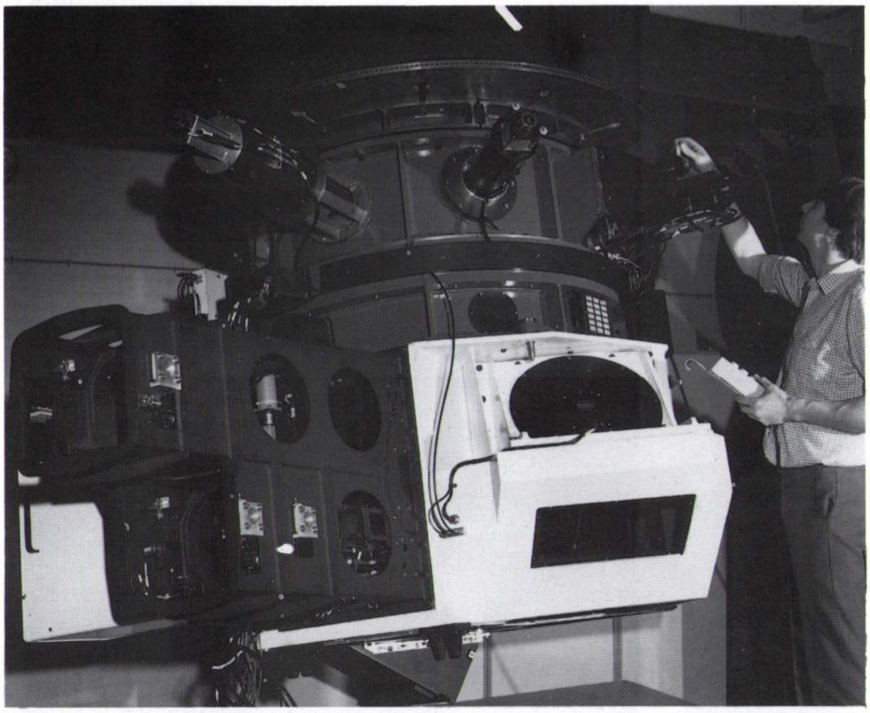
It consists of two intermediate dispersion spectrographs which can be operated simultaneously, one optimised for the blue and one for the red part of the optical spectrum, together with a Faint Object Spectrograph, which is a third independent channel optimised to give extremely highly efficient, fixed-format, low-resolution spectroscopy of the faintest astronomical objects.

ISIS is a very complex and versatile instrument, requiring a high degree of engineering precision. The main structure, the camera components and the collimators have all been subject to finite-element analysis. The whole instrument and its interface to the telescope acquisition and guidance unit were designed using computer aided design. The spectrograph weighs 1500 kg. Despite this and the fact that, while observing, its attitude on the WHT will be constantly changing, the optical elements are stable to better than 5 microns over any one-hour observing run. The angular stability in the dispersion direction is 0.5 arcseconds.

The ISIS spectrograph will become the major instrument on the William Herschel Telescope and it is estimated that more than 60% of the available observing time will use ISIS in one of its operating modes.

Features

The blue and red arms are medium dispersion spectrographs that operate simultaneously with conventional diffraction gratings. They give dispersions between 130 and 16 Å/mm in the first order, corresponding to resolving powers of 800 to 7000 with a narrow slit.



ISIS, the new spectrograph for the William Herschel Telescope (lower part of picture) and the Acquisition and Guidance Unit (upper part) are both shown here mounted on the telescope simulator at Herstmonceux a few days before they were flown to La Palma for commissioning on the telescope. The first scheduled observations using ISIS took place in August 1989.

Maximum sensitivity has been achieved by optimising the design to match the detectors, the spectrograph and the telescope to the excellent seeing which is experienced on La Palma.

The Faint Object Spectrograph which forms the third channel on ISIS was made collaboratively by Durham University and RGO. As its name implies, it is designed to work on faint astronomical sources and so a major consideration was to keep the light throughput high by reducing the number of optical surfaces to a minimum. The primary disperser is a transmission grating mounted in the diverging beam coming from the spectrograph slit. Cemented to the back of the grating are the cross-dispersing prism assembly and the aspheric corrector plate for the Schmidt camera which forms the rest of the spectrograph. A fixed format spectrum is obtained on a charge-coupled detector (CCD) which is mounted internally in the camera. The peak throughput of the system is 70% and the spectral range is from 3500 to 10500Å. The sensitivity of this spectrograph when attached to the WHT is such that it could record the spectrum of a hypothetical light source on the surface of the Moon equivalent to four household candles.

The Faint Object Spectrograph has already been used as a stand-alone instrument at the Cassegrain focus of the WHT and has proved highly successful. A joint RGO-Queen Mary College group, studying galaxies found by the Infrared Astronomical Satellite, obtained 1500 spectra in 18 clear nights.

Maximum operating efficiency has been achieved through the design of the software package controlling ISIS. This allows rapid switching between the red and blue channels and the Faint Object Spectrograph, and rapid alteration of any of the set-up parameters. The change from quick-look survey work to detailed spectroscopic study will be extremely rapid, allowing identification and study of peculiar objects whose exact positions are not known (for example, X-ray sources discovered using a satellite). Advanced data reduction facilities will be available to the observer in real time.

Extended objects can be studied using the long-slit facility which will give spectra of objects up to 4 arcminutes across at a single exposure. Multi-object spectroscopy with fibre-optic feeds will allow many objects in the same field of view to be studied at the same time (for example, the members of a distant cluster of galaxies).

Detectors

Two types of detector are used on ISIS: the CCD and the (CCD-based) Image Photon Counting System (IPCS).

CCDs are widely used on all La Palma telescopes, and several will be used on the WHT. These devices consist of a large silicon chip, constructed as a two-dimensional array, which directly converts photons to electrical charge. They are used in solid-state TV cameras but are particularly important as low-light level astronomical sensors: when cooled to -125°C to suppress dark current, CCDs can be used for exposures of up to one or two hours.

In ISIS it is planned to use the new EEV P88200 CCD, which has an array of almost 1 million elements covering an 18 by 27 mm active area. This large silicon chip is expected to be one of the most powerful sensors available anywhere in the world. It will be the principal detector on the red arm of ISIS, and it will also be possible to use one simultaneously on the blue arm. The very high sensitivity at red and near infrared wavelengths makes the CCD uniquely attractive for astronomical spectroscopy in this wavelength region.

The CCD-based IPCS is a highly sensitive camera capable of detecting and counting individual photons. It has been developed jointly between University College London and RGO. The CCD-IPCS will be used as the principal blue-light detector on many WHT instruments, including ISIS. It is likely that at least one third of all observations carried out with the WHT will use the CCD-IPCS.

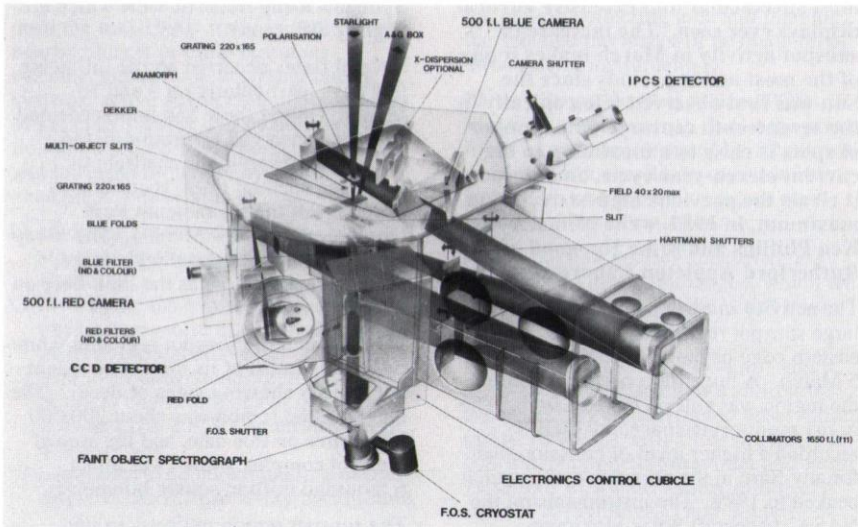
In the photon counting concept, individual photons which come from an object are first imaged on an image intensifier. The output of the intensifier is monitored by a CCD camera which can see the scintillations caused by the individual photons. The video signal from the camera is processed by high-speed electronics which detect the position of the scintillations, and hence the photons, in the field of view. The photon coordinates are recorded in a computer which can then build up an image. For some astrophysical experiments, exposures may last several hours.

Detectors which use the photon-counting principle have low noise characteristics, allowing faint objects like quasars to be detected which might otherwise be lost in the noise. They also allow observations to be resolved in time: for example, of pulsars and X-ray binary stars which vary rapidly. Earlier versions of the IPCS have been used on the 2.5-metre Isaac Newton telescope, the 3.8-metre Anglo-Australian telescope and the 5-metre Mount Palomar telescope; some of the most important discoveries in astrophysics have been made using the IPCS.

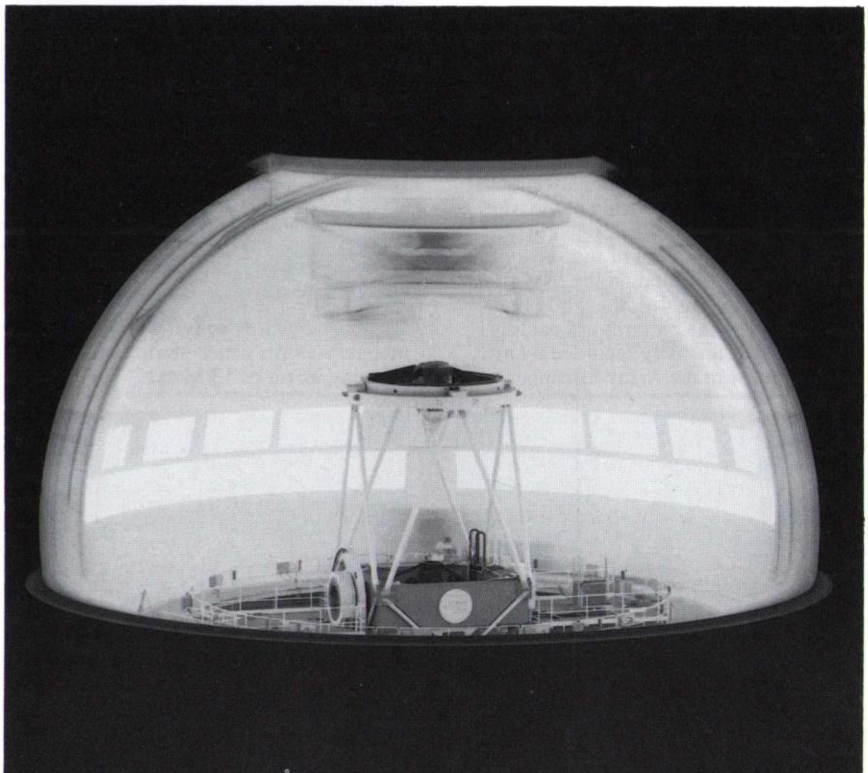
The Acquisition and Guidance Unit

The Acquisition and Guidance Unit, attached to the rear of the telescope mirror-cell, has been designed to support ISIS or any other instrument to be used at the Cassegrain focus. It is used to acquire and track stellar objects. Using an internal auto-guidance system locked on to a suitable guide-star, it feeds correction signals to the telescope drives during tracking, maintaining the position of the observed object to an accuracy of 0.1 arcseconds.

Dr K P Tritton
Royal Greenwich Observatory



The internal layout of the spectrograph shows the light paths of both red and blue channels. The faint Object Spectrograph, which forms a third channel, is shown attached.



The William Herschel Telescope has been operating on La Palma since 1987. This time-exposure photograph was taken by rotating the open shutter of the dome in front of the telescope, illuminated from inside, apparently causing the dome to disappear.

RAL monitors solar storm

Several enormous flares occurred on the Sun, starting on 6 March 1989. These have been linked to one of the most spectacular and extensive auroral displays ever seen. The increase in sunspot activity in March makes it one of the most active periods since the Sun was first observed telescopically in the seventeenth century. The number of spots is close to a maximum in the current eleven-year cycle, and already it rivals the previous highest-recorded maximum, in 1957, write Mike Cruise, Ken Phillips and Mike Hapgood of Rutherford Appleton Laboratory.

The activity in early March was due to a large sunspot region that rotated over the eastern edge or limb of the Sun on 5 March. A huge flare occurred while the region was still on the east limb. The X-ray monitoring spacecraft GOES recorded a higher level of emission than for any flare in the previous cycle, which peaked in 1979. The instruments on the NASA spacecraft Solar Maximum Mission (SMM) all recorded this flare. The X-ray Polychromator, a Bragg-crystal spectrometer sensitive in the soft X-ray wavelength region (down to about 1Å) for which RAL has part responsibility with the Mullard Space Science Laboratory of University College London, imaged the flare in the light of spectral lines due to highly ionised sulphur and iron. The images show a region of extremely intense, hot plasma (or highly ionised gas) high above the surface of the Sun, probably at the tops of several loops that are defined by the complex magnetic field of the sunspot region which is located on the Sun's surface. (In the figures, the white lines running across the pictures are contours of white-light intensity recorded by an optical sensor in the X-ray instrument, while the X-ray emission itself is the elongated blob just above the white-light limb; the white boxes define the white-light and X-ray fields of view which are slightly different.)

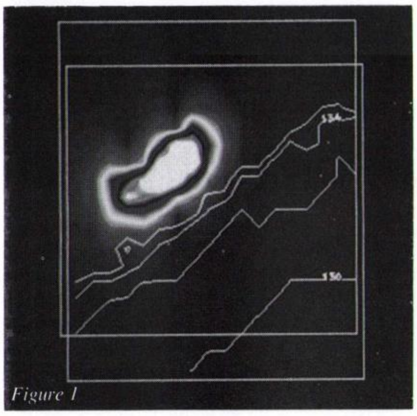
Several flares occurred on the following few days, particularly on 9 and 10 March. One of these had unprecedented extent as observed by ground-based telescopes observing in the light of hydrogen spectral lines, according to observers at the Sacramento Peak Observatory in New Mexico. The X-ray emission was correspondingly large, although not as large as the limb flare on 6 March.

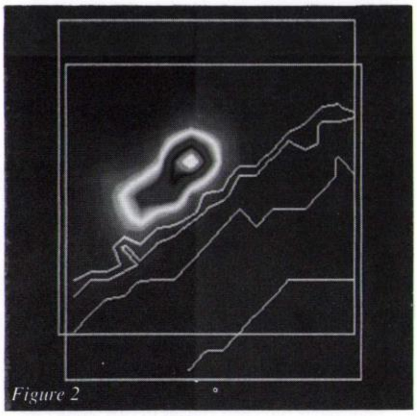
By 12 March the sunspot region in white-light was almost at its maximum extent but already showing signs of decay. The length of the region was about 200,000 kilometres on this date, and the area of the spot complex shown was about 6 thousand million square kilometres.

The sunspot region returned around 2 April, but was much reduced in size and activity. RAL's ground-based geophysical data sources, coordinated through the World Data Centre, began to observe the impact of the solar flares a few days later.

On the evening of 13 March a magnificent display of the aurora was visible in the skies over Europe. It was seen throughout the UK (right down to the south coast of England) and in France, Belgium and The Netherlands; in the US it was seen as far south as southern Florida. This event was seen by many members of the public and was widely reported in the press and on radio.

This aurora was the visible result of a magnetic storm which started in the early morning hours of 13 March. The storm followed the week of very high solar activity, most of which occurred in the active region that appeared on the east limb on 6 March.





Images of the large flare observed on 6 March 1989 at 1404 UT/GMT obtained by the XRP instrument on Solar Maximum Mission. Figure 1: In the light of the helium-like sulphur resonance line at 5Å. Figure 2: In the light of the helium-like iron resonance line at 1.9Å.

The occurrence of the storm was noticed at RAL early on 13 March when staff in the World Data Centre received an enquiry about problems with high frequency radio communications. Examination of data from the Slough ionosonde showed that the F2 region of the ionosphere had vanished. This is the classic daytime storm response of the ionosphere and thus indicated that a storm was in progress. Confirmation was received when the World Data Centre received the regular afternoon telex from Meudon Observatory in Paris and this reported the two sudden storm commencements. And so, by late afternoon, we knew that a storm was taking place and that aurorae might be visible that evening.

In the event, the display was much more spectacular than expected with aurorae visible in the sky all evening from dusk until midnight. For most of the time there was a diffuse auroral arc in the northern sky. This was a broad horizontal band which looked like a large white cloud except that bright stars could be seen through it. At times auroral rays could be seen moving back and forth, sometimes slowly and sometimes rapidly. For a period of 15 minutes, between 2130 and 2145 Universal Time the display became much more spectacular. The aurora became much brighter and colours (red and green) could be seen. In the north, there were very tall rays about 100 degrees long. The aurora could be seen all over the sky, even to the south. It was this bright period which drew the attention of the public as it could be seen even against the glare of street lights and a first-quarter moon. The diffuse glow that was visible for most of the evening could be seen clearly only at a dark site away from town lights.

The solar flares, magnetic storms and aurorae are all part of the coupled system of solar terrestrial interactions which the SOHO-Cluster Mission seeks to explore (see *SERC Bulletin* Volume 3 No 12, Autumn 1988). UK universities, together with RAL, are providing major parts of seven instruments which will study the complex phenomena on the Sun and their effects on the Earth's magnetosphere and ionosphere. SOHO-Cluster is presently due for launch in 1995.

Dr A M Cruise, Dr K J H Phillips and Dr M A Hapgood
Rutherford Appleton Laboratory

UK participation in ESA X-ray mission

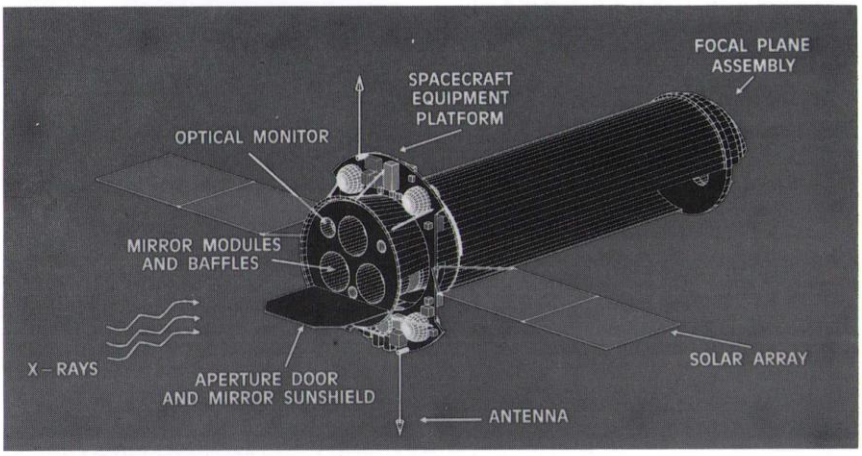
In June this year the European Space Agency (ESA) selected the payload instruments for XMM — a high throughput X-ray spectroscopy mission due for launch in 1998. XMM is the second of four major cornerstone projects in ESA's long-term Space Science Programme, *Horizon 2000*. The UK has a major involvement in all three selected instrument proposals — a recognition of the preeminence of British X-ray astronomy groups.

XMM will be a long-duration satellite observatory, and will make available to astrophysisists worldwide a major X-ray spectroscopic tool in the late 1990s. X-ray astrophysics deals with the study of highly energetic phenomena. Hot plasmas at temperatures above a million degrees radiate the bulk of their energy at X-ray wavelengths (1 - 100 Å). Space-based X-ray instruments are necessary to observe such X-rays since the Earth's atmosphere absorbs these strongly.

Apart from the West German national satellite ROSAT (in which the UK and USA are also collaborating) most previous and currently planned missions until the mid-1990s study in detail either nearby objects or more luminous systems, either stars, accreting binary systems, active galactic nuclei or clusters of galaxies. XMM will be able to extend this limited view to far greater distances and intrinsically fainter systems. For example it will be able to:

- ☐ study the large and medium-scale structure of (hot) matter in the Universe
- ☐ investigate the evolution of, and the physical structure in, the inner regions of Active Galactic Nuclei
- ☐ lead to an understanding of the physical characteristics of degenerate stars and black holes, neutron stars or white dwarfs
- ☐ contribute to an understanding of the origin of the diffuse X-ray background

as well as establishing the characteristics of its principal components.



XMM spacecraft in-orbit configuration. (picture: ESA).

In addition to mirror-modules to provide the photon collecting area and imaging, the selected payload will be made up of three sets of instruments:

Three charge-coupled device (CCD) imaging array cameras, one at the prime focus of each mirror module. These will combine high sensitivity over a wide bandwidth and be able to detect weak sources of X-ray emission.

Two reflection grating spectrometers fitted to two of the telescopes, which will allow simultaneous medium and low-resolution spectroscopy.

One optical/ultraviolet monitor which, together with the satellite's ability to carry out long uninterrupted observations (up to 18 hours), will allow the study of coordinated optical/ultraviolet and X-ray variations in a wide variety of objects such as X-ray binaries and Seyfert galaxies.

The CCD cameras, called the European Photon Imaging Camera (EPIC), will be led by Milan University but groups at Birmingham and Leicester Universities will have a central role in providing the detectors. The Mullard Space Science Laboratory will have the lead role in the construction of the optical monitor and also a major role in the reflection grating spectrometer which will be led by Utrecht University.

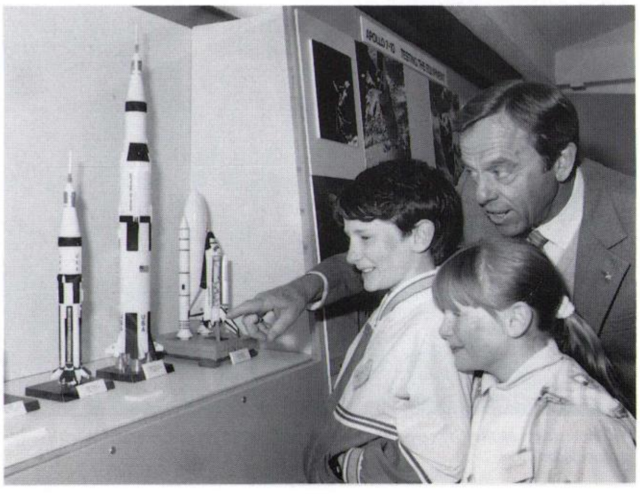
The Space Science Programme Board of the British National Space Centre has endorsed the science, and the involvement of the UK groups in the selected payload will be subject to formal approval and financial support by SERC.

Astronaut 'exploring space'

American astronaut Alan Shepard is seen (right) describing to Mark and Sarah Longair a model of the Saturn V rocket that launched him on his journey to the Moon on Apollo 14. The model was part of the exhibition, **Exploring Space*****, at the Royal Observatory, Edinburgh.***

Rear Admiral Shepard opened the exhibition, on the rooftop gallery at the ROE, in bright sunshine on 2 April. It was the inaugural event of the first Edinburgh Festival of Science and Technology which ran from 3 to 12 April, although the ROE exhibition remained open throughout the Summer, proving a big public attraction.

The exhibition was in three parts: the 20th anniversary of the first moon walk and the story of man's quest to reach the Moon; the quest of the astronomer to explore the Universe beyond the Moon; and examples of the work supported by SERC and its establishments.



Astronomers of the future ?

UK entrants to the European Space Agency's essay competition ***Astronomy from Space*** enjoyed a day's visit to the Mullard Space Science Laboratory on 14 July. The visit was at the invitation of Professor Len Culhane, Director of the Laboratory, and was made possible by funding from the Holmes-Hines Memorial Fund. The essay competition was part of the celebrations to mark ESA's Silver Jubilee this year and was open to all European students aged 16 to 21. The Space Science Programme Board, who assessed the UK entries, were impressed by the quality of the submissions and were keen to recognise and encourage the interest shown by the youngsters (mostly 6th formers). The visit was designed to show some of the Laboratory's activities in high energy astronomy, space plasma physics, solar physics and Earth remote sensing. A full programme was arranged which included a tour of the electronic and mechanical workshops, clean room and test facilities, a look at the work of the detector development group, and a talk about the Giotto mission. It finished with a NASA film of the 1985 Spacelab 2 mission which had carried, as part of its payload, an MSSL instrument designed to measure the abundance of helium in the Sun.

UK national winner Andrew Gentles, who will, he hopes, be pursuing his interest in astronomy at Cambridge University in October.

Thirteen of the 20 eligible young essayists attended and during the course of the day John Andrews from SIRA Ltd, a member of the SSPB, presented the UK national winner (Andrew Gentles — aged 18) and the runner-up (Miss Bissan Lazikani — aged 16) with book token prizes kindly donated by SIRA of £50 and £25 respectively. Miss Lazikani also received a set of publications from ESA.

Andrew had already travelled to Noordwijk in the Netherlands to a presentation ceremony for all the European winners at the June meeting of the ESA Council where he received his set of ESA publications and an invitation to visit the European Southern Observatory at Garching, West Germany, in the Autumn.

Bissan Lazikani, whose essay, Dreams of the Red God, *won her second place in the UK competition, receives her prize from John Andrews of SIRA Ltd.*

Holmes-Hines support for science centre

Young visitors at the Green Science Centre in Nottingham experiment with a plasma ball.

A donation of £2,000 has been made from the Holmes-Hines Memorial Fund to the George Green Memorial Fund for technical assistance at the Green Science Centre in Nottingham. This Centre, which was opened in 1985, contains about a dozen interactive exhibits as well as biographical information on the mathematical physicist George Green (1793-1841) and was visited by 50,000 people last year. The money will be used to develop new exhibits. The Centre is in the yard of the windmill, now fully restored and working, which was Green's workplace. Best known for Green's functions and Green's theorem, he made contributions to electricity and magnetism, elasticity and the reflection of light and sound.

The Holmes-Hines Memorial Fund provides annual prizes, scholarships, exhibitions or research grants, the incidental expenses of visiting scientists, the purchase of scientific apparatus and equipment and funds for such other purposes for the advancement of scientific knowledge as the Council shall select. It can be used to help individuals achieve their scientific aspirations and to sponsor activities related to science for which public funds are not available.

Applications for awards from this fund should be made to the Council's Finance Officer, G L Addison, at the Swindon Office.

UK and West Germany collaborate on ISIS

West German and British scientists will collaborate to provide a new type of spectrometer to be installed at the ISIS neutron facility at Rutherford Appleton Laboratory (RAL).

An agreement to this effect was signed in Wurzburg on 9 May by Dr Paul Williams, Director of RAL, and Professor Reinhard Gunther, Chancellor of Wurzburg University. The new £1 million instrument, called ROTAX, will be used to determine the properties of materials.

When it comes into operation in 1991, ROTAX will be a valuable addition to the existing range of 13 instruments available at ISIS. These cover an unparalleled energy and resolution range for neutron-scattering research, and ensure the position of ISIS as the world's leading high intensity pulsed neutron facility, primarily used for condensed matter research using slow neutron scattering techniques.

ROTAX is a new type of crystal analyser time-of-flight spectrometer for elastic and inelastic scattering measurements at a pulsed neutron source. It incorporates a novel non-uniformly rotating analyser system, and will be used to measure collective excitations such as phonons and magnons in single crystals. This research has usually been carried out at reactors using the so-called Triple Axis Spectrometer.

Speaking at the ceremony, Dr Williams said: "I welcome this new development, which enhances the links between the United Kingdom and the West German scientists. There are already a number of West German collaborations at ISIS, including the KARMEN neutrino experiment and the joint European Pulsed Muon Facility.

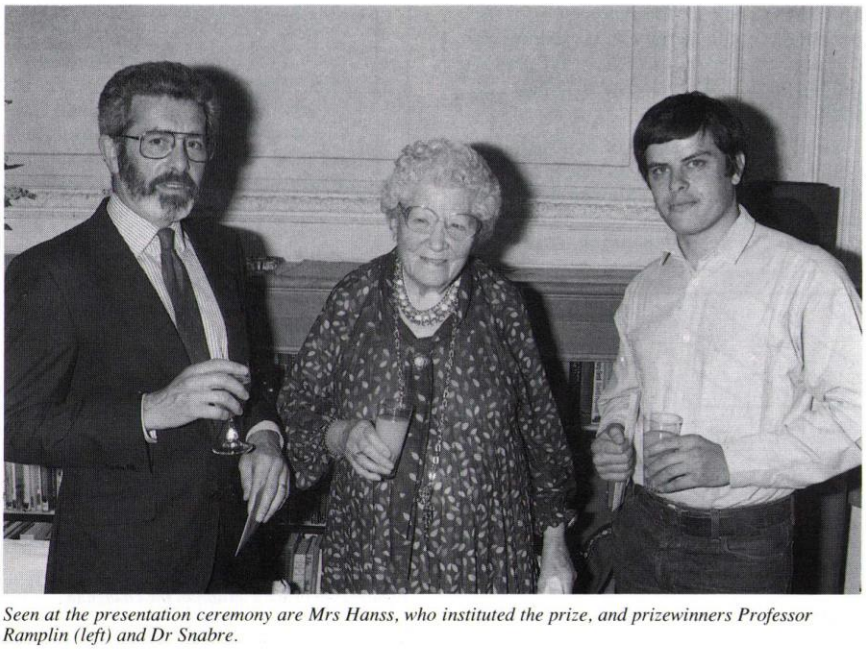
"This new agreement represents a further development of ISIS as a truly international facility, already used by France, Italy, The Netherlands, Sweden, India and Japan."

The spectrometer design has been developed by a group at the University of Wurzburg led by Professor Reinhart Geick. Work on the prototype began early last year at Wurzburg. Scientists from RAL and UK universities will be involved in its installation and exploitation at ISIS.

New France-UK science prize

SERC was pleased to share with its French counterpart the Centre National de la Recherche Scientifique (CNRS) in commemorating the life and work of one of France's leading researchers in Haemorheology, Maxime Hanss, by participating in the selection for a new science prize set up by his mother.

To keep the memory of her son alive, Mrs Victoria Beatrice Hanss decided to set up a foundation which would award the Maxime Hanss Prize every year to a French or British research worker specialising in biophysics. To this end the Fédération Britannique des Alliances Française was instructed to set up and manage the Maxime Hanss Foundation.



Seen at the presentation ceremony are Mrs Hanss, who instituted the prize, and prizewinners Professor Ramplin (left) and Dr Snabre.

Maxime Hanss died in 1984. He devoted his years as a research worker to the study of biophysics, and particularly to the study of the physical aspects of red blood cells and micro-electrophoresis. He developed a red cell filter (haemorheometer) and was co-founder and vice-president of the Societé Française d'Hemorheologie Clinique.

The first award of the Maxime Hanss Prize was made jointly to Professor Michael Rampling of St Mary's Hospital Medical School, London University, and Dr Patrick Snabre of the Laboratoire de Biorhéologie et d'Hydrodynamique Physico-chimique, Université de Paris, by Mrs Hanss at a presentation ceremony held at the British Council in Paris on 30 May 1989. The UK community was represented by Dr Tony Watts, Oxford University, and Mr Richard Coombs, Royal Postgraduate Medical School.

Professor Rampling intends to use his share of the prize to develop further research collaboration between his laboratory and its French counterparts, one of which is Maxime Hanss's old laboratory.

Diana Herbert
SERC Swindon Office

A new light source for the UK ?

Synchrotron radiation is now established as a special source of 'light', from the infrared to hard X-rays, which can be used as a probe in a wide range of problems in pure and applied science and engineering not accessible to conventional laboratory sources. Professor Philip Woodruff of Warwick University describes here the science and the potential of this type of facility.

Typically experiments in spectroscopy and in X-ray scattering exploit the high photon fluxes at the sample which can be achieved over a wide range of continuously variable wavelengths or photon energies, although many experiments also make use of the strong polarisation or special time structure of the radiation. A range of pioneering synchrotron radiation experiments performed in the 1970s by parasitic use of electron synchrotrons built for high energy physics (by cutting holes in these machines to let out the light!) demonstrated the potential utility of the source and led to the construction of dedicated storage rings, specifically for synchrotron radiation use. The Synchrotron Radiation Source (SRS) at Daresbury Laboratory was one of the first such machines to be built and has been serving an increasingly large and diverse range of users for the last eight years.

Recently some important developments in the use of electron storage rings as light sources are opening up new opportunities for researchers. In the vacuum ultraviolet (VUV) and soft X-ray (SXR) energy range (say 10-1000 eV or 12-1200 Å) these include chemical studies at the carbon, nitrogen and oxygen K-edges, microscopy (both transmission and photoelectron), especially in the 'water window' (allowing *in vivo* studies of wet samples), and particularly complex and demanding absorption and photoelectron spectroscopies (such as spin-polarised studies of ferromagnetic systems). These new developments are based on a range of *insertion devices*.

Bending magnets

The basic source of synchrotron radiation is the dipole bending magnets which are spaced around the storage ring between straight sections of vacuum pipework and cause the high energy (typically MeV-GeV) electrons to turn the corners in the nominally circular (but really polygonal) storage ring. In general any accelerated charged particle emits electromagnetic radiation, but one forced to travel in a circular orbit emits dipole radiation at the circulating frequency. Very high velocity electrons (above MeV energies), however, emit radiation which is strongly modified by relativistic effects; energy is transferred into high harmonics of the (microwave) circulation frequency producing an effective continuum, the frequency is strongly Doppler shifted and the dipole emission pattern is distorted into a narrow cone of radiation directed tangential to the bending path. This leads to the special characteristics of synchrotron radiation.

Apart from small variations due to differences in the electron beam size and divergence, all the bending magnets offer radiation with the same spectral characteristics. Additionally, however, one can add magnet arrays to the straight sections to deflect the electrons and emit radiation. Provided that the electron beam is restored to its original path at the end of the straight, the radiation produced by this array can be tailored to a specific experiment without influencing the properties of the source at other points in the storage ring.

Figure 1 shows the kind of magnet array which can be used, and its effect on the electron trajectories. This simple dipole array emits radiation of qualitatively different character depending on the magnitude of the magnetic field strength. If the field strength is sufficiently large for the angular 'wiggles' of the electron beam to exceed the intrinsic angular width of the synchrotron radiation emitted by a bending magnet of this strength, then each wiggle (or more exactly, each half-wiggle) acts as an independent source of this synchrotron radiation along the axis of the device, and the flux in this direction is enhanced by a factor 2N (where N is the number of wiggles). Operated in this mode, the magnetic field strength is often arranged to be higher than in the bending magnets; the synchrotron radiation spectrum is then not only more intense, but is also displaced towards shorter wavelengths.

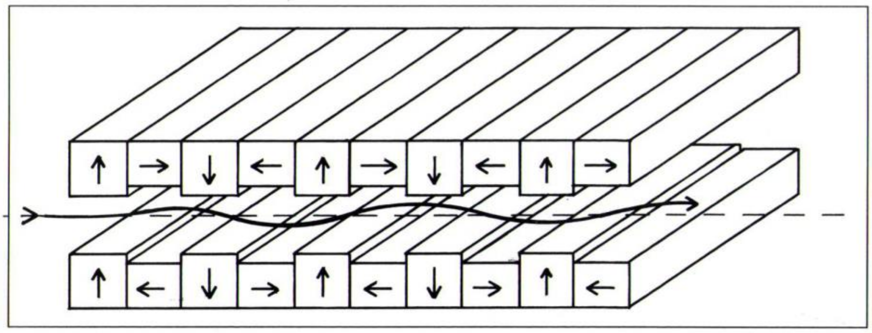


Figure 1: Schematic magnetic array for an undulator or multipole wiggler, showing the effect on the electron trajectory through it.

The wiggler

Even for a single half-wiggle (plus end corrections) a device of this kind is valuable as a *wavelength shifter*. A wiggler of this kind is already installed on the SRS at Daresbury and a second such device is being planned. At lower field strengths, however, emission from successive wiggles, or undulations, can become temporally coherent. The device can then act rather like a multiple slit source in optics; coherent interference between emission from these 'separate sources' leads to a more intense and narrower beam. This constructive interference also occurs, along the axis of the device, for odd-numbered harmonics of the fundamental wavelength satisfying these conditions. Moreover, because this is a weak magnetic field device, the

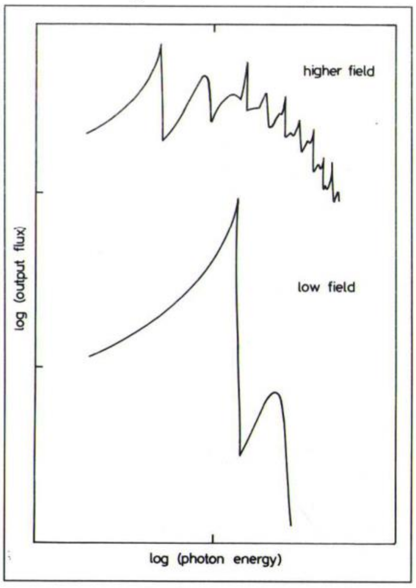


Figure 2: Schematic graph of the change in spectral output from an undulator as the magnetic field strength is increased.

underlying continuum synchrotron radiation is weak. The spectral output of this device is therefore strongly structured, with peaks at the appropriate harmonics. Of course, there is a smooth progression in the spectral output of this low field undulator to the high field wiggler, with increasing field strength causing stronger emission in the higher harmonics and a rise in the underlying synchrotron radiation continuum (figure 2). A key design parameter for an undulator is the fundamental wavelength emitted along the axis at low fields which is given by half the undulator (magnetic) periodicity divided by the square of the electron energy expressed in units of the electron rest mass (this is approximately twice the energy in MeV). The basic spectral output of the undulator is therefore dictated by the physical dimensions of the magnet array and the electron energy in the storage ring, although tunability of this output can also be achieved by varying the magnetic field strength, for example by closing the magnetic gap in the device.

Designed to match

Insertion devices offer a new way of thinking about synchrotron radiation sources. With bending magnets alone, the user of the radiation is presented with a source to which he must match his experiment; with insertion devices, there exists the possibility of designing the source to match the experiment. Undulators are particularly attractive for users of longer wavelength radiation because most of the energy content of conventional (bending magnet) synchrotron radiation is in the short wavelength end of the spectrum. This means that high useful intensity is accompanied by vast amounts of unwanted energy which can distort (and even melt or vaporise) the first optical elements in the experimenter's beam-line.

There has been a lot of design work over the last few years and several prototypes have been built to test these ideas. Wigglers (mainly with rather few wiggles) are becoming common and undulators have been shown to work. But the full potential can only be realised with storage rings built specifically to house them. Existing storage rings typically have too few (and too short) available straight sections. Also, to realise the full potential of undulators needs rings in which the electron beam emittance (product of the beam size and the beam divergence) is smaller than in existing sources. In such rings, the *brilliance* (photon flux divided by its emittance) of undulators can be much greater than on conventional sources (figure 3), although not all experiments can take full advantage of this increase.

Several new machines based on these principles are now planned. Most of these follow one of two general designs; machines with operating energies of 1.5-2.0 GeV should allow optimisation of undulators for use in the photon energy range of 10 or 20 eV to 1000 eV, while machines with an operating energy of 6-7 GeV will provide output from essentially the same undulators in the energy range 300 eV to 20 keV. The European Synchrotron Radiation Facility now being built at Grenoble, of which the UK is a full partner, is a device of the latter type. A similar machine is being constructed at Argonne in the USA. The lower energy machine, designed for users of VUV and SXR radiation, is typified by the facility being constructed at Berkeley in the USA and by the Italian facility being built at Trieste. A similar proposal for West Germany (BESSY II) is still awaiting final approval.

The future

In the UK we have the successful SRS providing valuable bending magnet and wiggler radiation operating at an electron energy of 2 GeV, chosen to optimise the performance of these sources in the medium X-ray energy range.

The ESRF offers X-ray facilities for the future. The VUV and SXR user community in the UK, however, are not well served by these facilities. This deficiency led the Blundell committee, which reviewed synchrotron radiation work in the UK in 1986, to recommend explicitly that a specialised VUV/SXR source should be built in the UK. A workshop of some potential users held at Warwick University last year led to considerable enthusiasm for the scientific potential of such a source (a report, outlining some of the opportunities, is available from the author). Finally, SERC's Science Board agreed in January of this year to fund a design study for a new facility for the VUV/SXR energy range. Although much of the basic work for this design study will be performed by staff at SERC's Daresbury Laboratory, it is essential that the whole potential scientific user community should be involved in determining the future of this work in the UK and in defining the properties of any new facility. Moreover, if a new facility is to be built we should consider whether, bearing in mind the timescale, there are even newer design ideas which should be incorporated, such as novel variable polarisation undulators or even coherent radiation sources such as an optical klystron or free-electron laser by-pass capability. Many of these ideas, and their implications for the scientific user, will be discussed at workshops which are planned for late 1989 and early 1990, but input from any interested parties will be welcome now. The author will be mainly responsible for interacting with the scientific community in this design study, and would appreciate hearing from such people directly.

Professor D P Woodruff
Warwick University

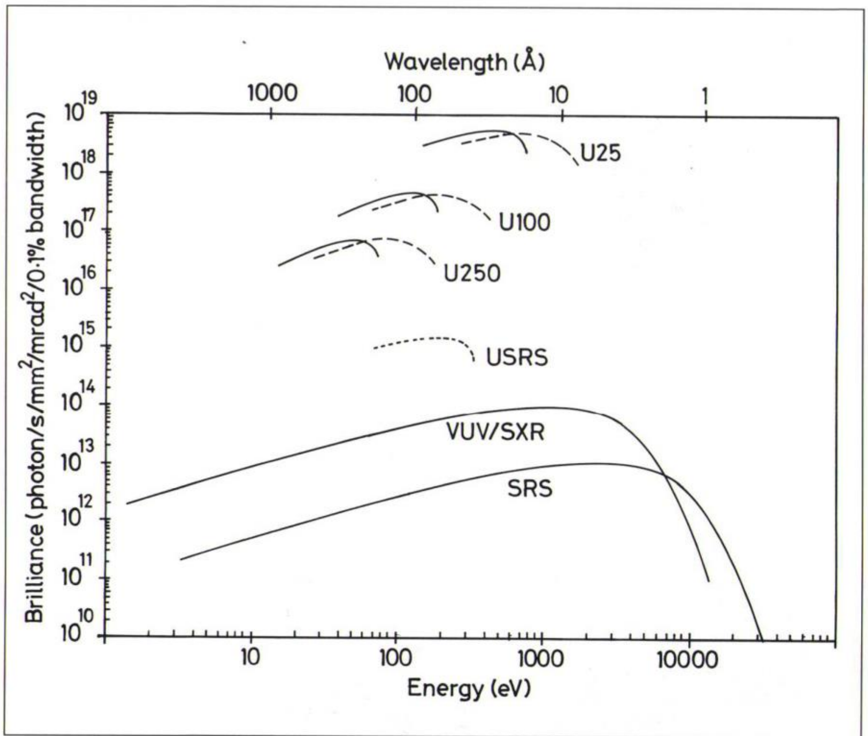


Figure 3: Illustrative brilliance of some undulators through their tuning range in the first (full lines) and third (dashed lines) harmonics for a possible VUV/SXR ring, compared with the performance of the bending magnets on such a source, and on the SRS. USRS shows the calculated output of a simple undulator on the SRS.

DELPHI — the world's largest superconducting solenoid

For many years the Rutherford Appleton Laboratory (RAL) has been in the forefront of developing materials and techniques for superconducting magnet technology. Previously these techniques have been used to build small magnets such as polarised targets and a wiggler for the Synchrotron Radiation Source at Daresbury Laboratory. More recently RAL has constructed two of the world's largest superconducting solenoids for particle physics experiments at CERN in Geneva and DESY in Hamburg.

To design, develop special techniques, construct and test the DELPHI solenoid for LEP at CERN took members of the Technology Department at RAL almost seven years but, by taking advantage of this experience and using common equipment, the H1 solenoid for DESY has been built in three years.

In this article, Peter Clee of RAL covers the latest situation on the DELPHI magnet. In the next issue, we shall be presenting an update on the H1 at DESY.

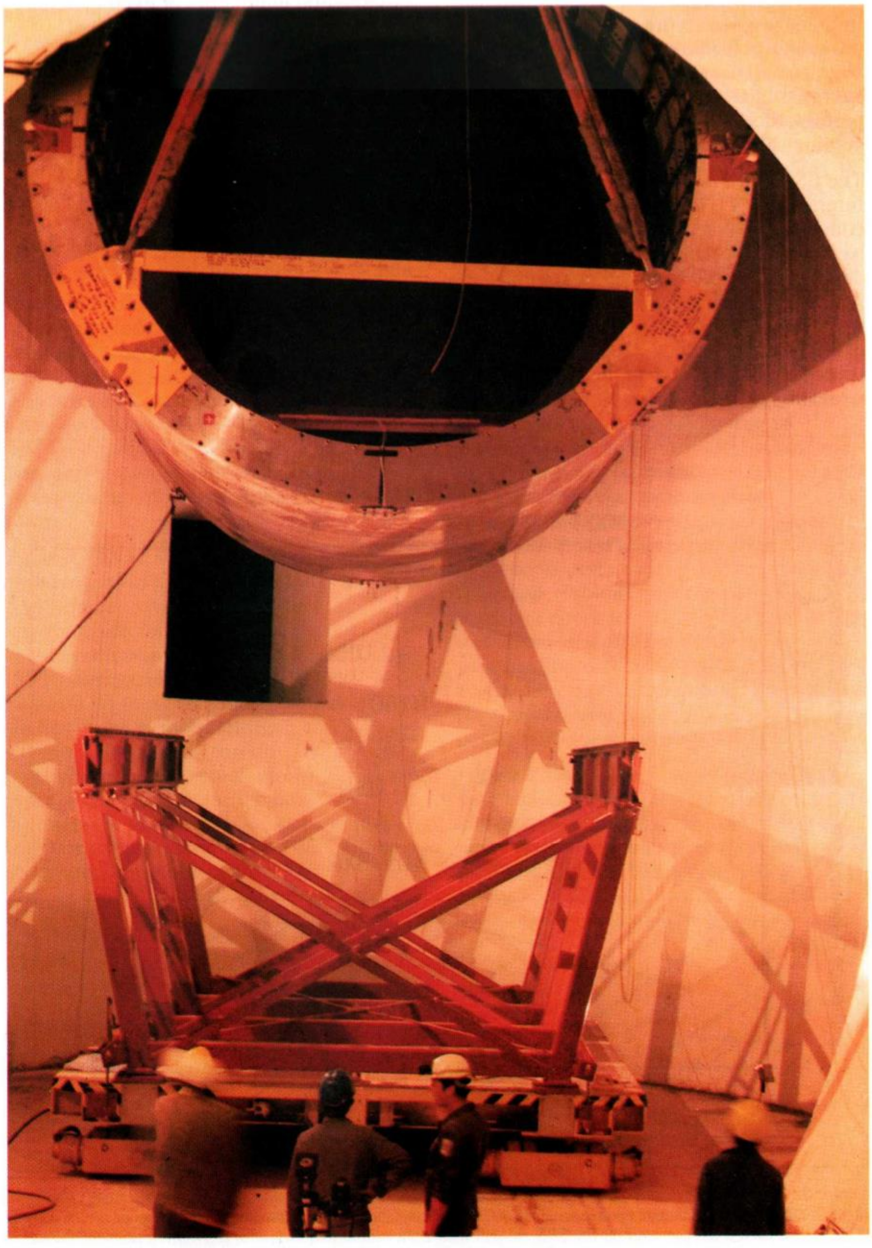


Figure 1: The 84-tonne solenoid is lowered 100 metres down the shaft to Pit 8.

Having completed the tests in the CERN West Experimental Hall (see *SERC Bulletin* Volume 3 No 11, Summer 1988), the solenoid was moved in June 1988 to its final location in Pit 8 of the Large Electron Positron (LEP) collider. Because of the 84-tonne weight (which exceeded the capacity of the pit-head crane), special equipment was used to lower the solenoid down the 10-metre diameter by 100-metre deep shaft. Although there were only centimetres of clearance between the solenoid and shaft wall, it reached the bottom of the shaft in a few hours and was lowered on to the support frame and transfer trolley (figure 1). The solenoid was then installed in the bore of the 2400-tonne iron yoke and aligned geometrically on the yoke axis.

Several months of careful installation followed, to connect the service turrets at the end of the solenoid and to provide demountable connections at the outer surface of the iron yoke. The service equipment platforms were lowered down the access shaft and installed on the top of one of the control barracks located alongside the magnet and detector assembly. All the electrical, cryogenic and control systems were then installed, connected up and tested ready for operation. The vacuum pumping system was located beneath the iron yoke and connected to the solenoid by pipes passing through each end of the yoke.

In January 1989 the solenoid was connected to the helium refrigerator (provided by CERN) and was cooled down from room temperature to 4.5K in ten days. At this temperature the conductor became superconducting.

Powering of the solenoid was carried out in stages to enable the power supplies, breakers and control equipment to be checked out and to ensure that the protection system would handle the extraction of 110 megajoules of energy (at 5000 amps). The test progressed in steps of 500 amps and after each increase a slow rundown of the current from 5000 amps ($1\frac{3}{4}$ hours) and an emergency fast

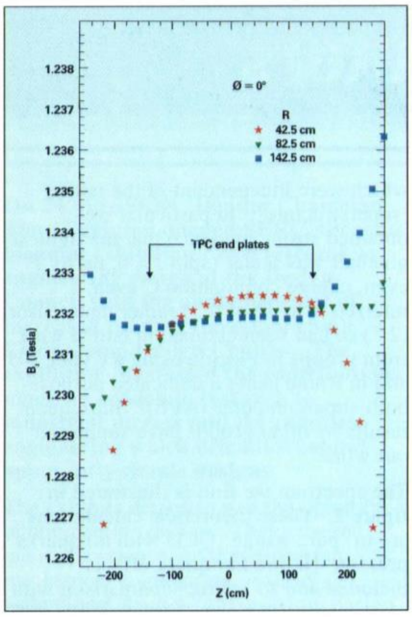


Figure 2: Magnetic field B_Z along length of solenoid

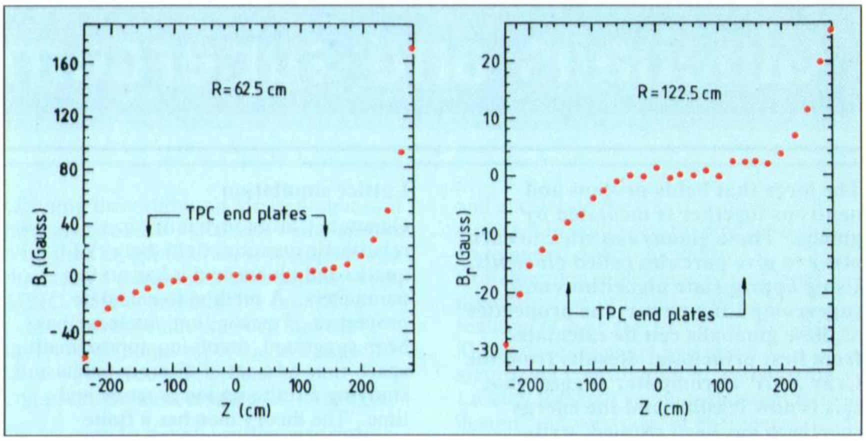


Figure 3: Variation in radial field over the solenoid length for two radii.

rundown (60 seconds) was carried out. In the latter case most of the stored energy is extracted and dumped in an external resistive load. The remaining energy is absorbed by the mass of the coil and support cylinder. The computed temperature rise for a rundown from 5000A was 42K as compared with the actual measured rise of 34K. At 5000A the required 1.2 Tesla central magnetic field was achieved.

To meet the required field homogeneity over the volume of the Time Projection Chamber (TPC) and the Electromagnetic Calorimeter (HPC), it was necessary to design in some compensation for the field fall-off at the ends of the solenoid. This was achieved by adding extra turns at the coil ends which were connected in series with the main coil. The extra turns are also connected to separate power supplies to provide adjustable correction within a range of plus or minus one kiloamp.

The tests indicated that the properties of the iron yoke were better than expected and the extra ampere turns over-compensated the field fall-off at the ends. This was corrected by passing several hundred amperes through the additional end windings, in the reverse direction to the 5000A main current.

In measuring the magnetic field (carried out by a CERN/Russian group) it was found to be asymmetric about the ends, thought to be due to a 6-millimetre axial offset of the solenoid relative to the iron yoke. This error was corrected by passing different correction currents through the end turns (700A in one end and 900A in the other).

At these current settings, the field was measured over a cylindrical volume of 202-centimetre radius and 560-centimetre length and out to a radius of 252 centimetres at the ends. The Bz fields at three radii are shown in figure 2 and are well within the required ± 0.01% over the volume of the TPC. Br was within specification (see figure 3) and Bφ was at most ± 1 Gauss within the volume of the TPC and ± 3 Gauss elsewhere. The stability of the field was 0.01% over a 12-hour period.

On completion of the test, the detectors and vacuum beam pipe were installed.

Figure 4 shows the Experimental Hall of Pit 8 with the control barracks and main body of the detector in the background, and the two magnet end-caps and detectors in the foreground. During the summer months a teach-in and handover of the magnet to the CERN staff were carried out, and the magnet was run, to test the detectors. This is being followed by the start of the physics programme.

P T M Clee
Rutherford Appleton Laboratory

Figure 4: The Experimental Hall in Pit 8: in the foreground the two magnet end-caps and detectors; in the background, the control barracks and main body of the detector.

Glueballs and supercomputers

The force that holds protons and neutrons together is mediated by gluons. These gluons can stick to each other to give particles called *glueballs*. Using appropriate algorithms and supercomputing power, the properties of these glueballs can be calculated from first principles. Results from the Cray XMP/48 computer suggest that this is now feasible and the energy spectrum has been studied, write Professor Christopher Michael of Liverpool University and Dr Michael Teper of Oxford University.

Glueballs

The proton and neutron are the dominant constituents of the matter around us as they are the main particles in the atomic nucleus. They are themselves made up of other particles (such as quarks and pions) and the theory of Quantum Chromodynamics (QCD) provides a detailed description of their structure and of the strong forces holding them together. This can be pictured (figure 1) as gluonic forces binding quarks. These same gluonic forces are also responsible for holding mesons (the pion, rho and so on) together.

The theory of QCD is formally rather similar to the theory of electric and magnetic forces and the gluon plays the role of mediating the strong force analogous to that of the photon in mediating the electromagnetic forces. The new feature in QCD is that the gluon can interact with itself: theoretically it is possible to have particles made purely out of gluons. These glueballs have been much discussed over the last decade. Experimental searches for them have been conducted, but it is always difficult to distinguish unambiguously between a glueball and an ordinary meson. Since QCD is a complete theory of quarks and gluons, another way forward is to calculate from first principles the glueball properties. This is now feasible using supercomputers.

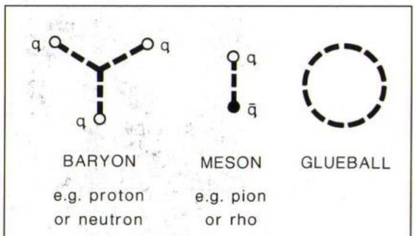


Figure 1: Schematic quark (q), antiquark ($\bar{q}$) and gluonic (- - -) content of states. The gluonic force between quarks can be pictured as an elastic string and the glueballs as elastic bands.

Lattice simulation

Quantum Chromodynamics is a relativistic quantum field theory of quarks and gluons and it has no free parameters. A method to calculate properties of mesons and nucleons has been suggested, involving approximating space-time as a set of discrete points and studying a finite region in space and time. The theory then has a finite number of degrees of freedom and, formally at least, results can be obtained by integrating over these degrees of freedom. A reasonable study requires around 20 sites in each of the four space-time dimensions and, taking into account the variables needed to describe the gluonic fields, this implies around 5 million variables to describe a single arrangement of the fields in such a region of space-time. A 5-million dimensional integration is therefore needed to average over all possible configurations.

It is possible to approximate such an average by suitably selecting samples in a random way. This is only realistic if the quantity being averaged is always positive and this can be arranged by using 'imaginary time'. Theoretically this is well defined, but it is hard to explain other than as a mathematical trick which converts quantum field theory into statistical mechanics: one can then use what is known as a Monte Carlo simulation, for which efficient algorithms have been developed. Even with such algorithms, massive computational effort is needed to update each variable successively and obtain a sequence of statistically independent samples of the gluonic fields. Much as in an experiment, these samples are 'data' and one can then measure correlations of appropriate quantities in these samples to get results for the mass values of states.

A major technical breakthrough in our work has been in choosing carefully the quantities to measure so as to get accurate values of the masses of the low lying states — a so-called fuzzing algorithm is the key advance.

Results

The authors combined ideas and Cray time allocations to make an assault on the glueball spectrum using these methods. The program was fully vectorised, the solid state disk was heavily used because of the large number of variables needed to describe the system and over 1000 hours were used. Compared to earlier work we were able to simulate relatively large volumes (about 1.5 femtometres across) with sufficiently small lattice step length (about 0.07 fm) to get results which were independent of the lattice 'superstructure'. In particular we obtained strong evidence that the lightest glueball was scalar (spin J = 0, parity P even, charge conjugation C even, referred to as J^{PC} of 0^{++}) rather than tensor (2^{++}) as had been claimed in lattice work from groups in Florida using a Cyber 205 and in Rome using a dedicated purpose-built supercomputer (APE). Subsequent results by other groups have supported our work.

The spectrum we find is illustrated in figure 2. These theoretical calculations are in 'pure-gauge' QCD with no quarks present. Nature has quark effects included and so a direct comparison with experiment is not possible: glueballs and mesons get mixed. One exception is for spin-exotic glueballs such as 1^{-+} or 2^{+-} for which there are no quark-antiquark mesons at all; these are known as 'oddballs'. We find no evidence for light oddball states (contradicting some earlier tentative work) which is rather discouraging from the point of view of an experimentalist wishing to observe glueballs unambiguously. It is possible to include quark effects in the lattice approach which would clarify comparison with accelerator experiments. This is currently under study but appears to need enormous computational resources of the order of 100 times those used for the work reported here.

Professor C Michael
Liverpool University
Dr M Teper
Oxford University

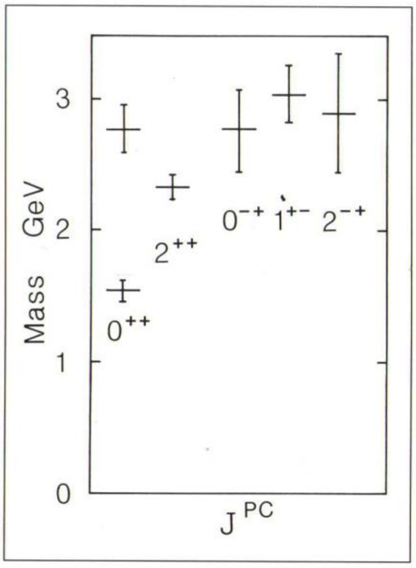


Figure 2: Low-lying glueball masses.

Engineering Design Initiative takes off

On 24 May SERC Deputy Chairman Tony Egginton opened SERC's second biennial exhibition *From research to engineering design* at the Design Council with the announcement of increased funding for establishing Engineering Design Centres. The exhibition illustrated the contributions made by academic research to industrial success and the complex engineering which often lies behind apparently simple designs.

The exhibits demonstrated the ubiquity of engineering design. They covered materials science, civil engineering, mechanical engineering, marine technology, medical engineering, design tools, expert systems and software systems in general. All involved industry and included new and improved products, cost reductions and new methods of modelling, none of which could have been achieved without the discipline of engineering design.

Opening the exhibition Mr Egginton said how much SERC valued its collaboration with the Design Council and emphasised that design remained a high priority with SERC. It was essential for the UK to achieve and sustain the very highest levels of skill and expertise in design for industry to succeed in today's competitive world market.

He referred to the £6 million research grant awarded in 1988 to a Scottish consortium of academic institutions for the Interdisciplinary Research Centre (IRC) in Engineering Design. He announced that SERC had received an extra allocation of some £1 million a year from 1990-91 onwards to establish some five or six smaller Engineering Design Centres (EDCs) at academic institutions. These were planned to form a complementary network of dedicated and compatible facilities. They will cooperate with each other and the Design IRC to draw together design expertise and accelerate the transfer of research results into both specific product design and general design methods. Collaboration with industry and rapid dissemination of results will be key features of both the EDCs and the IRC. These developments will make a significant contribution to realising the Lickley Report's recommendation to make design "the very core of engineering".

Professor David Morris, Chairman of SERC's Design Management Committee, wrote to all academic institutions in June inviting them to submit proposals for EDCs. Shortlisting the proposals began in September and the final selection will be announced early in 1990. One of the first EDCs to be established is expected to be based on the Automotive Design Programme at Birmingham University and will be jointly funded by the Electro Mechanical Engineering Committee, the ACME Directorate and the Design Management Committee.

RAL host to Engineering Council

Eleven members of the Engineering Council who visited Rutherford Appleton Laboratory on 16 March for their annual meeting with SERC took the opportunity to find out more about the engineering expertise, training and facilities at RAL.

It was the Engineering Council's first visit to the Laboratory and tours were arranged of the world-leading pulsed neutron source ISIS, the H1 Superconducting Solenoid (now being installed as part of the HERA experiment at DESY in Hamburg) and Electronics Division. There was also a talk on applications of the Cray X-MP/48 supercomputer to engineering.

The visitors were impressed by the wide range and high quality of engineering carried out in the Laboratory, and in view of the national need to encourage young people to make engineering their chosen career, were firmly of the opinion that such excellence should be more widely publicised.

Seen examining a Fastbus card full of microchips are (left to right) Council Members Michael Manzoni, Chairman of R M Douglas Construction Ltd and Tim Beynon, headmaster of the Leys School, Cambridge, with Dr Peter Sharp and Jim Stanton of RAL's Electronics Division.

Increasing production of secondary metabolites

Secondary metabolites are compounds produced by organisms that are not used in the synthesis of more cellular material. They are of particular interest as they include antibiotics such as Penicillin, and a large range of other bioactive compounds such as Cyclosporin — the drug that allows successful organ transplants.

To produce antibiotics and other secondary metabolites, organisms have to find novel metabolic pathways. This situation is of interest to both the pure scientist — How does the cell synthesise these unusual compounds? How does the cell switch synthesis on and off? Why does it do so? — and the industrial scientist — What novel compounds can we find in microorganisms? How can we get more of a useful compound? Dr David Hodgson of Warwick University examines these and other questions about secondary metabolites.

How do we increase production?

Let us presume that a scientist has isolated an organism that looks as if it is producing a commercially interesting compound. The first thing that needs to happen is to get the cell to produce more of it. Most secondary metabolites produced by newly isolated organisms are produced in vanishingly small amounts. Over the years a number of techniques and rules of thumb have been acquired to increase production empirically.

One part of the approach is to grow the cells under different nutrient conditions. The regime may involve inclusion or omission of particular compounds, altering the pH of the culture and/or changing the amount of oxygen the cells are getting. The actual regime will depend on the organism, the compound, and the knowledge and experience of the researcher. Often this is more of an art than a science.

The other part of the approach is strain improvement. This involves mutagenesis of the organism — treating the organism with agents that cause permanent alteration of its genes. The mutagenised cells are then screened for the ability to produce more secondary metabolite.

This entire procedure is, as can be imagined, laborious, expensive and very hit-or-miss. At least one case exists where a structurally complex antibiotic of great therapeutic value is being synthesised chemically because no one has been able to get the organism to produce it in commercial quantities.

Rationalising increased production

The Biotechnology Directorate and Biological Sciences Committee of the SERC, in partnership with the Department of Trade and Industry and a consortium of four companies — Beecham Pharmaceuticals, Celltech, Glaxo and ICI — recognised the need to move away from these empirical approaches. They set up the **Antibiotics and Recombinant DNA Club** in an attempt to encourage fundamental research into antibiotic producing organisms, with the long-term aim that any knowledge so gained could be exploited to generate rational strain-improvement programmes. The Club funds research at 13 academic groups and is coordinated by Dr Iain Hunter of Glasgow University.

Britain has a world lead in the genetic study of streptomycetes and the Penicillin-producing filamentous fungus *Aspergillus*. The aim was to exploit the genetic knowledge of these organisms to understand secondary metabolism.

Penicillin came from the fungus, *Penicillium*. However, of the more than 10,000 antibiotics now known, only 16% come from fungi. In contrast, 56% are made by bacteria and the majority of these (38%) are made by one genus — *Streptomyces*. The majority of the medically and veterinary important antibiotics were discovered in the *Streptomyces*.

The streptomycetes are unusual looking bacteria. As can be seen from figure 1,

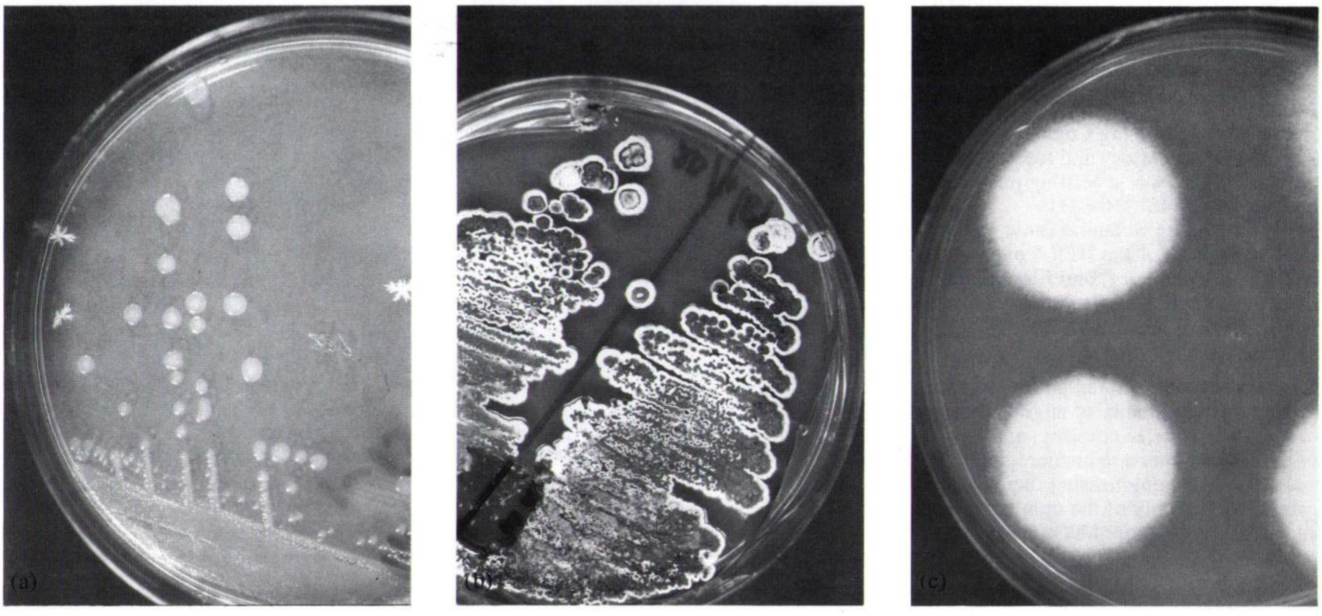


Figure 1: (a) A normal bacterium- E. coli*; (b) a streptomycete; and (c) a fungus* Aspergillus.

they look more like fungi than bacteria. However, despite this superficial resemblance, they are true bacteria.

The work at Warwick funded by the Club involves the genetically best understood streptomycete, *Streptomyces coelicolor* A3(2). Two of the antibiotics produced by this organism, Actinorhodin and Undecylprodigiosin, are pigments that change their colour depending on the acidity or alkalinity of the medium (figure 2). Our work has concentrated on investigating the effect that increasing precursor supply (in this case an amino acid) has on the production of an antibiotic. One technique that has been used to increase amino acid production in bacteria has been to isolate mutants resistant to analogues of the amino acid.

In the best studied bacterium, *Escherichia coli*, amino acid synthesis is regulated by the product; in other words, the enzymes responsible for synthesising the amino acid are switched off when enough amino acid has been made ('feedback regulation'). An amino acid analogue is a compound that has enough similarity to an amino acid to be able to switch off amino acid biosynthesis, but cannot be used in the essential synthesis of cellular material. And so, if an analogue is absorbed by a cell, the cell will become starved for the amino acid. A mutant that can grow in the presence of an analogue can be one of two types: it may be unable to transport the analogue (and the amino acid) into the cell; or it may have lost the mechanism for switching off the synthetic pathway; such cells will overproduce the amino acid.

Many groups have tried to exploit analogue resistance as a route to the isolation of antibiotic overproduction mutants of streptomycetes. The idea is to take an analogue of an amino acid known to be the precursor of the secondary metabolite of interest and use it to isolate resistant mutants. The assumption has been that any secondary metabolites overproducing mutants do so because they overproduce the precursor. This, as will be seen below, may not always be the reason.

Searching for the proline source

Our work has centered on the metabolism of the amino acid proline in *Streptomyces coelicolor* A3(2). Proline was chosen because it is known to be the precursor of Undecylprodigiosin. We set about trying to assess where the proline came from that ended up in Undecylprodigiosin. Did it come from outside the cell or was it newly synthesised by the cell? We isolated mutants that were blocked in proline transport using proline analogues. Some of these were also blocked in proline degradation. The surprising thing was that mutants overproduced Undecylprodigiosin (figure 3). One way of interpreting this result was that the cells were having difficulty in getting rid of excess proline, because they could not transport it out of the cell and/or because they could not break it down. Hence, one way of getting rid of it was to shunt it into Undecylprodigiosin synthesis.

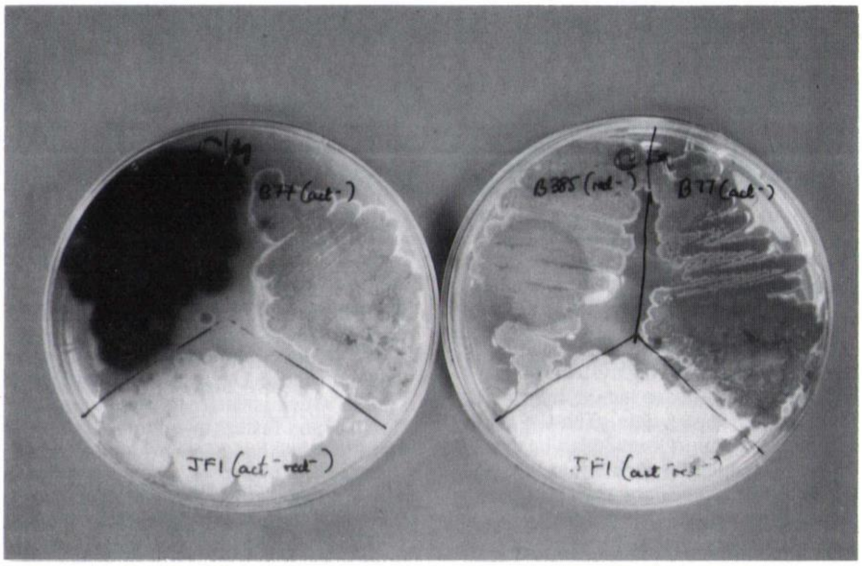


Figure 2: act+ red–, act– red+ & act– red– *strains in acid and alkali media.*

If this interpretation is correct it must mean that proline synthesis is not feedback regulated in *Streptomyces coelicolor* A3(2). If this is true then by increasing the number of copies of the proline synthesis genes present in the cell we might predict that we would increase proline synthesis in the cell and hence Undecylprodigiosin synthesis. In figure 4 we show the result of introducing many copies of proline synthesis genes into a cell. Obviously Undecylprodigiosin synthesis is increased. At present we are testing directly whether proline synthesis is regulated by proline.

These results may have direct relevance to strain improvement schemes. If our interpretation is correct, precursor synthesis is subject to little or no feedback regulation in streptomycetes. Indeed, those amino acid biosynthesis pathways studied in streptomycetes show little evidence of efficient feedback regulation. Therefore, one rational way to increase secondary metabolite production may be to increase precursor concentration by increasing the number of copies of biosynthetic genes and/or decreasing precursor removal.

Dr D A Hodgson
Warwick University

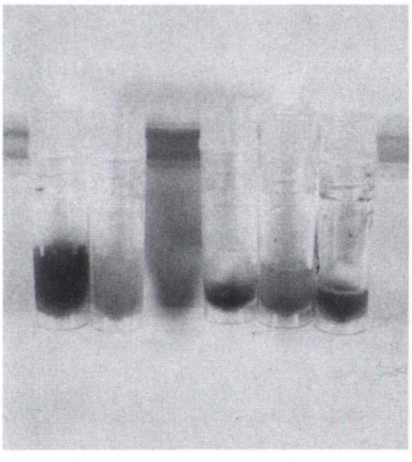


Figure 3: Wildtype and put– Streptomyces coelicolor *A3(2).*

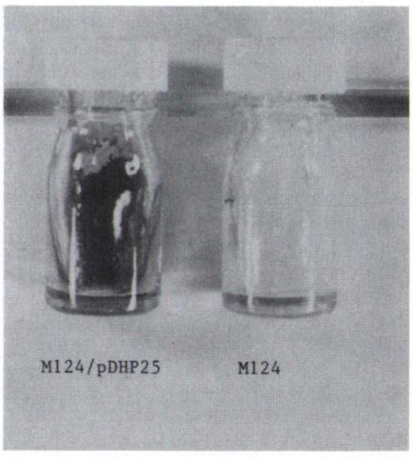


Figure 4: Wildtype and multicopy pro+ *containing* S. coelicolor *A3(2).*

Results from the Alvey programme

The Alvey programme of research in advanced information technology began in 1983 and many projects are now coming to an end. Some substantial successes have been achieved. The following articles describe just a few of the many topics being pursued. A full evaluation of the programme as a whole is expected to be published next year.

Intelligent File Store

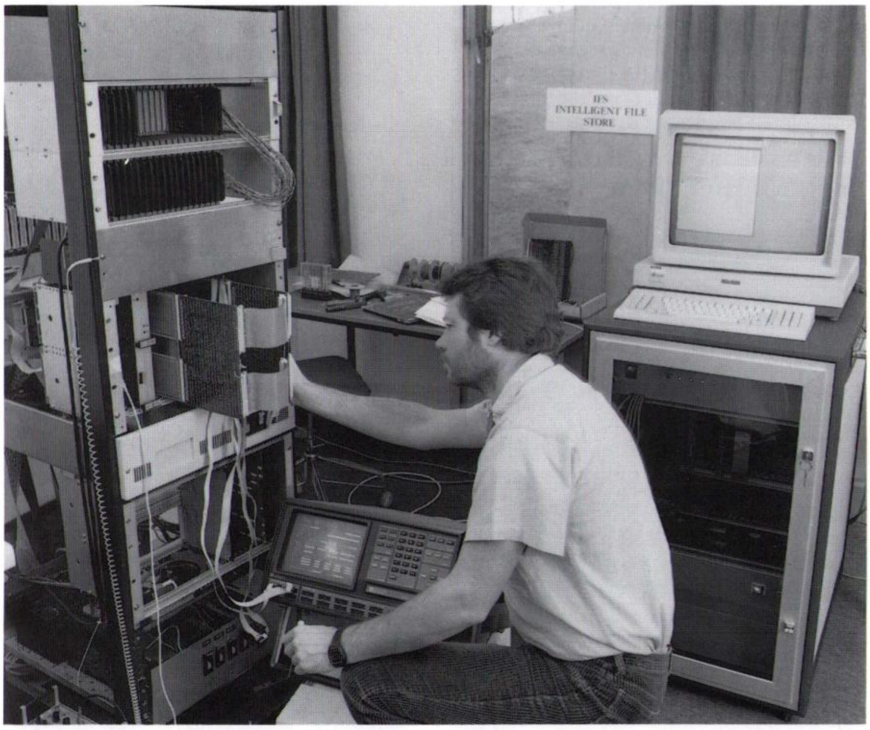
The Intelligent File Store is an add-on unit which, when connected to a conventional computing system, greatly improves the ability to handle large amounts of complex data. The IFS is designed to support knowledge-based systems in which the techniques of artificial intelligence are applied to realistic problems.

One of the principal requirements of knowledge-based systems is for rapid searching. Phase 1 of the project, the IFS/1, features 6 megabytes of semiconductor associative (content-addressable) memory — the world's largest. This associative memory provides fast pattern-directed searching, without the need for conventional indexing or other software techniques. The memory can be configured by software to suit a wide range of knowledge-representation formalisms, covering such things as relational databases, semantic nets, frames, logic clauses, s-expressions, and graph-reduction packets. High performance is achieved by fully exploiting the opportunity for parallel search, through novel hardware which operates in a SIMD ('single instruction, multiple data') manner. The result is a memory system which is easier to use, more flexible, and faster (by up to a hundredfold) than conventional systems.

The IFS/1 is a network-accessible resource which comes complete with interfacing software. The first production IFS/1 was built by Essex University and delivered in December 1987 to the Artificial Intelligence Applications Institute at Edinburgh University. An IFS simulator has been supplied to five UK research groups, and to three overseas groups (in West Germany, Canada and the USA). Phase 2 of the project, involving hardware which operates on sets and graphs, is now being designed.

Further information from:

Professor Simon Lavington,
Department of Computer Science, Essex University, Colchester CO4 3SQ; telephone (0206) 872677.



The Intelligent File Store at the Department of Computer Science, Essex University. On the left is the prototype development system and, right, the re-engineered phase 1 system, IFS/1, as delivered to Edinburgh University.

The Alvey DSS Demonstrator Project

Some problems in handling information are so large or so complex that it is difficult to provide manageable solutions using traditional data processing techniques. The Alvey DSS Demonstrator Project aims to show how techniques from research on Intelligent knowledge-based systems (IKBS), man-machine interface (MMI) and software engineering will make computer-based solutions to these otherwise intractable problems possible.

Organisations which are based upon legislation, such as the Department of Social Security, contain many examples of this type of problem. However it is not only central Government which experiences problems in handling information — many commercial operations are also concerned with the application and interpretation of complex policies and rules.

The project has four major objectives:

- ☐ To establish UK expertise in constructing knowledge-based decision support systems
- ☐ To provide a focus for research in the areas of IKBS, MMI and software engineering
- ☐ To establish effective methods for constructing large knowledge-based decision support systems
- ☐ To provide an opportunity for exploring emerging hardware and software technologies in the expectation that they will become cost effective by the end of the Alvey programme.

Demonstration systems which are under development include: assistance for adjudication officers and officers assessing Supplementary Benefit, information for claimants and potential claimants, assessment officer training and assistance for policy makers.

These systems are expected to show the following advantages for the intelligent knowledge-based systems approach, compared with traditional data processing techniques:

- ☐ More effective processing of information and quality of service
- ☐ Much greater flexibility of response to special cases and changes
- ☐ Treatment of the varying needs and skills of all users in a sympathetic and intelligent manner
- ☐ Safeguards for the rights of individuals and the integrity of the system.

The Alvey DSS Demonstrator Project is being conducted by a consortium led by ICL in collaboration with the DSS, Logica, Imperial College, London and Lancaster and Surrey Universities. It is funded jointly by the Alvey Directorate, SERC, ICL, Logica and the DSS.

Further information from:

E C Portman, Project Manager, ICL plc, Arndale House, Arndale Centre, Manchester M4 3AR; telephone 061-833 9111.

The SEMI-MAN project

To prosper in today's rapidly changing manufacturing environment requires a move from a traditional management structure to one that allows quick and flexible response to market forces.

The aim of the SEMI-MAN project is to enable this transition by the development and application of leading edge software technology.

The SEMI-MAN project is a collaborative venture between leading UK semiconductor manufacturers, SERC, the Department of Trade and Industry and the Knowledge Systems Group at Reading University.

The first result of this collaboration is the S2 real-time scheduling system based on artificial intelligence techniques engineered to enhance the performance and creativity of human schedulers and decision makers.

The constraint maintenance system at the heart of the S2 approach relieves the human of the task of recording and satisfying production constraints. The rule-based schedule generator can promptly produce a schedule satisfying all the existing production constraints. A new and more suitable schedule is automatically produced whenever constraints are added to the maintenance system.

The S2 system comprises a graphics interface in order to facilitate the assessment of scheduling decisions and improve management control. The S2 approach allows the experienced manager to make judgements about the resolution of conflicts in a proposed schedule. Such judgements are recorded as additional constraints in the maintenance system by the request interpreter.

The S2 approach also provides reaction to unexpected events in the manufacturing environment, as these correspond to the introduction of further production constraints in the maintenance system by the request interpreter.

Further information from:

P Elleby, Project Manager, Knowledge Systems Group, Department of Computer Science, Reading University Whiteknights, Reading RG6 2AX; telephone (0734) 751822.

Soft clay research site in Scotland

SERC's latest civil engineering facility — a 12-hectare field of soft clay at Bothkennar, Falkirk on the west bank of the Firth of Forth — was opened on 3 May by Martin O'Neill, MP for Clackmannan, within whose constituency the site is located.

The soft clay experimental site will act as a national facility for *in situ* testing and research on the range of problems related to construction in soft ground. The site is particularly useful for research since it consists of some 19 metres deep of homogeneous inorganic clay of high plasticity in a highly over-consolidated state.

SERC has already awarded seven research grants with a total value of £500,000 over the period 1986-92 to eight different academic institutions for research projects on the site. The Building Research Establishment is closely involved with a number of these projects, as well as its own, and will be providing the databank of research carried out on the site. Several industrial companies are also expected to become involved in full-scale research testing on the site.

The initial research programmes include detailed characterisation of the soil, description of engineering geology, performance of geosynthetic reinforced unpaved roads and negative skin friction on pile groups. The site is expected to provide a national base for geotechnics research for the next 20 years.

SERC has already invested considerably in the provision, through local companies, of a geosynthetic reinforced asphalted access road and hardstanding area, electricity, mains water and drainage. Work is well advanced on a permanent building which will provide office accommodation, instrumentation laboratory and workshops for research workers on the site. The building will be ready for occupation from 1 March 1990.

The opening of the site was attended by Councillor Joseph Kennedy representing the Provost of Falkirk District Council, members of the Bothkennar Soft Clay Site Management Committee, the SERC Geotechnics Steering Group, research workers funded by SERC and from Canada, and members of the local community.

The Royal Observatory, Edinburgh, is responsible for the day to day management of the site. It is proposed to hold an annual open day at the site for local schools and others interested in research being undertaken.

Dr David Greenwood, Chairman of the Bothkennar Soft Clay Site Management Committee, and Martin O'Neill MP, planting one of three trees SERC has provided along the access road to the site.

MTD Ltd making waves in Europe

The Marine Technology Directorate Ltd sees it as an essential part of its development that it should be able to provide a European dimension to many of its activities. Current involvement in some of the European Community programmes will, it is felt, help to establish the company successfully into the post-1992 European environment.

Having received a European Community grant under the Community Action Programme for Education and Training for Technology (COMETT), MTD Ltd in conjunction with five European partners has now established a University Enterprise Training Partnership (UETP) in Marine Science and Technology. Secretariat services are being provided by MTD Ltd, and the other five partners are:

- ☐ TNO-MOR (Netherlands)
- ☐ CETENA (Italy)
- ☐ Canal de Experiencias Hidrodinamicas (Spain)
- ☐ Ecole Nationale Supérieure du Petrole et des Moteurs (France)
- ☐ WEGEMT Foundation (multinational)

The main objective of the UETP is to identify any potential gaps in the advanced technology skills of European marine science and technology sector, and to promote international training schemes and courses to fill them. This sector includes shipping, shipbuilding, offshore oil and gas, subsea technology and marine minerals and resources.

The UETP is currently undertaking an extensive survey of European companies involved with the marine industry, to assess the priority areas and type of postgraduate training required by industry. The analysis of the results will be undertaken by MTD Ltd, and the final report should be ready by August. The UETP will, for the benefit of industry, also be developing a brochure listing the existing European advanced training courses in marine technology for publication in 1990.

The West European Graduate Education Marine Technology (WEGEMT) foundation has already been active for many years, providing an excellent series of short intensive courses of study (typically one to three weeks long), through which practising engineers and naval architects can update, refresh or extend their knowledge and skills. At present, WEGEMT has a membership of 25 universities, from 12 West European countries, and a secretariat which is now established at MTD Ltd.

MTD Ltd is also providing one of the two UK contacts for the European Communities Marine Science and Technology(MAST) programme. The purpose of this programme is to contribute to establishing a scientific and technological basis for exploration, exploitation, management and protection of European coastal and regional seas. It will run for three years from about mid 1989 to mid 1992, with a budget of 50 million ECUs (ECU 1 = £0.66). The programme is divided into four parts as shown below with the probable breakdown of funding for each area:

Part I: Basic and applied marine science with emphasis on mathematical modelling techniques and the study of marine processes. 30-35%

Part II: Coastal zone science and engineering, aimed at a better knowledge of coastal processes. 15-20%

Part III: Marine technology, mainly on the development of instrumentation and generic enabling technologies necessary for the advancement of marine science. 30-35%

Part IV: Supporting initiatives, aimed at obtaining more cost-effective use of large facilities to contribute to standardisation, to improved specialised training and to assist technology transfer. 10-15%

For further information on either of these two programmes please contact:

M J Staunton-Lambert, MTD Ltd, 19 Buckingham Street, London WC2N 6EF; telephone 01-321 0674.

RAL's IBM mainframe computer upgraded

IBM 3090-600E Supercomputer being installed at the Rutherford Appleton Laboratory in May.

The supercomputer is provided as part of a Joint Study Agreement with IBM for the exploration and development of techniques in advanced scientific computing (see* SERC Bulletin *Volume 3 No 12, Autumn 1988).

The machine now has six processors, six vector processors, 256 megabytes of main storage and one gigabyte of expanded storage.

The Study Contract with IBM, which runs for two years, will involve staff from RAL and IBM working closely with users to evaluate the applicability of IBM vector and parallel processing to the sort of problems being tackled by the scientific researchers being supported by RAL.

The 3090-600E together with the Cray X/MP-48 bring the facilities at the Atlas Centre to the level of the world's leading academic computer centres.

British Council building bridges to Europe

The British Council has played a significant part in building bridges between the UK and other countries, by encouraging and facilitating cooperation in the arts and the sciences.

Science, technology and medicine are important elements of the British Council's European work, and a third of all professional exchanges involve scientists and engineers. It spends over £3 million a year on promoting cooperative relations in Europe.

With an office in almost every country and qualified Science Officers in a number of key countries, the British Council is well placed to promote UK scientific interests, put people in touch with one another on a bilateral basis and help collaborative projects to get started. The offices normally have budgets which may be utilised for the support of researchers *from the UK* visiting a country, or for researchers from another country to come *to the UK*. Several of the European offices have established schemes for support (see below) which are aimed at bringing researchers together to focus on a particular topic in science, and eventually to submit joint proposals for funding to other organisations such as the European Community. The Science Officers work closely with government ministries and research-funding organisations in the countries to which they are assigned, and liaise with British Embassies in areas of common interest. They are supported by the British Council's Science and Technology Department in London, which keeps them in touch with developments in UK higher education and research.

The British Council's scientific and technological activities complement the work of the UK Research Councils, the Royal Society, Department of Trade and Industry and the Fellowship of Engineering. It works closely with them to maximise the benefits arising from collaboration. SERC and the British Council cooperate on an informal level to support exchange visits by high level research workers. The British Council promotes dialogue and provides support during the early stages of collaboration. Many joint projects have started with British Council help, and have continued with further financial support from the EC, NATO and other sources.

The complete list of British Council schemes in Europe is:

France — Exchange programmes in science, engineering and medicine support more than 200 scientists each year. In addition, a new collaborative research scheme will start later this year.

West Germany — Currently around 200 exchanges a year in science and technology. The new Academic Research Collaboration Scheme will in addition provide support for some 80 collaborative projects.

Spain — Anglo-Spanish *Acciones integradas*, collaborative research projects between universities, polytechnics and research institutes, 70 projects and 280 exchanges a year.

Eastern Europe — bilateral exchange schemes with the USSR, Hungary, Czechoslovakia, German Democratic Republic, Romania and Bulgaria, and scholarships to enable young UK scientists to work for periods in Eastern Europe.

Poland — bilateral scientific exchange programme, guided by a joint committee which meets every two years.

Hungary — British-Hungarian Cooperative Science and Technology Programme, for the exchange of scientists and engineers.

Yugoslavia — a bilateral cultural programme providing the basis for the exchange of about 100 scientists a year.

Italy — British Council sponsors around 150 scientific exchanges a year. One third of these are under an agreement with CNR (Italian National Research Council).

Norway — a bilateral cultural convention including medicine and environmental science as priorities.

Portugal— 200 exchanges a year, one third under the Anglo-Portuguese Joint Research (Treaty of Windsor) Programme. This is complemented by a protocol with the JNICT (Portuguese National Board of Scientific and Technological Research) concerned with research exchanges outside the university and polytechnic sector.

Travel grants can be provided by the British Council to contribute towards the cost of professional visits to most European countries. Visits can be for seminars, exploration of possible research projects, lecture programmes, and training. Fellowship programmes permit postgraduates from overseas to undertake research or advanced study in the UK.

The British Council also plays an important part in developing science and technological relations worldwide. Its role in developing scientific relations with Japan, in conjunction with SERC will be described in a future article.

Alison Bowen
SERC Swindon Office

Further information can be obtained from Dr Jim Taylor in the British Council's Science and Technology Department in London (01-930 8466) or the British Council's Science Officers in:

Austria — The Representative, Schenkenstrasse 4, A-1010 Vienna; telephone 010-43-222-533-26-16/7/8

France— Dr June Rollinson, 9 rue de Constantine, 75005 Paris; telephone 010-331-45-55-95-95

West Germany — Marcus Gilbert, Hahnenstrasse 6, 5000 Cologne 1; telephone 010-49-221-20-644-33

Greece — The Representative, Plateia Philikis Etairias 17, Kolanaki Square, Athens 106/73, PO Box 3488, 102 10 Athens; telephone 010-301-36-33-211/ 36-06-011

Italy — Dr Penny Aspden, Via Quattro Fontana 20, 00184 Rome; telephone 010-396-47-56-641

Norway — The Representative, Fridtjof Nansens Plass 5, 0160 Oslo 1; telephone 010-47-24-26-848

Poland — The Representative, Al Jerozolimskie 59, 00-679 Warsaw; telephone 010-48-22-287-401/3

Portugal — The Representative, Rua Cecilio de Sousa 65, 1294 Lisbon Codex; telephone 010-35-11-36-92-08/9

Spain — Chris Brown, Plaza de Santa Barbara 10, 28004 Madrid; telephone 010-341-419-12-50

Yugoslavia — Dr C Briggs, Generala Zdanova 34-Mezanin, Post Fah 248, 11001 Belgrade; telephone 010-3811-332-441

Fellowships 1989

Allocation, applications and awards in 1989 for the various Fellowship Schemes

Type	Allocation	Applications	Awards
Senior	4	17	4
Advanced	18	75	19
SERC/NATO Postdoctoral	65	207	65 *
RS/SERC Industrial	10	14	10
IT Fellowships	—	41	23 †

* 36 of the postdoctoral fellowship awards offered were designated for support under the NATO Science Fellowships programme. A further nine awards tenable in Western Europe were taken over from the Royal Society, plus two awards in the Natural Environment Research Council's field, also NATO supported.

† two at senior level (including one 'Logic for IT'), five advanced and 16 postdoctoral (including one 'Logic for IT').

Industrial fellowships

For 1989, Royal Society/SERC Industrial Fellowships have been awarded to:

Dr N C Billingham (Sussex University) — to Courtaulds Research plc;

Dr M J Kelley (GEC Hirst Research Centre) — to Cambridge University;

Dr S B Ross-Murphy (Unilever Biopolymers) — to Cambridge University;

P J Skitt (Gloucester CAT) — to Smiths Industries;

Dr R A Snowdon (STC Technology Ltd) — to Manchester University;

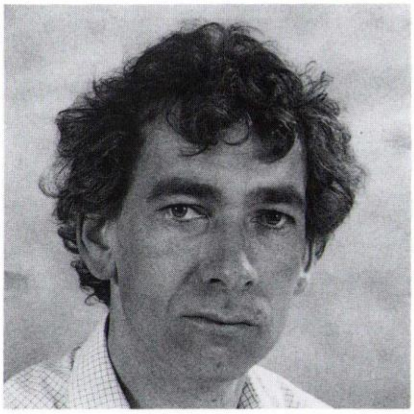
(A further three awards have also been recommended).

Senior fellowships

Senior Fellowships have been awarded to **Professor R S Ellis** of Durham University, **Professor P Hall** of Exeter University, **Dr R J Nelmes** of Edinburgh University and **Dr S E V Phillips** of Leeds University.

Professor Richard Ellis graduated from University College London with first class honours in astronomy. He won the 1970 Huggins Astronomy Prize and the 1971 UCL Faculty of Science Silver Medal. In 1971 he moved to the Department of Astrophysics at Oxford and was awarded his D Phil in November 1974.

He joined the Department of Physics at Durham University as a Senior Demonstrator in 1974, became a Lecturer in Astronomy in 1981 and holder of the newly founded Chair of Astronomy in 1985. During a period of leave from 1983 to 1985 he was a Principal Research Associate at the Royal Greenwich Observatory and a Senior Visiting Fellow at the Space Telescope Science Institute in Baltimore, USA.

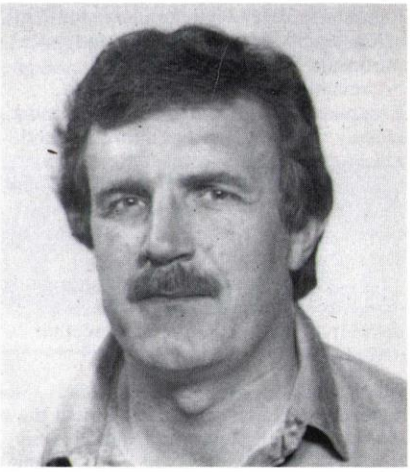


Professor Richard Ellis

Professor Ellis is one of the international leaders of research in studies of the origin and evolution of normal galaxies and has built up a strong research group in this area at Durham. He is an expert in observational research and the development of associated instrumentation, and is involved in many international collaborative programmes.

The completion of the 4.2-metre William Herschel Telescope and the planned launch of the Hubble Space Telescope were the key reasons for Professor Ellis's new appointment as a Senior Fellow. During the five years of his fellowship he will be concentrating on the origin and evolution of galaxies through observations of the distribution and spectral properties of galaxies and associated matter at high redshift. Such observations are especially demanding and require good instrumentation for studying the faint objects involved. Professor Ellis has been involved in developing such instrumentation both for the Anglo-Australian and William Herschel Telescopes. This ground-based programme will be complemented with high resolution and ultraviolet information obtainable only from the Hubble Space Telescope.

Professor Philip Hall graduated from Imperial College, London, where he also took his PhD in applied mathematics. He is now at Exeter University.



Professor Philip Hall

He is at the forefront of vital research in theoretical and computational fluid dynamics, focusing particularly on fluid dynamic instability theory and the transition of flows from laminar to turbulent states. This is an area which is currently of tremendous scientific importance and technological potential. In recent years, he has done highly original and seminal work on nonlinear Tollmein-Schlichting growth, Goztler vortices on curved surfaces and on nonlinear wave/longitudinal vortex interactions: fundamental ingredients throughout transition. These crucial contributions have provided the concepts, models and analytical and numerical tools which have increased the understanding of transition in fundamental and important ways.

Professor Hall's research during the five years of his fellowship forms a powerful programme of much needed research on the transition to turbulence which is exciting both in the range of problems to be tackled and in the variety of techniques proposed for their solution. He proposes three connected areas of research: incompressible instability interactions, computation on transition, and transition in the compressible regime. In each of these profoundly difficult areas, Professor Hall is well placed to achieve the kind of breakthrough required.

Professor Hall has established strong links between Exeter, where he has developed an excellent research school, and NASA Langley Research Centre, where he has been a visiting professor every Summer since 1983. This collaboration is to continue and forms an important ingredient in the research programme of the fellowship.

Dr Richard Nelmes

Dr Richard Nelmes graduated from Cambridge University in mineralogy and petrology. He then moved to the physics department at Edinburgh University where he was awarded his PhD in 1969. He was an SERC postdoctoral fellow from 1969 to 1971, and has remained in the physics department at Edinburgh where he is now a Reader. He was awarded an ScD by Cambridge University in 1982.

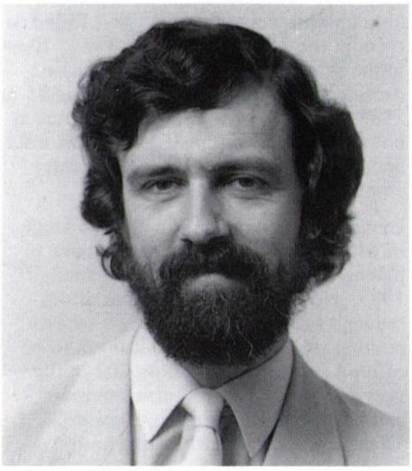
Dr Nelmes is a recognised authority on diffraction studies of structural phase transitions, especially those involving hydrogen ordering. Through investigations of the structural basis for pressure effects on H-ordering transitions, he became one of the first to carry out accurate high-pressure structure determinations by neutron diffraction. More recently, he has specialised in high-pressure diffraction, with both X-rays and neutrons, and is now a leading member of the international community in this field. He is currently involved in projects designed to raise the pressure limit of structure determination by neutron techniques substantially, and to promote full structure determination under pressure on synchrotron sources.

During his five-year fellowship he will work on the development of high-pressure diffraction by neutron techniques at ISIS (at Rutherford Appleton Laboratory) and at the Institut Laue-Langevin and by X-ray techniques at the Synchrotron Radiation Source (Daresbury Laboratory) and the European Synchrotron Radiation Facility and on laboratory sources. His work will involve a series of international collaborations and use of neutron and synchrotron sources in the USA, Japan and Germany. Recent advances in sources and techniques make this a time of exceptional promise for high-pressure X-ray and neutron scattering science.

Dr Simon Phillips graduated from University College London where he was also awarded his PhD in 1974. He received a Thomas Witherden Batt Scholarship 1971-72. He has held appointments at the University of British Columbia, the Medical Research Council Laboratory of Molecular Biology and the Insitut Pasteur, where he played the leading part in solving the structure of the first antigen-antibody complex, which provided clear answers to a series of unsolved problems in immunology. On leaving the Institut Pasteur, he returned to England in 1985 and took a 'new blood' lectureship at the Astbury Department of Biophysics at Leeds University, where he has now solved the structure of a key protein in the genetic control of protein synthesis, the methionine repressor of *E coli*.

Dr Phillips's programme during the five years of his fellowship is in an area of great biological interest: the structure and function of repressor molecules, and the mechanism by which they regulate transcription. The project is poised at an exciting stage, in which particular met repressor and DNA operator interactions can be determined by X-ray analysis from crystals now available. Their role in biological recognition will then be probed by varying the DNA operator sequence and by site-directed mutagenisis of the repressor protein itself.

Dr Phillips has established productive collaborations with Dr Stockley at the Genetics Department at Leeds, and with the group at the Institut Pasteur. These provide the capacity to mutate the DNA operator sequence and the repressor protein, and study their binding behaviours.



Dr Simon Phillips

International fellowships tenable in Canada

In 1990-91, the Natural Sciences and Engineering Research Council of Canada is offering non-Canadians a limited number of International Fellowships for tenure in Canadian universities. These awards are:

- ☐ available to recent doctoral graduates of universities outside Canada;
- ☐ for research in any field in the natural sciences and engineering;
- ☐ valued at $28,000 per year, plus travel allowance;
- ☐ tenable for one year with the possibility of renewal for a second year.

The deadline for applications for 1990-91 awards is 1 December 1989.

For application forms and information about these awards contact the Canadian university department of interest, or:

International Fellowships
Scholarships and International Programs Directorate
Natural Sciences and Engineering Research Council of Canada
200 Kent Street
Ottawa, Ontario
Canada
K1A 1H5

Studentship numbers 1988-89

1988 report

The Council's Boards and Directorates allocated 4929 studentships for 1988 (compared with 4910 in 1987). This included 915 awards for the information technology conversion course scheme, through which honours graduates from other disciplines are trained to Masters level for careers in the buoyant IT area. A further 183 conventional advanced course awards were made available in the IT electrical and electronic fields under the Department of Education and Science's Engineering and Technology Programme commonly known as 'the Switch'. The final target was thus 5112 awards.

As can be seen in Table 1, by 1 November 1988 a total of 4800 awards had been taken up — about the same level as in 1987, allowing for Switch awards. However some worrying trends have begun to emerge. The take-up of CASE (Cooperative Awards in Science and Engineering) of 644 was 11% lower than the previous year's figure of 721. The performance in engineering, although no worse than in 1987, failed to recover the 35% downturn in 1986. Even in the science area there was a marked decline from 402 CASE in 1987 to 325 in 1988. Allowing for later CASE (there is no closing date for CASE) there has only been a partial recovery to 722 awards compared with 840 in 1987.

Demand for awards at the appeals stage of 617 for unfilled department quota places was also some 4% lower than in 1987. However a consequence of the reduced take-up has been that a record number of 455 appeals awards could be offered compared with only 202 in the previous year. All first class honours candidates received offers of awards. There were 121 awards taken up by candidates from the EC, providing free postgraduate tuition in the UK, compared with 54 in 1987.

Table 1: Distribution of 1988 awards taken up by 1 November 1988

(1988 targets agreed by Boards in brackets)

	APS	Engineering ø	NP	Science	Biotechnology	DES Switch	TOTAL
Research studentships							
Standard	76 (74)	605 (571)	62(58)	965 (971)	41 (42)	— (—)	1749(1716)
CASE	2 (6)	277 (389)	3 (7)	325 (384)	37 (45)	— (—)	644 (831)
Instant	3 (3)	24 (29)	2 (2)	66 (70)	— (—)	— (—)	95 (104)
TOTAL	**81 (83)**	**906 (989)**	**67(67)**	**1356(1425)**	**78 (87)**	**— (—)**	**2488(2651)**
Advanced course studentships							
Standard	15 (18)	1663(1759)	—(—)	327 (337)	22 (22)	160(183)	2187(2319)
Instant	1 (1)	90 (104)	—(—)	19 (21)	— (—)	— (—)	110 (126)
TOTAL	**16 (19)**	**1753(1863)**	**—(—)**	**346 (358)**	**22 (22)**	**160(183)**	**2297(2445)**
Awards tenable overseas	**2 (3)**	**4 (5)**	**—(—)**	**7 (6)**	**— (—)**	**— (—)**	**15* (16)***
TOTAL	**99(105)**	**2663(2857)**	**67(67)**	**1709(1789)**	**100(109)**	**160(183)**	**4800*(5112)***

ø Includes IT provision of 426 research and 350 advanced and 915 conversion course awards of which 460 and 279 advanced and 930 conversion course awards respectively were taken up.
* Includes two overseas awards outside the Council's field resulting from SERC's obligations under the NATO Fellowship Scheme.

Table 2: Allocations decided by Boards for 1989

	APS	Engineering ø	NP	Science	Biotechnology	DES Switch	TOTAL
Research studentships							
Standard	73	626	58	963	50	—	1770
CASE	6	391	10	379	50	—	836
Instant	3	29	2	70	—	—	104
Advanced course studentships							
Standard	15	1759	—	329	22	183	2308
Instant	1	104	—	21	—	—	126
Awards tenable overseas	3	5	—	6	—	—	17*
TOTAL	**101**	**2914**	**70**	**1768**	**122**	**183**	**5161***

ø Includes provision for IT and in particular 915 conversion course awards.
* Includes three overseas awards for provision outside the Council's field resulting from SERC's obligations under the NATO Fellowship Scheme.

Plans for 1989

Under the alternating biennial review approach, advanced course provision for 1989-90 is based on peer review decisions taken last year. In the longer term, however, the Engineering Board may wish to respond to the ready demand from students and industry for the more successful advanced courses by increasing provision appropriately.

The Council has agreed that the overall level of research studentship awards should be maintained in line with its second *Corporate plan* published in January 1989 and that it should continue to direct interest towards CASE, despite the disappointing response in 1988. It will be exploring ways of stimulating greater interest in the scheme, by both students and academics. To allow for a more strategic but flexible approach, the Council introduced a quota-type approach to the allocation of CASE similar to that operating for standard research studentships. Project approval and acceptance of the cooperating company will in future only be necessary for CASE quota when nominating the student. This will allow departments with a CASE quota and companies to set up projects in the certain knowledge that SERC support for the students will be forthcoming, thus avoiding much wasted effort and hopefully fostering greater interest in the scheme.

Furthermore, the Council has approved the allocation of 4978 studentships plus the DES Switch provision of 183 awards (compared with 4917 and 183 respectively for 1988-89), which makes a grand total of 5161 studentships for 1989-90. Table 2 sets out the distribution of studentships to be made in 1989.

Thesis submission rates for research students

As part of this year's review of standard research quota provision, the Council has applied mandatory sanctions in compliance with the finding of the Committee of Public Accounts (17th Report 1987-88 session). Under this approach departments with a poor thesis submission rate have been subject to a real cut in the provision of quotas of standard research studentships, unless special circumstances prevailed.

The minimum level to escape a mandatory sanction is set at 35% of SERC's research students submitting of those who started their training four years previously. Students terminating in the first year are excluded but those submitting a thesis for a Masters degree are included.

The new level of 35% is an increase of 10% on the previous sanctions level, enforced in 1987, and reflects a determination by the Council to maintain the pressure for improvement in the performance of departments. The overall position on submission rate performance over the past years is as follows:

1985	1986	1987	1988
53%	59%	61%	62%

The aim is to achieve a 70% submission rate after four years of starting an award with 85% after five years.

The details of the latest exercise covering SERC research students starting in 1984, including for the first time the overall percentage submission rate for each institution, are set out below.

For sanctions, SERC relied on the fourth-year submission rates by department, consolidated over the latest four-year period (1981-1984 starters). Allowing for special circumstances, such as small numbers, new initiatives, servicing by more than one SERC committee, reorganisation and staffing of departments, the Council finally sanctioned 71 departments compared with some 40 two years ago.

Table 1: Submission rates for a research degree

	Nos starting in 1984	Nos submitting by 1.10.88	Percentage submitting
Universities of England:			
Aston	22	15	68
Bath	31	24	77
Birmingham	73	38	52
Bradford	21	12	57
Bristol	67	38	57
Brunel	11	5	45
Cambridge	166	125	75
City	17	7	41
Cranfield	19	8	42
Durham	23	19	83
East Anglia	23	19	83
Essex	12	10	83
Exeter	22	17	77
Hull	22	14	64
Keele	10	7	70
Kent	25	14	56
Lancaster	19	11	58
Leeds	73	47	64
Leicester	29	22	76
Liverpool	52	38	73
London:			
Birkbeck	14	9	64
Imperial	133	81	61
King's College (KQC)	50	18	36
Queen Mary	32	13	41
University	62	33	53
Royal Holloway and Bedford New	14	7	50
Other institutions	36	25	69
Loughborough	32	17	53
Manchester	86	69	80
UMIST	70	40	57
Newcastle	40	22	55
Nottingham	88	59	67
Open	5	1	20
Oxford	146	103	71
Reading	24	10	42
Salford	20	13	65
Sheffield	59	36	61
Southampton	66	37	56
Surrey	19	14	74
Sussex	49	28	57
Warwick	42	26	62
York	20	16	80
University of Wales:			
Aberystwyth	17	12	71
Bangor	11	6	55
Cardiff	55	38	69
Swansea	28	14	50
Universities of Scotland:			
Aberdeen	25	15	60
Dundee	16	13	81
Edinburgh	80	50	63
Glasgow	57	32	56
Heriot-Watt	15	8	53
St Andrews	21	17	81
Stirling	8	5	63
Strathclyde	34	21	62
University of Northern Ireland:			
Queen's	5	2	40
Total universities	2216	1400	63
Total polytechnics *	104	41	39
Other institutions *	7	4	57
Grand total	2327	1445	62

* Numbers for polytechnics and other institutions were generally too low to permit meaningful comparisons.

Table 2: Submission rates by SERC Boards and Directorates

	Nos of students starting in 1984*	Nos submitting by 1.10.88	Percentage submitting
Science Board:	1287	878	68
Biological Sciences	481	315	65
Chemistry	514	377	73
Mathematics	124	82	66
Physics, Neutron Beam and SBA	168	104	62
Engineering Board	842	433	51
Astronomy and Planetary Science Board	78	51	65
Nuclear Physics Board	62	46	74
Biotechnology Directorate	58	37	64
Grand total	2327	1445	62

* This figure was arrived at by subtracting all those students who withdrew in the first year.

RGO Cambridge work in progress

Work is going well on the construction of the new Royal Greenwich Observatory at Cambridge, with the building having been 'topped out' on 25 July. Haymills (Contractors) Ltd, who won the main construction contract, began work on site in September 1988 and the Science Minister Robert Jackson MP laid the foundation stone in October (see *SERC Bulletin* Volume 4 No 1, Spring 1989). Little time was lost through bad weather during the mild Winter and completion of the new building is planned for the end of January 1990.

Members of RGO staff on a conducted tour of the building site in May 1989.

The design brief for the new building was to provide accommodation suitable for the future role of the Observatory, with low maintenance and operating costs, and a long building life. The lease agreed between the SERC and Cambridge University is for 125 years. The new building is linked to the old Observatory Building of the Institute of Astronomy (a Grade 2 Listed Building) and this places constraints on its appearance and construction. (An artist's impression of how the new building will look appeared in *SERC Bulletin* Volume 3 No 11, Summer 1988).

A traditional approach to the construction of the building was chosen with external walls of brick and a slate roof to match the existing building and give the intended long life and low maintenance. The main entrance has a more 'hi-tech' appearance, being fully glazed with tinted glass through two floors. This area, together with the adjacent library and common room, forms a focal point for the Observatory. Interactions between staff from different sections and with the Institute of Astronomy are considered to be extremely important; the layout of the building and the location of the various divisions within it are intended to encourage this.

A total floor area of approximately 4700 square metres is being provided. This consists of offices, laboratories, computer/terminal rooms, remote observing facilities, workshops, design offices, library, conference rooms etc. A comprehensive data link system will be installed throughout the building reflecting the need for good electronic communications together with a new telephone exchange having the latest facilities. There will be no operational telescopes at the Observatory (these are sited on the island of La Palma in the Canary Isles) but a large simulator facility will enable instruments and equipment to be tested before shipping to La Palma and mounting on a telescope.

Plans are well advanced for fitting out the Observatory and transferring equipment from Herstmonceux during February and March of 1990.

R Tolcher
Head of Council Works Unit, SERC

Royal visit to ROE

On 4 July, the Royal Observatory, Edinburgh, was honoured by a private visit by HRH The Duke of Edinburgh. In the course of a morning visit to the Edinburgh site, the Duke was able to see some scientific results from the James Clerk Maxwell Telescope on Hawaii, which he opened in 1987, as well as touring some of the facilities of the Observatory. He is seen in the Plate Library with the Chairman of SERC, Professor William Mitchell (left), and Dr Ray Wolstencroft of the Observatory.

The same evening, the Chairman officially opened the Observatory's new South Building which houses a staff common room and refectory together with purpose-built laboratories and much needed offices. Following the opening, over 200 staff and guests enjoyed a buffet and dance as well as viewing an exhibition showing how the Observatory has changed and developed over the past 100 years.