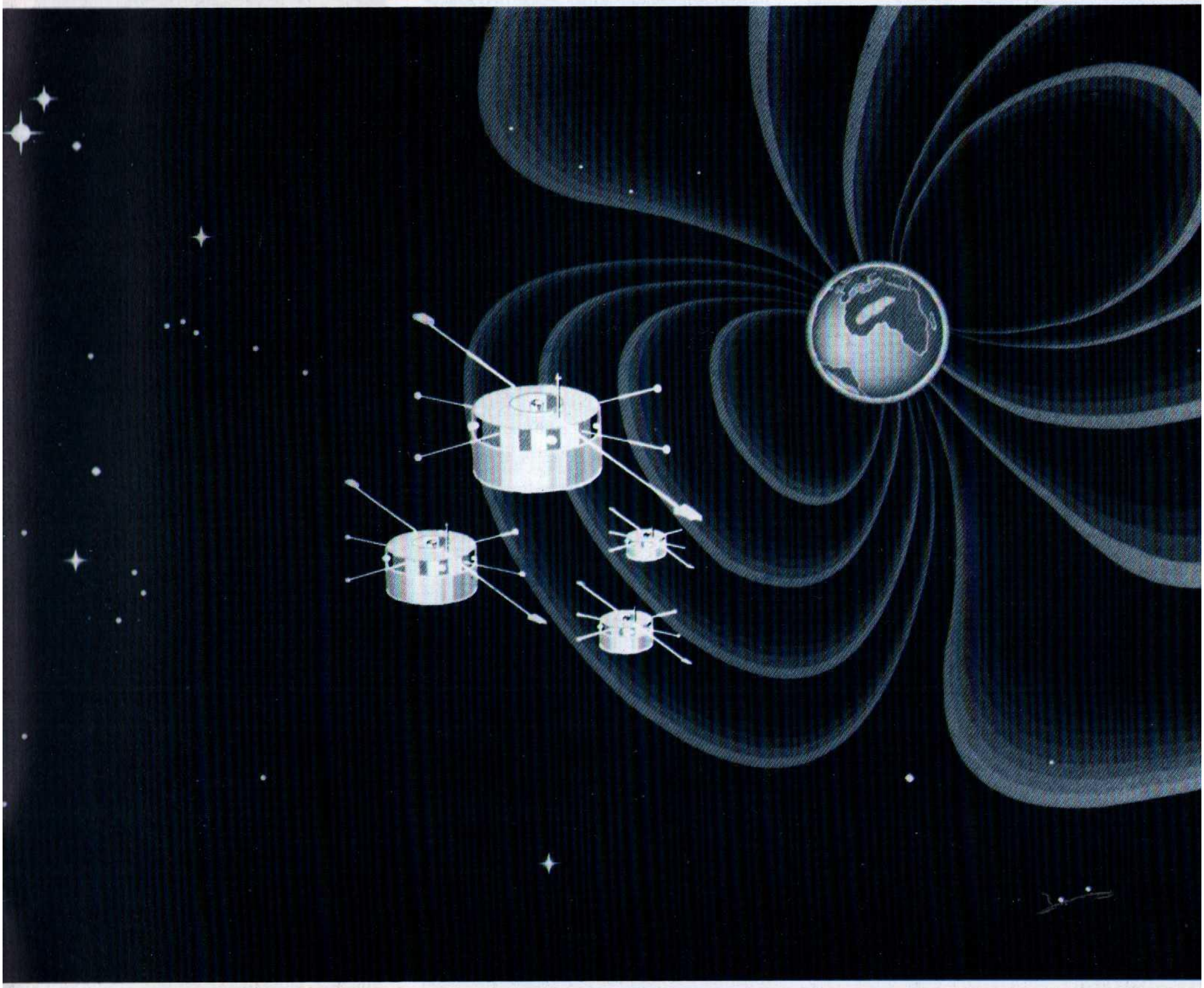
SERC BULLETIN

SCIENCE & ENGINEERING RESEARCH COUNCIL

Volume 3 Number 12 Autumn 1988



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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

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

Royal Greenwich Observatory (RGO)
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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 031-667 3321

London Office SERC has moved its London Office from Great Portland Street to 22 Henrietta Street (see above). All correspondence for SERC should still be sent to the Swindon address.

Swindon Office telephone As from 21 November 1988, the telephone number for SERC's Swindon Office will be: Swindon (0793) 411000. As this is a 'direct dialling in' line, the last three digits may, in most cases, be replaced by the last three digits of an existing extension number for direct access to an extension.

Teaching Company Directorate has moved to new offices:
Sudbury House
London Road
FARINGDON
Oxon SN7 8AA
Telephone Faringdon (0367) 22822
Fax: Faringdon (0367) 22831

Missions to the Sun

The British National Space Centre (BNSC) and SERC announced in August the UK's largest ever participation in an international collaborative space science mission. SERC is to contribute up to £76 million — £20 million on instruments and £56 million on the satellites — for two spacecraft missions to be launched in 1995. They will investigate the Sun's interior and how this interacts with the Earth's magnetic field and environment.

The two missions, called SOHO and Cluster, are part of the European Space Agency's 20-year science programme "Horizon 2000". They will be undertaken by ESA in association with NASA at a total cost of £800 million. There is also the possibility that the Soviet Union could join the Cluster mission.

The object of the two missions is to investigate the critical stages in the chain of events associated with the ejection of high-speed ionised material from the solar surface. This material, when it interacts with the Earth's magnetic field and the upper atmosphere, has a major influence on the Earth's climate. An understanding of the physics of rarified ionised material on plasmas will also lead to a greater understanding of fusion processes.

SOHO (Solar and Heliospheric Observatory) will measure changes in the structure of the Sun. It is known that the Sun's core constantly vibrates and the oscillations travel like sound waves. By analysing surface fluctuations, details of the Sun's inner core will be recorded.

Four identical spacecraft forming Cluster will investigate the evolution and properties of plasma in the Earth's magnetosphere and the reactions to the varying solar conditions.

UK scientific groups and their collaborators have been successfully chosen against stiff international competition to participate in SOHO and Cluster. The UK has a leading role in four of the instruments:

On SOHO — CDS (Coronal Diagnostic Spectrometer): University College London, St. Andrews, Oxford and Cambridge Universities, together with Rutherford Appleton Laboratory (RAL);

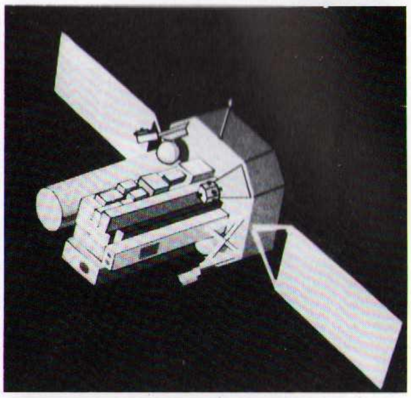
On Cluster — FGM (Flux Gate Magnetometer): Imperial College of Science and Technology;

— PEACE (Plasma Analyser): University College London and Mullard Space Science Laboratory. Also collaborating are RAL and Queen Mary College, London;

— DWP (Digital Wave Processing): Sheffield University. Also collaborating are Sussex University and the British Antarctic Survey.

Other participation in SOHO includes Birmingham University on LASCO (Large Angle Spectrometric Coronograph), Cambridge University on GOLF (Global Oscillations at Low Frequency) and MDI (Michelson Doppler Imager), and Durham University on the Energetic Particle Package.

Other involvement with Cluster is provided by RAL on RAPID (Research with Adaptive Particle Imaging Detectors), the proposed coordinated Data Handling Facility and the Project Office.



An artist's impression of SOHO, part of the European Space Agency's Horizon 2000 Science programme

Front cover picture

An artist's impression of Cluster, a four-spacecraft space plasma-physics mission under ESA's Horizon 2000 Science programme.

SERC *Annual Report* (available from HMSO Bookshops) 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

Council commentary

Interdisciplinary Research Centres (IRCs)

In June, the Council reviewed the current position on the plan to establish a number of IRCs for research in areas of strategically important science and engineering. A short-list of topics has been made, and expressions of interest invited, for a second round of six centres to join the four already announced. The Council will make its final selection early next year in the light of any additional funds it may be successful in obtaining in this Autumn's public expenditure survey.

Outturn 1987–88

The Council received a statement of the outturn of 1987–88 expenditure. The Chairman congratulated the staff on matching expenditure to the available funds (£357.5 million) within £18,000. One of the notable features of the 1987–88 expenditure was that grants to universities and polytechnics had increased to £121.8 million from £99.5 million in 1986–87.

Revisions to the Space Plan

Professor Wilson, as chairman of the Council's Space Planning Committee, presented revisions to the SERC Space Plan (1986) made necessary by launch delays and the UK decision not to support annual, real, 5 percent increases in the budgets of the European Space Agency (ESA) from 1990. Liaison with the Space Science Programme Board of the British National Space Centre had produced, nevertheless, a good programme of future activity in this area, based both on ESA collaborations and on bilateral agreements between the UK and other countries. It was hoped to be able to preserve a small British activity in 'microgravity' experiments through participation in the Columbus programme and its 'polar table' satellite vehicle. In Earth observation studies, a problem arose from the vast scope of possible lines of research that the technique opened up and there was room for improved agreement between user national funding agencies about where respective responsibilities lay. In the engineering aspects of space exploitation, the Council's Engineering Board intended to develop its present modest involvement, principally in systems engineering and materials technology.

Participation in space missions

The Council approved UK participation in the following space missions:

- The ESA SOHO/Cluster mission within an overall financial envelope of £16.3 million and 150 man-years at the Rutherford Appleton Laboratory (RAL) (see facing page).
- The USSR Spectrum-X mission at a level of £6 million and 37.5 man-years at RAL.
- The Japanese Solar A mission at a level of £1.2 million and 13.5 man-years at RAL.

Department of Education and Science (DES) approval for this expenditure is being sought.

International access to SERC facilities

Two agreements have recently been signed. The first, with the Netherlands Organisation for Scientific Research (NWO), will allow Netherlands academic scientists access to ISIS, the spallation neutron source at RAL, for an annual contribution of £250,000. The second was with the Spanish Ministry of Education and Science and will allow Spanish academic scientists access to SERC's Synchrotron Radiation Source at Daresbury Laboratory.

Superconducting wiggler at the SRS

The proposal to construct a second superconducting wiggler magnet for the Synchrotron Radiation Source at Daresbury Laboratory was discussed by the Council in July. The second wiggler will allow full use to be made of the recently completed high-brightness lattice in the machine and ensure that it remains at the forefront of synchrotron radiation research across a wide range of scientific disciplines.

The proposal was approved by the Council, recognising the intention to bid for funding from the European Community's Large Facilities Programme to support the development of the facility, and the need for approval of the Department of Education and Science.

Major research grants

Particle physics. Council approved the award of special renewable rolling grants to Birmingham, Cambridge, Glasgow, Lancaster, Liverpool, Manchester and Oxford Universities, Queen Mary College, Imperial College of Science and Technology and University College London (subject to DES approval as appropriate).

In addition, the following research grants were approved:

Phase 2 of the MERLIN project. Special renewable research grant: £4.9 million to Manchester University (subject to DES approval).

The fabrication of new silicon devices using molecular beam epitaxy (MBE) and ion implantation. Grant: £417,000 plus facilities over three years to Salford University for collaborative research with Warwick and Surrey Universities. (Ministry of Defence (MoD) will provide 50% of funding).

Studies in atmospheric, ionospheric and magnetospheric physics. Grant: £748,300 over four years to University College of Wales, Aberystwyth.

A programme of astrophysical research 1988–92. Grant: £422,200 over four years to Queen's University of Belfast.

Support for the common user facility for automated photographic measurements. Grant: £544,500 over four years to Cambridge University.

Consolidated support for the Mullard Radio Astronomy Observatory. Grant: £453,700 over one year to Cambridge University (subject to DES approval).

Consolidation of protein structural analysis. Grant: £538,900 over four years to York University.

Studies in heterogeneous catalysis. Grant: £645,200 over four years with 10% MoD contribution, to Royal Institution.

The physics of interfaces in low dimensional structures. Grant: £448,300 over four years to University College, Cardiff.

Oxford Radiocarbon Accelerator Unit. Grant: £887,000 over four years to Oxford University.

Ultra-high-field nmr spectroscopy at 14T (600 MHz). Grant: £998,400 over four years to Edinburgh University (subject to DES approval).

Congratulations to:

Dennis Baker of British Telecom (Solid State Devices Subcommittee); **Brian Cook** of Shell UK Ltd (Board of MTD Ltd); and **Professor Anthony Cusens** of Leeds University (Environment Committee and Civil Engineering Subcommittee): all elected Fellows of the Fellowship of Engineering;

Sir Michael Atiyah FRS of Oxford University (Council member): awarded the Royal Society's Copley Medal for his fundamental contributions to a wide range of topics in geometry, topology, analysis and theoretical physics;

Professor Cyril Hilsum FEng, FRS of GEC Research Laboratories (former Council member): awarded the Institution of Electrical Engineers' Faraday Medal for his outstanding contributions to applied physics research in the UK, particularly in the field of flat-panel electronic displays.

Appointments to Council

In July the Secretary of State for Education and Science made the following appointments to the Science and Engineering Research Council:

- ☐ Sir Michael Atiyah FRS reappointed for one year;
- ☐ Professor Colin Humphreys, Mr David Nash, Dr Alan Williamson and Professor Arnold Wolfendale FRS appointed new members.

They replace Professor Brian Clarkson FEng, Professor Cyril Hilsum FEng, FRS, Professor Sir Alan Cook FRS and one vacancy.

Within the Council, SERC has appointed Professor Wolfendale Chairman of the Astronomy and Planetary Science Board in succession to Professor Sir Alan Cook; and Professor Colin Humphreys Chairman of the new Materials Commission (see page 9).

Commenting on the appointments, Professor Bill Mitchell, Chairman of the Council, said: "I welcome these appointments which will bring added strength to the Council. I particularly welcome Dr Alan Williamson who will bring additional biotechnology experience to the Council and Mr David Nash whose financial background will be invaluable."

Professor Colin Humphreys is Head of the Department of Materials Science and Engineering at Liverpool University. He has been a member of SERC's Materials Committee since 1986 and of many other SERC committees and panels, including the Materials Task Force. He is at present serving on the SERC/Department of Trade and Industry (DTI) National Superconductor Committee and the SERC/DTI LINK Advisory Panel on advanced semi-conductor materials.

Professor C J Humphreys

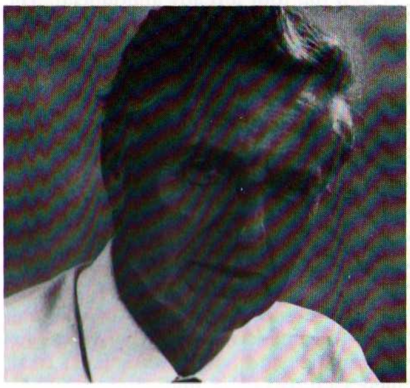
David Nash, a chartered accountant, has been group finance director of Cadbury Schweppes plc since 1987. He was previously Acquisitions Manager for ICI plc having joined that firm in 1965. With them he spent several years in Nigeria and Argentina before rejoining the Finance Department, becoming Financial Group Manager in 1977 and ICI Corporate Treasurer in 1979.

David P Nash

Dr A R Williamson

Dr Alan Williamson was until recently Director of the Glaxo Institute for Molecular Biology SA in Geneva and a Research Director at Glaxo Group Research Ltd (1981–87). He was formerly on SERC's Biotechnology Directorate Management Committee and is a member of the Research Councils' Advisory Group on Biotechnology, as well as the Health and Safety Executive Advisory Committee on Genetic Manipulation. His previous posts include Director of Graduate Studies at the National Institute for Medical Research, 1970–72; and Gardiner Professor of Biochemistry, Glasgow University, 1974–81.

Professor Arnold Wolfendale is head of the Physics Department at Durham University. He is a Fellow and former Council Member of the Royal Society and a former President of the Royal Astronomical Society. He was a member of SERC's Astronomy, Space and Radio Board from 1984–86 and its successor the Astronomy and Planetary Science Board from 1986–87. Professor Wolfendale has also served on SERC's Space Planning Committee and has been chairman on the panels covering the Mullard Radio Astronomy Observatory and the Nuffield Radio Astronomy Laboratory.



Professor A W Wolfendale FRS

In addition to these appointments, **Professor Ronald Oxburgh FRS** joined the Council on 1 September 1988, on succeeding Professor Sir Richard Norman FRS as Chief Scientific Adviser to the Ministry of Defence. Professor Oxburgh was the Professor of Mineralogy and Petrology at Cambridge University from 1978; Head of the Department of Earth Sciences from 1980; and President of Queen's College, Cambridge, from 1982. Educated at Oxford and Princeton Universities, he was Lecturer in Geology at Oxford from 1962 to 1978, in which year he was elected to the Royal Society. He was President of the European Union of Geosciences, 1985–86, and chaired the University Grants Committee's Committee on the Rationalisation of Earth Sciences. He is the author of numerous research papers.

MTD Ltd appoints Director

Don Lennard has been appointed Director and Chief Executive of the Marine Technology Directorate Limited. A Chartered Engineer, Mr Lennard has been acting Temporary Director and Chief Executive of MTD Ltd since December 1987.

New management arrangements for information technology

The future support of research in information technology was one of the subjects considered in the White Paper CM278, *DTI – the Department for Enterprise* published in January 1988. The paper discussed the setting up of national collaborative research programmes, and considered the possibility of using this approach for IT. SERC and the Department of Trade and Industry have now agreed to the establishment of such a programme, not only to follow on from the Alvey programme, established for five years in 1983, but also to cover the majority of the IT research supported by both bodies, including that currently supported by SERC's Information Engineering Committee (IEC). The objective is to establish a unified framework for the support of IT by SERC and DTI across the whole spectrum of research, ranging from fundamental work in universities and polytechnics through collaborative LINK programmes to industry-led activities, often in collaboration with the academic sector.

To oversee the programme, a new joint advisory structure will be established, drawn from academics and industrialists in roughly equal numbers, to advise both SERC and DTI on research strategy and resource allocation and on individual applications for support. On the SERC side, this structure replaces IEC and its subcommittees. Serving the advisory structure will be new joint administrative arrangements which will provide greater coordination between various components of the overall national programme, and between the national programme and European Community activities such as ESPRIT. Furthermore, programme managers are being appointed to work alongside committees within the advisory structure, to encourage the integration of the various programme elements and to direct the more industrially orientated components.

The new framework is due to be in place by Autumn 1988 in time to deal with applications received at the beginning of the 1988/89 session. Traditional academic-only applications for basic or strategic research will be handled in the normal manner, and subject to normal SERC procedures. New procedures are being established for applications involving industrial collaboration. Each collaborative programme will be the subject of a strategy statement, and applications will be assessed in relation to that strategy. In the case of LINK schemes, guidance has been published in respect of various programmes such as Industrial Measurement Systems and Personal Communications (see pages 6 and 7). In the case of the topics previously supported under the Alvey programme, three strategy statements have been published for the subjects of Devices, Systems Engineering and Systems Architecture, which will provide the initial guidance for collaborative work. It is intended however that these strategies should be reviewed by the new joint advisory structure with the intention of broadening the programme to areas not previously the subject of collaborative research proposals.

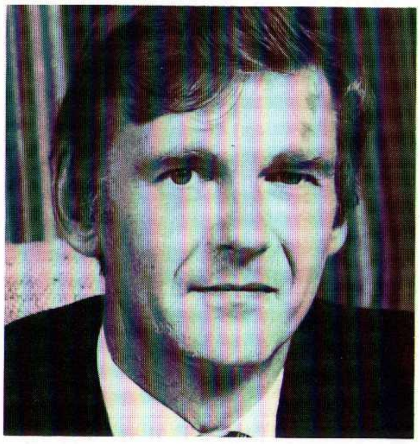
The decision to bring together into one coordinated research effort SERC's and DTI's support for IT will further strengthen the links between industrial and academic researchers and provide the coordination necessary for future development of advanced technologies in the IT field. Such a broad spectrum of programmes will not only help industry to advance in a key area of future growth but will also maintain the excellence of fundamental research in IT in the academic sector.

For further information on the new management arrangements, please contact Neil Williams at SERC Swindon Office, ext 2478*.

Information Technology Advisory Board

Dr Nigel Horne has been appointed Chairman of the new Information Technology Advisory Board which will advise both SERC and DTI on their policy and funding for information technology and some aspects of telecommunications.

Dr Horne is Main Board Director, Technical and Corporate Development of STC plc and a Board Director of ICL. He is currently a member of the ESPRIT Advisory Board of the European Commission and of the National Electronics Council.



Dr Nigel Horne

Asteroid named Boksenberg

An asteroid has been named in honour of Professor Alec Boksenberg FRS, Director of the Royal Greenwich Observatory. Dr Eleanor Helin, Planetary Scientist/Astronomer at the Jet Propulsion Laboratory, Pasadena, presented a plaque and the discovery photo of Asteroid 3205 to Professor Boksenberg in September.

Asteroid Boksenberg was discovered at the 1.2-metre Schmidt Telescope at the Anglo-Australian Observatory and is thought to be about 12–15 kilometres in diameter.

Eleanor Helin decided to honour Professor Boksenberg for giving her advice and guidance in setting up an asteroid program at the UK Schmidt in 1979. This asteroid was discovered during the first program, using photographic plates taken with the UK Schmidt Telescope (see page 23).

The official citation also recognises his invention of the Image Photon Counting System and its application to a wide variety of astronomical problems.

The asteroid orbits outside the orbit of Mars and can be seen periodically from Earth, but not with the naked eye.

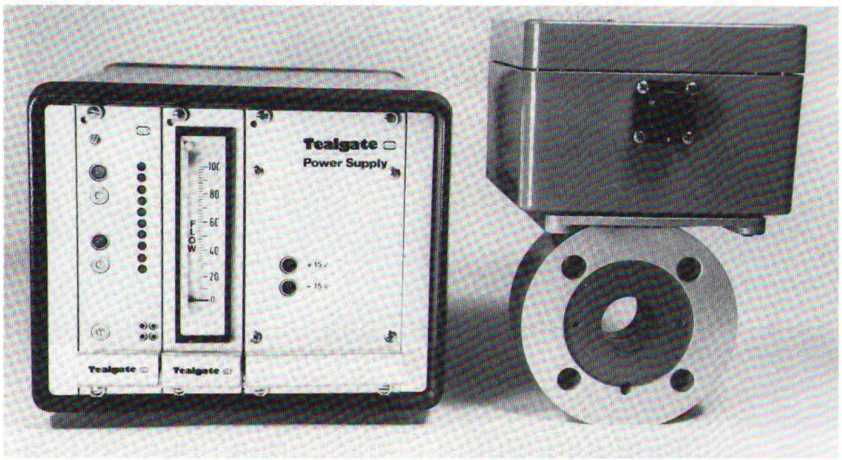
* See page 2: Swindon Office telephone

LINK for industrial measurement systems

One of the first five LINK programmes announced in February (see *SERC Bulletin* Volume 3 No 11, Summer 1988) was a programme on Industrial Measurement Systems. This programme was launched publicly at a meeting in Birmingham on 28 April. More than 200 people attended, half of them industrialists and half academics. The number and variety of the questions, raised both on the day and since, has provided encouraging evidence that the programme is generating much interest, writes Don Tallantire, one of the programme's coordinators.

The Industrial Measurement Systems Programme is administered jointly by the Department of Trade and Industry and SERC through a Swindon-based secretariat. It will seek to promote the development of instrumentation and measurement technologies; key areas include microelectronics, optical and spectroscopic methods, sonics and ultrasonics. There will be particular emphasis on systems integration aspects to ensure that relevant and usable information is received and transmitted in measurement and control instrumentation. The programme aims to encourage advances applicable in a broad range of industries.

The programme builds upon the success of the Specially Promoted Programme (SPP) in Instrumentation and Measurement (1977–84) in which SERC invested £3 million. The SPP increased the awareness of the field in the UK, established measurement centres in four universities, led directly to substantial sales of new instruments and systems, supported the growth of a strong research community and provided more and better equipped postgraduate engineers for industry. The new initiative aims to utilise the LINK mechanisms to ensure that industry and the academic community in partnership can draw together the SPP's advances with the most recent progress in very large-scale integration, signal processing and sensor technology to reinforce the established success of the UK instrument industry in exploiting new technology to penetrate world markets.



Flowmeter for abrasive solids now regularly used on precision shot-peening processes, developed by Bradford University and the University of Manchester Institute of Science and Technology with SERC support under the former Instrumentation and Measurement SPP.

In the instrument industry, small firms have a particularly good record of successful innovation and it is expected that they will find the programme attractive. They are likely to see advantage in the freedom, not afforded by earlier schemes of collaboration, to participate without involving another company. Firms with more that 500 employees will however still need to join forces with other companies, as in earlier initiatives.

The SERC funding available to the programme is £5.5 million over six years. With a similar provision by DTI and with the matching commitment required from industry for any LINK programme, the total expenditure will be around £22 million. Continuation for the full term will however be subject to a review to be undertaken after two years.

The programme will be run by a joint SERC/DTI Management Committee under the Chairmanship of Professor G D Pitt, Renishaw Transducer Systems Ltd, and two coordinators have been appointed. They are J D Tallantire for SERC (telephone 058–285 2239) and R C Allen for DTI (telephone 01–215 2700).

For further information about the programme, please contact Phil Hicks, Information Technology Directorate, SERC Swindon Office, ext 2401*, or one of the coordinators. Further information on general aspects of the LINK initiative may be had from the LINK Coordinator, Stuart Ward, SERC Swindon Office, ext 2173*.

J D Tallantire
SERC Coordinator, Industrial Measurement Systems Programme

Further LINKs

Four further research programmes have now been announced within the LINK collaborative research initiative, bringing the total number of approved programmes to nine (see *SERC Bulletin* Volume 3 No 11, Summer 1988).

The LINK initiative supports collaborative research involving industry and the scientific community with the aims of encouraging strategic research with medium-term industrial significance, increased industrial investment in such R&D and, by strengthening links between industry and the science base, improving the transfer of new technology into industry. Government support of up to 50% is available for approved projects.

Here are brief details of the four latest programmes.

Biotransformations
This is a £4 million programme, funded by SERC, Department of Trade and Industry (DTI), and industry, to exploit the use of enzymes as catalysts in chemical reactions. Primary topics include identification of suitable enzymes, development of new processes, including low water systems for utilising enzymes, and optimisation and stabilisation of whole-cell enzyme biotransformation reactions.

For further information contact Dr Maurice Lex (ext 2410) or the LINK Biotransformations Programme*

* *See page 2: Swindon Office telephone*

Secretariat (Biotechnology Directorate, SERC Swindon Office).

Selective drug delivery and targeting
This £3 million programme, funded by SERC, DTI, the Medical Research Council and industry aims to produce fundamentally new methods for achieving the selective delivery of drugs to their biological sites of action. Primary topics include drug entry and penetration of mucosal epithelia, with emphasis on gastrointestinal and lung epithelia, and site-specific drug delivery, with emphasis on polypeptide and protein drugs and carrier systems.

For further information contact Dr Geoff Richards (ext 2323) or the LINK SDDT Programme Secretariat (ext 2305*) at SERC Swindon Office.*

Personal communications
This £12.7 million programme, funded by SERC, DTI, and industry, aims to extend existing research on mobile radio and satellite communication into the area of mobile personal communication. Primary topics include signalling, transmission and internetworking, systems integration, management of high density communication environments, particularly for the highly efficient use of the radio spectrum, and equipment technology.

For further information contact Richard Bond (SERC Swindon Office, ext 2436) or the LINK Personal Communications Programme Secretariat (DTI, Kingsgate House, 66–74 Victoria Street, London SW1E 6SW; telephone 01–215 8090).*

Construction technology and management for maintenance and refurbishment
This programme is currently being developed by SERC and the Department of the Environment (DoE). It will focus on the large and increasing UK market sectors involved with maintaining and updating buildings and their infrastructure. Initially, Government funding of £1.5 million over three years is available for this programme.

To assist in the development of the programme, a market appraisal study has been commissioned. This has been examining the markets for repair, maintenance and refurbishment, and identifying those industrial sectors most likely to benefit from research. Likely subjects include development of automated building management systems, intelligent building services, automated pipelaying and monitoring, and improved building material, repair and non-destructive evaluation techniques.

*For further information contact Dr Robyn Thorogood, the DoE-SERC Research Coordinator, at SERC Swindon Office, ext 2300**

For more information regarding the LINK initiative contact:

S D Ward
LINK Coordinator (ext 2173)*

P D Tomsen
LINK Unit (ext 2162)*
SERC Swindon Office

Research in logic for information technology

The Logic for IT Initiative aims to promote joint research between those working in the separate fields of logic and information technology in order to put IT on a rigorous, theoretical foundation.

From hardware design to the development of new programming languages and the construction of artificial intelligence programs, logic is the major mathematical tool. Logic will perform the function in IT that calculus performs in other areas of engineering. It will provide IT with a rigorous theoretical foundation.

There is, however, a need for more contact between computer scientists and logicians. Computer scientists are not adequately trained in the appropriate mathematical techniques. Logicians are not fully aware of the needs of computer science. Furthermore the situation is not helped by the comparative smallness of the logic community.

This specially funded initiative is designed to improve the situation using the following methods:

Summer schools for 60 to 80 people for the mutual education of computer scientists and logicians. It is hoped that the community at large will suggest topics for and organise such meetings.

Workshops to enable logicians and computer scientists to meet for technical discussions. These are envisaged as short weekend-length meetings for about 20 people.

Senior fellowships of 12 months' duration to free established researchers from their other duties and enable them to visit centres of excellence in a complementary discipline.

Postdoctoral fellowships of two years' duration to enable recent postgraduate students to pursue interdisciplinary research.

Research studentships to recruit young people into this interdisciplinary area.

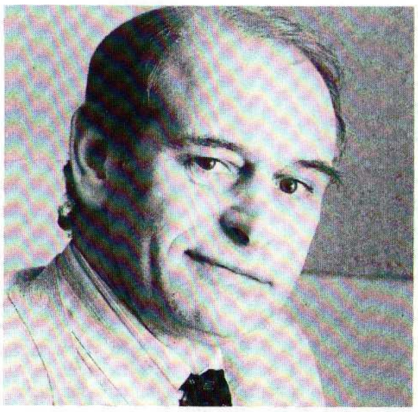
These activities should eventually lead to the setting up of interdisciplinary research programmes and appropriate courses at both postgraduate and undergraduate level.

The initiative is overseen by a management panel drawn from the relevant parts of the community under the chairmanship of Dr Samson Abramsky, of the Department of Computing, Imperial College of Science and Technology. The day-to-day administration and organisation are under the direction of Rowena Sirey at SERC Swindon Office, ext 2260*. The scientific aspects are handled by the part-time coordinator, **Dr Harold Simmons.**

Dr Simmons has wide research interests and has published papers in mathematical logic, category theory, lattice theory and lattice theoretic topology. He is a member of the London Mathematical Society, the American Mathematical Society and the Association for Symbolic Logic, and has been vice president of the British Logic Colloquium.

As coordinator of the Logic for IT Initiative, he will visit the major relevant research centres, attempt to match researchers with complementary interests, and offer advice on the various activities. Dr Simmons may be contacted at:

Department of Mathematics
Aberdeen University
The Edward Wright Building
Dunbar Street
ABERDEEN AB9 2TY
Telephone Aberdeen (0224) 272744



Dr Harold Simmons

The microstructure of concrete

Concrete is made by mixing together cement powder, sand, aggregate and water. The cement powder reacts with the water to give cement paste which binds the sand and aggregate together and hardens to produce a rigid mass. Despite its widespread use the chemical reactions which occur during this hydration are complex and not fully understood, because cement itself is a complex substance. This lack of understanding of the chemistry of cement and concrete and consequently of the development of structure at a microscopic level is a severe impediment to improving and predicting their behaviour. The region around the interface between the aggregate and the cement paste is generally an area of weakness and so there is particular interest in understanding how the microstructure in this region differs from that in the rest of the cement paste. A new technique for studying the microstructure of concrete, developed with support from SERC's Materials Committee, is described here by Dr Karen Scrivener and Professor Peter Pratt of Imperial College of Science and Technology.

In the past, studies of the microstructure of concrete have been based largely on examination of thin sections by optical microscopy and of fracture surfaces in the scanning electron microscope (SEM). Both these techniques have their limitations; optical microscopy due to the lack of resolution and difficulty of interpretation; and SEM of fracture surfaces as these reveal only the weakest path through the specimen. Over the past five years the relatively new technique of backscattered electron imaging in the SEM has been used at Imperial College to study the microstructure of cement and concrete on flat polished surfaces which are representative of the material.

In the electron microscope, backscattered electrons are produced from elastic collisions of the incoming electrons with nuclei of the atoms in the specimen. This means that the intensity with which electrons are backscattered increases with the atomic number of the specimen, so that areas with a high average atomic number appear bright in the resultant image and areas of low atomic number appear dark. In cement paste, the regions of highest atomic number are the remnant cores of the original grains of cement powder which have not yet reacted, while the phases produced by the reaction of the cement powder with water have lower average atomic numbers and so appear darker and the pores occupied by water before the specimen is dried appear black. A typical backscattered electron image of a polished section of cement paste is shown in figure 1.

As can be seen from the figure the arrangement of unreacted cement, hydration products and pores can be seen quite clearly in backscattered electron images and this technique has enabled a much better understanding of the microstructure of cement and concrete to be gained. The histogram in figure 2 demonstrates the distribution of grey levels in a digitised image of the area shown in figure 1. The sharp peaks

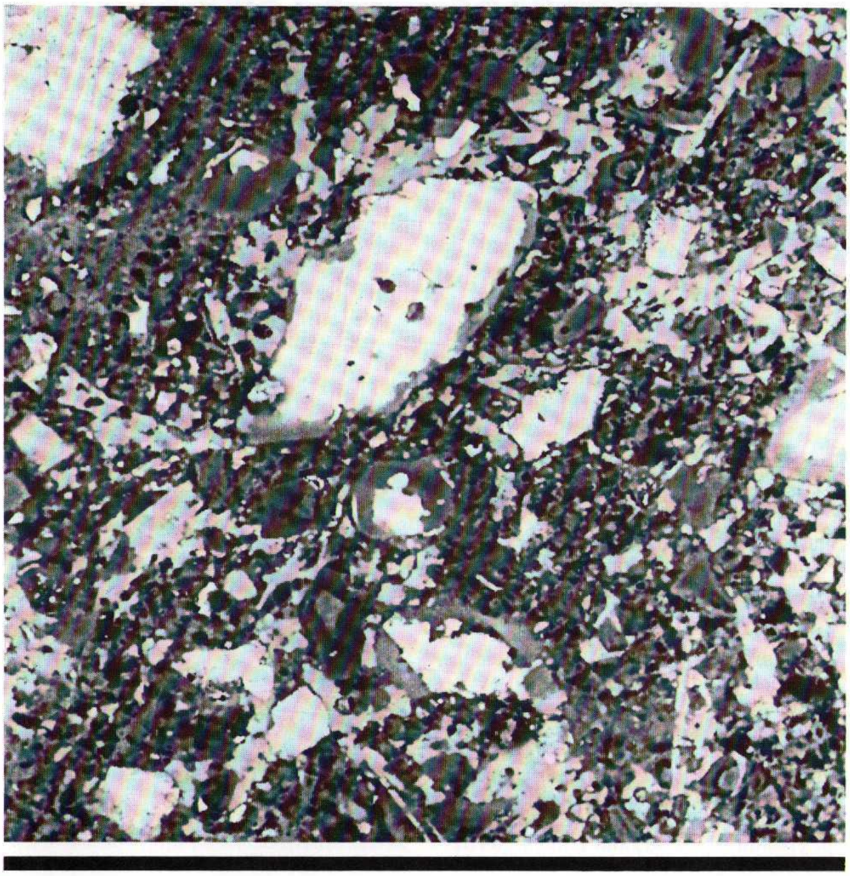


Figure 1: Backscattered electron image of a polished section of cement paste hydrated for 28 days. The bright areas are the cores of the original grains of cement which have not yet reacted. These are surrounded by a layer of grey hydration product. The remainder of the space is filled with a mixture of hydration products (calcium hydroxide light grey and other products darker grey) and pores.

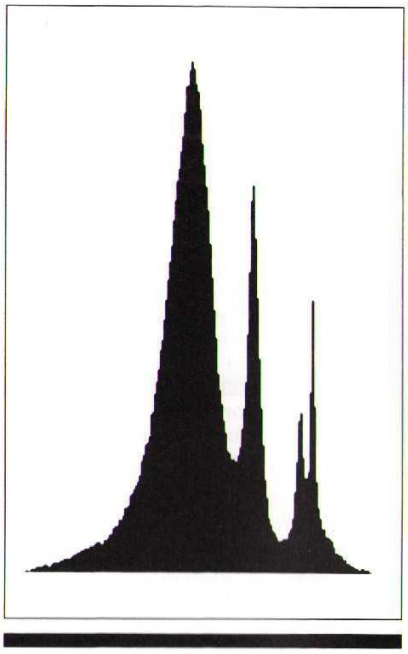


Figure 2: Histogram of the grey levels of the pixels of the image shown in figure 1. The peaks correspond to the different microstructural constituents — unreacted cement, calcium hydroxide and other hydration products in decreasing order of bightness.

in the histogram correspond to the different components present and are sufficiently well separated for the components to be distinguished automatically by a computer-based image analysis system. The image analyser can then be used to produce more quantitative information about the amounts and distributions of the components in the microstructure.

Traditionally various methods have been available to determine the overall amounts of the different microstructural components. For example, the amount of unreacted material can be estimated from the weight lost by evaporation of the combined water when a sample is heated to 1000°C, and the porosity can be determined from the change in weight of a sample when the uncombined water is replaced by another liquid such as methanol. However, with the back-scattered electron technique, many measurements can be made on the same sample at the same time, including a quantitative assessment of the way in which the various components of the microstructure are distributed in space.

The study of the interfacial region between cement paste and aggregate in concrete is one area where the quantification of distributions has been of particular value. The measurement of the relative amounts of the various components at increasing distances from the aggregate surface clearly indicates why this is an area of comparative weakness in concrete. As the graphs in figure 3 show, the interfacial region has a much higher porosity than the remainder of the paste which is associated with the lack of cement grains in the vicinity due to the physical difficulties of packing the grains of cement powder (about 10–30 microns in diameter) close to the large pieces of aggregate (about 10 mm or more in diameter). A study has also been made of concretes containing silica fume, which have been found to have high strengths. Here the particles of silica fume, which are small (generally less than 0.1 micron), can pack much more efficiently in the region adjacent to the aggregate particles so that the porosity in the interfacial region is considerably reduced.

From a practical point of view, the production of concrete with good durability is perhaps more important than obtaining high strengths. In this area, the backscattered electron technique is also proving useful for studying the degradation processes which occur when concrete is exposed to the environment. Two examples of this type of problem are the carbonation of concrete in the atmosphere, which eventually may lead to the corrosion of the reinforcing steel, and the exposure of concrete to deicing salts or to seawater, which may also lead to the corrosion of reinforcement and to the disintegration of the concrete itself. In both cases work with the backscattered electron technique is in progress to study the changes that occur in the microstructure, the rate at which degradation takes place and the factors which affect this rate.

Our quantitative knowledge of the microstructure of cement and concrete has been greatly increased by the use of the backscattered electron imaging technique. This technique, together with other electron microscopy techniques, has led to a basic understanding of the hydration mechanisms and of the way in which the chemistry of the hydration process is related to the development of microstructure with time. This knowledge and understanding is being used to help formulate mathematical models of the hydration process and to relate engineering properties of concrete, like strength and durability, to the microstructure. From the microstructual database which has been established, it is already possible to estimate the original mixing and curing conditions, and to identify the degree of hydration of the cement phases and of reaction and mineral additives, as well as the type and extent of degradation of the concrete by its environment.

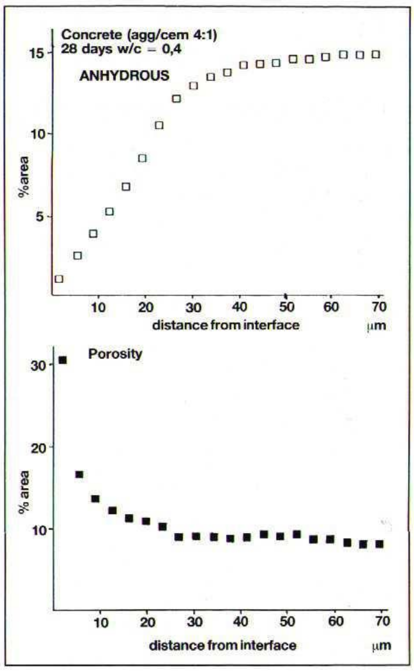


Fig 3: The distribution of unreacted (anhydrous) cement and porosity in the vicinity of the interface between cement paste and aggregate in concrete.

Dr K L Scrivener and
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Department of Materials
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Launch of Materials Commission

SERC has set up a Materials Commission to oversee its support for materials research in universities and polytechnics. The aim of the Commission is to improve coordination of materials research and forge better links between basic research in materials and its application.

Hitherto, this support has been provided through the Materials Committee of the Engineering Board and the Physics and Chemistry Committees of Science Board. Under the new arrangement, an interdisciplinary commission, supported by both Boards, will advise the Boards and the Council of priorities for materials research, education and training.

The Commission will be chaired by Professor Colin Humphreys of Liverpool University (see page 4). The Commission will involve industrialists and academics representing materials 'users' and 'suppliers'. It will comprise seven committees — Ceramics and Inorganic Materials, Polymers and Polymer Composites, Metals and Metallurgy, Semiconductors, plus three existing SERC interdisciplinary committees for Molecular Electronics, Superconductivity, and Medical Engineering. The Commission will Administer a grants budget of some £15 million a year. The Council has also agreed additional support for materials through normal grant funding.

This reorganisation was one of the recommendations of a major study of SERC support for academic materials research undertaken by a panel chaired by Oxford chemist, Dr Peter Day FRS. The report emphasised the increasing importance for UK industry of novel materials for high performance applications in areas such as communications, transport, construction and energy conversion.

Biocatalysts in organic liquids

Interest has grown rapidly over the last few years in the use of biocatalysts in the presence of organic solvents. Dr Peter Halling of Strathclyde University reviews the directions that recent research has taken.

For a long time industrialists have cited the need to operate in dilute aqueous solution as a major disadvantage of biological processes. In doing so, they recognise what the text books said about the environment required by whole cell and enzyme catalysts, and the undoubted problems it caused for many industrial operations. Many molecules which people would like to interconvert, especially in the chemical industry, are poorly soluble in water — and few can be supplied to the biocatalyst as a concentrated solution. Product recovery therefore involves the expensive removal of large quantities of solvent. What is more, the high boiling-point and latent heat of water can make it particularly expensive to evaporate.

Yet all these drawbacks can be avoided in reaction mixtures containing high proportions of organic solvents or other liquids. And it is now clear that many biocatalysts (enzymes and whole cells) can work perfectly well in such systems.

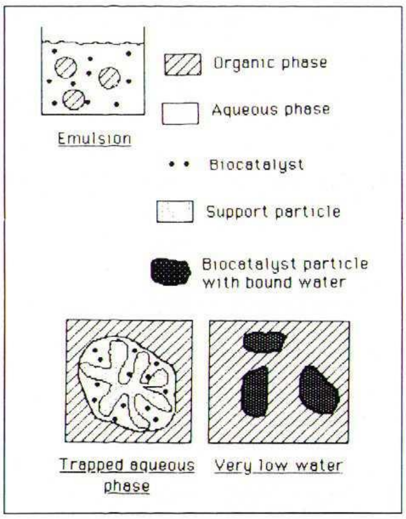
These advantages of increased solubilities in organic media have been particularly demonstrated for oils and fats, other non-polar esters and steroids. But work with biocatalysts in the presence of organic liquids has revealed a number of other benefits. Readily available hydrolytic enzymes can be made to catalyse the reverse, synthetic reactions — because the equilibrium position is shifted in an organic phase. Thus esterases can be used to catalyse condensation of acids and alcohols, while proteases will synthesise peptides. Adverse effects on the activity of the biocatalyst by exposure to a harmful reactant can be reduced if the latter can be made to partition mainly into an organic phase. For example, cells producing epoxides may be protected from inactivation by this product, while cells making tryptophan may be protected from the starting material indole. Unwanted side reactions occurring in aqueous media may be suppressed, such as the polymerisation of o-quinones produced by an initial enzymic oxidation.

Organic media for a biocatalytic step should make it easier to integrate into a synthetic sequence of mainly chemical steps, for which organic solvents will normally be preferred. This may be very important in view of the fast-growing interest in biological catalysis among synthetic chemists. Finally, the use of organic reaction mixtures can enable simple 'immobilisation' of the biocatalyst for ready removal and recovery — it will not dissolve, and can be readily recovered, usually by association with some hydrophilic particles.

The greatest industrial interest so far has been in processes for the selective transesterification of triglyceride oils and fats, using lipases in organic two-phase systems. Organic media offer high solubilities of the reactants, and the ability to use this normally hydrolytic enzyme in a synthetic role. It is reported that the Fuji Oil Company in Japan is already operating a process of this type, and pioneering work on these systems was carried out by Unilever plc in the UK, who are thought also to be considering commercialisation.

A typical conversion possible with this process starts with a fraction from cheap palm oil and produces a mixture of triglycerides similar in composition to cocoa butter, one of the most expensive of all fats. The lipase catalyst will be associated with a porous support particle such as celite, and is hydrated with a small amount of adsorbed water. The reaction system consists predominantly of an organic phase containing the fatty reactants, usually dissolved in a solvent such as hexane.

The SERC Biotechnology Directorate has provided considerable support for this area in recent years. Three main groups have been funded, with several projects supported in cooperative ventures with industry, involving ICI, Tate & Lyle and Unilever among others.



Structures of some organic two-phase reaction mixtures used with biocatalysts.

At Kent University, Robert Freedman and Brian Robinson (now moved to East Anglia) have been studying the behaviour of enzymes in water-in-oil microemulsions. They have made careful kinetic studies on a variety of enzymes, much aided in these systems by their optical clarity. After allowance is made for the effects of reactant partitioning and related factors, they have been able to show that under proper conditions the kinetic constants of the enzyme can be unchanged from those found in aqueous solution. They have also made considerable structural studies to determine how the enzymes are located in the microemulsion.

Malcolm Lilly at University College London leads a team making Biochemical Engineering studies on reactors containing organic two-phase systems. They have been investigating how the observed rate depends on factors such as stirring speed, phase volume ratio and support particle sizes. These are thought to exert their influence through changes in the rate of interfacial mass transfer and in the total surface area available, both of which may limit the overall rate in these systems. They have also produced comprehensive classifications of the various types of organic reaction mixtures possible, and of the options for catalyst and product recovery.

At Strathclyde, the author collaborates with George Bell and Colin Suckling, and a particular theme has been the role of the small amount of water left in even the driest reaction systems. We use the thermodynamic water activity to characterise its effects, particularly on the position of hydrolytic equilibria (and hence yields of synthetic products), and have studied measurements of water and its mass transfer behaviour. We have also tried to compare reaction rates in the various types of reaction mixture, and are studying methods of pH determination when direct measurements on the tiny aqueous/catalyst phase becomes impossible.

In conclusion, despite what can still be read in the textbooks, it is clear that many biocatalysts will work well in predominantly organic media. These reaction systems can be highly advantageous for industrial application, and offer the potential for important new growth in the exploitation of biological processes.

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Biological membranes: a Science Board Initiative

The biological membrane is involved in a wide variety of the most important processes of the cell and in consequence exhibits a diversity of both organisation and function. Many of the functions of membranes and the mechanisms by which membrane diversity are generated are amenable to study at the molecular level. To maintain and extend the position of the UK scientific community in this rapidly expanding field, the Biological Membranes Initiative was established in 1986, and is described here by Dr Ian Booth of Aberdeen University.

The aim of the initiative is to develop an understanding of fundamental membrane processes at the molecular level. In practice this has been limited to just three major areas of research: the analysis of the structure/function relationships in membrane proteins, the mechanisms of solute translocation across membranes, and the mechanisms of protein localisation in organelles and cytoplasmic membranes. In these areas the initiative has allocated some £900,000 in research funds (17 project grants) and has distributed seven earmarked studentships.

One of the major limitations in membrane molecular biology is the lack of detailed knowledge of the structure of membrane proteins and so the initiative has supported many projects directed towards the resolution of this problem. Most of these studies are firmly based in molecular biology and protein biochemistry but are targeted on systems that might be used for the development of a range of protocols that will enable the purification, reconstitution and crystallisation of these and other membrane proteins. In addition these investigations are being complemented by work into the application of nuclear magnetic resonance and micro-fluorescence techniques to membrane systems. One of the ultimate objectives, however, remains the isolation of good crystals of membrane proteins since in most instances X-ray crystallography is the technique that gives the greatest structural resolution.

Since the pioneering studies on bacteriorhodopsin and the reaction centre complex, it has become clear that crystals of membrane proteins are a realistic objective. In part the problem is one of obtaining large quantities of membrane proteins in a state of high purity. Equally, however, there is a need to establish suitable protocols for crystallisation of membrane proteins from detergent solutions. Three groups have been funded to attempt crystallisation of membrane proteins and the initiative would like to encourage other groups to become similarly involved in this type of research so that centres of experience in this difficult area of technology can be established.

Another major area of activity within the initiative is that of protein localisation. The assembly of cells requires the distribution of enzymes and structural proteins to the correct compartments. Given that in eukaryotic cells there are many alternative membranes into which proteins may be inserted, the problem posed for the cell is both one of recognition and of translocation across the membrane. Additionally, while some proteins must pass through the membrane, others remain located within the bilayer and must be correctly oriented. The principal focus of the projects that have been funded in this area through the initiative is the identification and characterisation (both genetic and biochemical) of the components involved in the translocation of proteins across the membrane (see figure).

This initial phase of the Biological Membranes Initiative has seen both the improved funding of established workers and the funding of new researchers. The initiative is now entering its second phase in which new systems will be developed that will ultimately provide insights into membrane processes at the molecular level. Thus we seek to encourage well conceived applications with clearly defined objectives and well designed programmes on systems that have shown potential in the applicant's laboratory for the molecular analysis of membrane processes.

For further information or a copy of the Initiative booklet contact: Dr J M Bentham, SERC Swindon Office, ext 2421.

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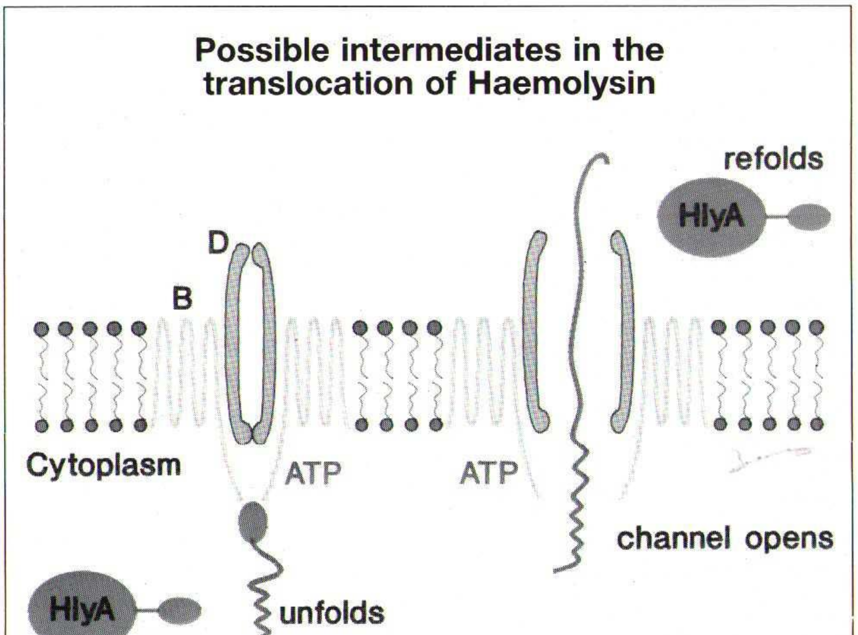

Secretion of haemolysin by E coli. *The HLYA polypeptide, the precursor of active haemolysin, is secreted by* E coli *cells by a mechanism involving the HLYB and HLYD proteins that are believed to form a channel spanning both the inner and outer membranes. The HLYA protein is composed of two domains, a large N-terminal toxic domain and a C-terminal secretory domain. The targeting sequence is believed to reside in the last 36 amino acids of the secretory domain. This novel system is expected to have many basic features in common with other more complex protein transport systems. (Illustration: Leicester University).*

Femtosecond pulse generation

As research continues on high-speed electronic and optoelectronic components, potential devices are being considered which operate in the picosecond regime and below. In photochemistry and photobiology, fundamental processes are now routinely examined on a picosecond timescale. In the search for faster devices and improved temporal resolution of reaction rates, sources of probe pulses in the femtosecond regime are required. In the future, optical techniques and sources will have an ever-increasing importance, both in device testing and in the study of ultrafast phenomena. Apart from the wavelength selectivity of optical techniques, the present temporal resolution obtainable far exceeds that attainable using using any other method, writes Dr Roy Taylor of Imperial College of Science and Technology.

Since its introduction in 1972, the passively mode-locked cw pumped-dye laser has been the source of the temporally shortest pulses. However, the greatest practical limitation of the source has been the wavelength range of operation, which was restricted to around 620 nanometres, in the red region of the visible spectrum. This remained the situation until early 1986 when members of the Femtosecond Optics Group at Imperial College demonstrated, for the first time, system operation at alternative wavelengths. Over the past two years, research in this field carried out solely at Imperial College has resulted in the attainment of femtosecond pulses, frequency tunable from 450 to 850 nanometres using various cw passively mode-locked dye laser systems.

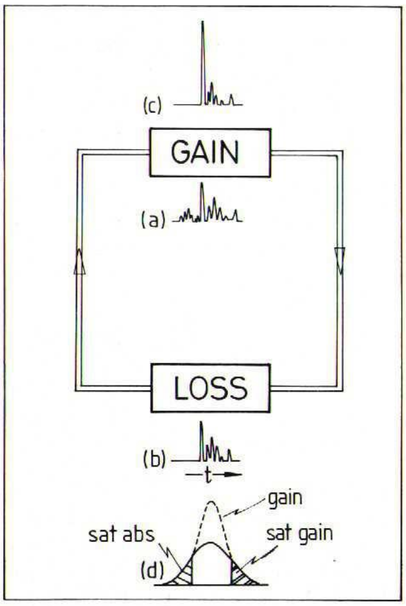

Figure 1: The passive mode-locking mechanism in dye lasers.

Organic dyes are one of the most suitable media for frequency tunable ultrashort pulse generation. Because the solvent and the dye molecules interact, the energy levels of the distinct vibrational and rotational modes smear and generate almost a continuum within each electronic state, providing continuous tuning of the system over a broad spectrum, typically around 100 nanometres, and the capability of supporting pulses of some 2 to 3 femtoseconds.

The operation of the passively mode-locked cw pumped dye laser is similar to that of earlier solid-state laser systems but with subtle and important differences. Professor G H C New, of Imperial College, was the first to identify the relevant mechanism in the dye laser systems. The principle of the technique is shown in figure 1. On a femtosecond timescale, the emission from the laser dye (amplifier) is noise (see figure 1(a)) with the duration of the noise-bursts the order of the inverse of the bandwidth of the fluorescence — in other words, femtoseconds. On propagating in the laser cavity, this noise-burst encounters a saturable absorber, which is the passive mode-locking element. The saturable absorber, which is also typically an organic dye, exhibits an intensity-dependent transmission, low-level signals are absorbed, inverting the system, and high-intensity signals are preferentially transmitted. The absorber returns to the ground state with a characteristic relaxation time. In solid-state laser systems, it is this relaxation time which determines the duration of the generated pulses. However, in dye laser systems, the recovery time of the dye can be many hundreds of picoseconds, yet the laser is capable of generating femtosecond pulses.

In addition to saturable absorption, saturable amplification plays an important role in the dye laser mode-locking process. This was first identified by New in 1974. The effect of the absorber is to remove the low-level signal to the front of the more intense spike (see figure 1(b)). On encountering the amplifier, the spike receives gain. The saturation flux is low in dye laser systems, consequently the gain saturates and the structure following the spike receives no gain (see figure 1(c)). These two effects continue until an equilibrium is established, the saturable absorption removing the front of the pulse, saturable amplification preferentially depressing the rear, while the centre is amplified (see figure 1(d)). To ensure stable passive mode-locking, New defined a set of stability criteria which basically constricts the system to operate only where saturable absorption occurs before saturable amplification. Consequently the choice of the absorbing dye is crucial with the absorption coefficient and relaxation time being important.

Since 1972 the pulse durations obtainable from passively mode-locked cw dye lasers have decreased by almost two orders of magnitude. However, the active dyes have primarily been from the xanthene, coumarin or styryl families, while the saturable absorbers have been cyanines, although not exclusively.

The reductions in the pulse duration from passively mode-locked systems have been principally due to improvements in the laser resonator design and to an increased understanding of the limiting process on femtosecond pulse propagation in the laser cavities. Figure 2(a) shows the typical cavity arrangement originally used, based on a linear geometry. The active and passive dyes were flowed in jet streams of about 100-micron thickness, placed at the focal points of the mirror-folded sections. In order to ensure saturation of the absorber, the focal spot-size in the absorber jet should preferably be smaller than that in the gain medium, although how critical this is depends on the relative magnitudes of the absorber and gain cross-sections. Generally, most of the testing of potential dye combinations was carried out in a linear system after the relevant photophysical parameters of the dyes had been characterised. In most cases, the minimum pulse durations obtained from the above cavity arrangements were in the region of 100 femtoseconds.

A major step forward in the generation of femtosecond pulses was the introduction of the 'colliding pulse-mode-locked' (CPM) ring laser configuration by Shank and co-workers at Bell Telephone Laboratories in 1981. Figure 2(b) shows a typical CPM cavity configuration. In this case, pulses travel in both directions around the cavity; the point of minimum loss is when the counter propagating pulses collide coincidentally at the absorber jet giving rise to preferential pulse formation with this configuration. This cavity arrangement leads to an enhancement of the absorber saturation and can also give rise to coherent effects contributing to a reduction in the pulse widths. The introduction of the CPM technique allowed for the first time the reliable generation of sub 100 femtoseconds albeit in a rather restricted wavelength range.

The attainment of even shorter pulses directly generated in the laser systems came through the realisation of the significance of group velocity dispersion and self-phase-modulation on the pulse shaping of ultra-short pulses in laser cavities. At the gain and absorber jets, the intensity in the focal region is sufficient to give rise to spectral broadening and 'chirp' (a change in frequency with time within the pulse envelope) through self-phase-modulation induced through the intensity-dependent refractive index of the solvent. Saturation effects within the absorber and gain media can also give rise to frequency 'up chirp' and 'down chirp' (frequency increasing or decreasing with time). Consequently the positioning of the jets in relation to the focal position of the mirrors plays an important role on the duration of the generated pulses.

With femtosecond pulses, the dispersive reflection off multiple-layer dielectric mirrors is particularly relevant to the operation and design of ultra-short pulse laser systems. To obtain the minimum pulse widths, it is necessary to employ single stack, dielectric high reflectors used near normal incidence. Used at an angle, the mirrors can give rise to chirp and introduce spectral windowing or limiting.

To control the overall dispersion in the laser system and obtain minimum output pulse durations, most cavities now incorporate a four-prism sequence (see figure 2(b)). This sequence of Brewster-angled prisms allows the introduction of controlled dispersion without overall beam-deviation. The amount of negative dispersion is in proportion to the separation of a pair of prisms, while the amount of glass introduced by the prisms themselves leads to positive dispersion. With fused quartz prisms, typically a 30-centimetre prism separation will permit all the processes contributing to positive dispersion to be cancelled by the negative dispersion. By simply translating one of the prisms along an axis perpendicular to its base, the overall laser dispersion can be varied. This results in the generation of stable and controllable pulses lasting about 30 femtoseconds. Figure 3 shows a typical autocorrelation of a 40-femtosecond pulse generation in the far red region of the spectrum, using a dispersion-controlled cavity.

Through this research carried out on dye dynamics in the femtosecond regime and on cavity design, the group at Imperial College has developed a unique facility worldwide: frequency tunable femtosecond pulses over the visible spectrum with the potential to expand this range. Figure 4 shows a prototype laser system. The refined, final design has been the subject of many recent articles in international optoelectronics journals. Financial assistance towards equipment was provided by the Royal Society through a grant from the Paul Instrument Fund, and also by SERC's Physics Committee.

There has been major international interest in the configurations developed, with groups in France, Japan and the USA reproducing specific laser systems for various applications, and it is hoped that UK funding in this area will increase significantly as a result of the Physics Committee's initiative in Quantum, Non-Linear and Solid State Optics.

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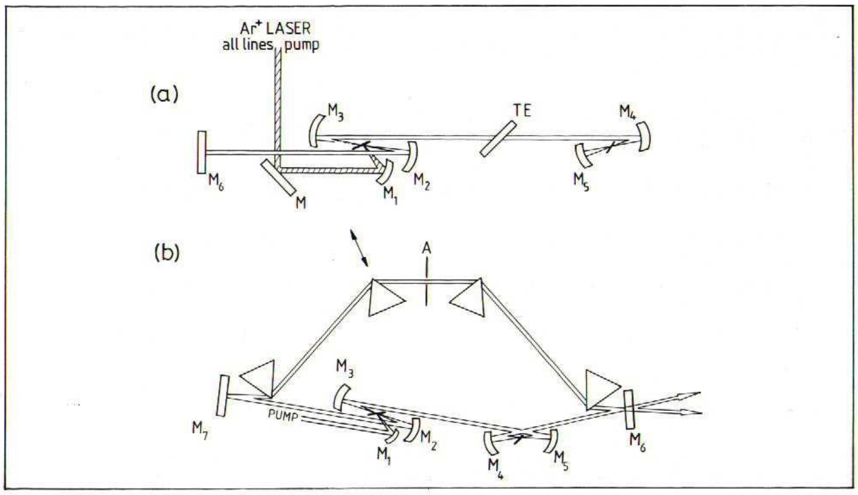

Figure 2 (above): Typical passively mode-locked dye laser cavity configurations: (a) linear, (b) CPM.

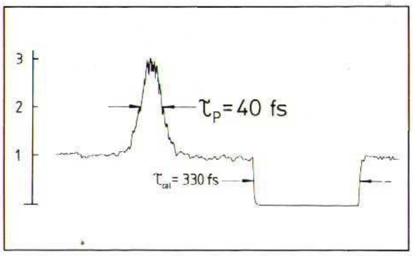

Figure 3 (right): An autocorrelation profile of a 40-femtosecond pulse from a cw passively mode-locked dye laser in the far red region of the spectrum.

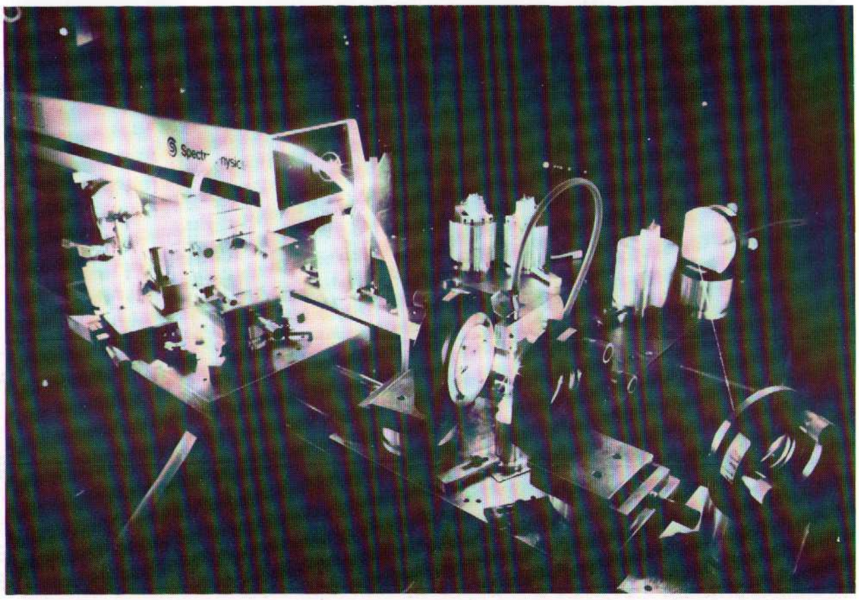

Figure 4: Prototype CPM dispersion compensated passively mode-locked dye inset.

Powder diffraction using synchrotron radiation

New advances in powder diffraction using synchrotron radiation have enormously increased the scope of this technique. The capacity for structural refinement, *ab initio* structural determination, very precise lattice parameter measurements, stress analysis, and identification of small quantities of subsidiary phases in samples have been much enhanced by improvements in both intensity and resolution. Here Robert Cernik, Paul Murray and Phil Pattison of Daresbury Laboratory, and Richard Catlow and Andrew Fitch of Keele University describe in outline the latest powder diffractometer built at the Synchrotron Radiation Source at Daresbury.

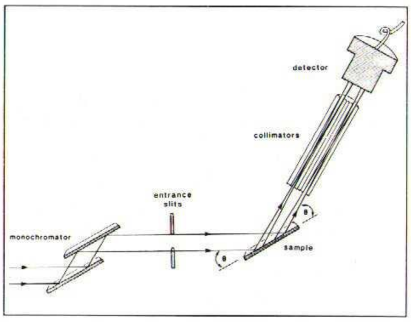

Figure 1: Schematic representation of the new diffractometer 8.3.

The new high-resolution diffractometer 8.3 is situated on a bending magnet of the storage ring, and is equipped with a channel-cut silicon 1 1 1 mono-chromator, giving a range of X-ray wavelengths from 1-2.5Å. The sample is contained in a rotating flat-plate specimen holder, and scanning in either theta/two-theta mode or at fixed-sample orientation is possible. Because of the parallel nature of synchrotron radiation in the vertical sense, the resolution of the instrument is controlled by a set of long, fine, diffracted-beam collimators. To enter the detector, photons from the incident beam must fulfil the strict conditions of scattering direction imposed by the collimators (figure 1). For 8.3, peak widths of about 0.05° are obtained for highly crystalline samples. A coarser set of vertical Soller slits minimises the effects of the axial divergence of the incident radiation, so that well defined, symmetric peaks are obtained, even down at low angles.

Precision lattice parameter measurements

The optics of the instrument ensure that the positions of the diffraction peaks are largely free from a number of systematic and geometric errors which can occur with conventional X-ray diffractometers. The diffractometer is therefore ideally suited to obtaining accurate peak positions for precision lattice parameter measurements. Accurate peak positions are also essential for the determination of the unit cell and for indexing of the pattern in *ab initio* structure determination from powder data alone. There is increasing interest in direct determination of crystal structure from powder-diffraction data, for the wide range of materials for which single crystals are difficult or impossible to grow, for example industrial catalysts (which may be multi-component systems) or the new classes of oxide superconductors. The diffractometer is equipped with high-resolution encoders linked directly to the two-theta and sample theta axes, with a precision of 0.0001 and 0.001°, respectively.

Peak positions have been found to be reproducible to 0.0004°, or within two standard deviations of the average peak position determined by least-squares fitting of an assumed peak-shape function to the diffraction profile (figure 2). The diffractometer is driven by servo motors with direct feedback from the encoders, so that the detector or the sample may be rapidly driven to any desired angular position. At present, data are collected in the step-scan mode, but modifications are planned to allow continuous scanning, thus leading to more rapid rates of data acquisition. The excellent signal-to-noise of the data will

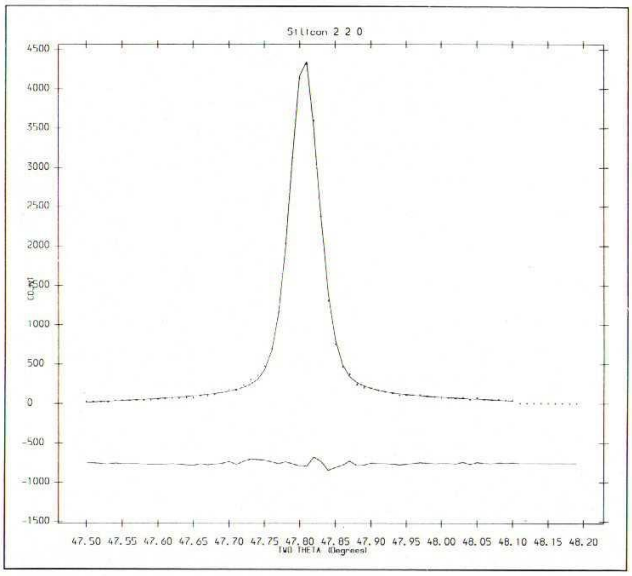

Figure 2: Fit of a symmetric pseudo-Voigt peak to silicon 2 2 0.

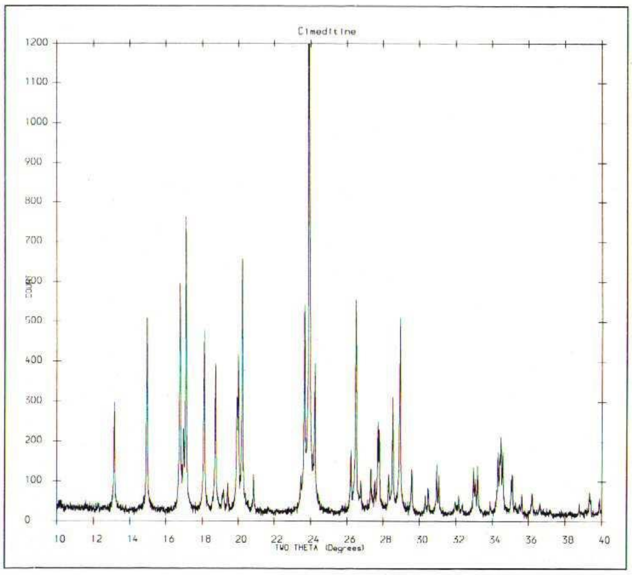

Figure 3: Diffraction pattern of Cimetidine collected on 8.3.

be useful in revealing small quantities of crystalline impurity phases in a sample, or for the identification of weak superlattice reflections.

As well as operating in a monochromatic, angle-scanning configuration, the diffractometer can be operated in an energy-dispersive mode. By fixing the detector at a chosen angle (two theta), and by scanning the monochromator through its range of accessible wavelengths, the Bragg condition ($n\lambda = 2d\sin\theta$) can be fulfilled at wavelengths corresponding to the various lattice spacings (d) of the sample. In this way a diffraction pattern can be obtained, with a resolution more than an order of magnitude better than that obtained using the conventional energy-dispersive technique which uses white radiation and an energy-sensitive detector. The geometry of this arrangement has great advantages when using restricted sample environments, for example a pressure cell with fixed entrance and exit windows.

Early results

Although operational for only a few months, several important experiments have already been carried out which illustrate the scope and potential for the new diffractometer.

The high intensity of the synchrotron radiation and the flat-plate nature of the sample are ideally suited to experiments on thin, crystalline surface layers. Thus experiments performed by workers from Kent University, on a 5-micron layer of lead phthalocyanine on a sapphire support, showed that the structure of the film is quite different from that of the bulk material. Thin films of metal phthalocyanines exhibit marked changes in their conductivity in the presence of adsorbed gases (nitrous oxides, for example) and so provide the basis for a simple, cheap and highly effective sensor.

A layer of oxide grown on a metal substrate can be under considerable stress, owing to the mismatch between the structures of the two components, or to differences in their thermal expansions. It is recognised that these stresses can play an important role in the adhesive properties of the film, as to whether it sticks, forming a protective layer, or spalls off, leaving an exposed area where renewed oxidation can occur. The stresses in the layer cause small changes in the spacings of lattice planes as a function of their inclination to the surface of the sample. By observing the change in the position of a diffraction peak with sample orientation, these stresses can be investigated. With 8.3 there are no problems associated with parafocusing, peak-broadening or beam-penetration as are observed with conventional diffraction geometries.

Measurements on layers of nickel oxide (5 to 20 microns) on nickel (provided by AERE Harwell) showed, from small splittings of the peaks, that the nickel oxide layer has a rhombohedral structure. Small, stress-induced peak shifts from 0.001 to 0.04° with sample orientation were easily identifiable owing to the high resolution and precision of the diffractometer drive system.

Data collected on the ulcer drug Cimetidine, by workers from the Chemical Crystallography Department at Oxford University, illustrate the excellent quality of the diffraction patterns that can be obtained (figure 3). Such data should be suitable for least-squares refinement by the Rietveld method, which calculates a complex diffraction profile as a sum of overlapping peaks of assumed peak shape (for instance, Gaussian or pseudo-Voigt). Peak positions are determined from the refined values of the lattice parameters (and zero point), peak widths follow a simple function of theta, and peak intensities depend on the structure factors and hence on the refined values of the atomic parameters.

Rietveld refinement is being performed on a number of samples of cement, at Birkbeck College, London. Distinction between the various proposed structural models for this multi-component system will eventually be possible, leading to a greater understanding of the solid-state chemistry of this important material.

The powder-diffraction programme at the SRS is served by two other instruments. Station 9.1 collects high-resolution data in the Debye-Scherrer mode, with peak widths of about 0.04°. The instrument has a furnace, and a position-sensitive detector is also available for rapid data collection. Station 9.7 is dedicated to energy-dispersive diffraction studies using white radiation and an energy-sensitive detector. The station is particularly suitable for high-pressure work, or for time-dependent diffraction studies.

Access to the diffractometers 8.3, 9.1 or 9.7 can be obtained through a number of channels. There are the usual SERC grant applications (major, small or exploratory) but, in addition, the Daresbury Laboratory has recently established a **powder-diffraction service**, open to both academic and industrial users, who wish to make use of the diffraction facilities offered by synchrotron radiation, without necessarily becoming specialised users themselves. Details may be obtained from the authors (PP or CRAC).

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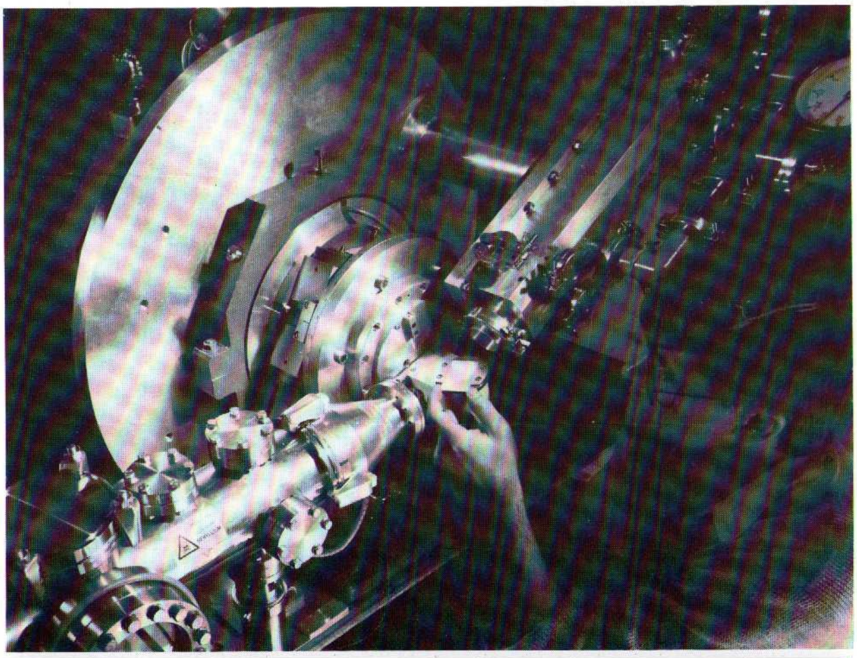

The new powder diffractometer on Station 8.3 at Daresbury Laboratory. Dr A N Fitch is mounting a specimen. The parallel collimator housing can be seen on the two-theta arm above the specimen.

Metalloprotein spectroscopy and biology

Designated research centre at East Anglia University

The UK Centre for Research on Metallo-enzymes has been established under the SERC Molecular Recognition Initiative at the University of East Anglia (UEA). The UEA group, which comprises the authors of this article — Professor Colin Greenwood, Professor Andrew Thomson and Dr Geoff Moore — has a long-established tradition of interdisciplinary work in the area of metallobiology, having developed a set of novel spectroscopic techniques for the detection and study of transition-metal ions such as iron, molybdenum and nickel bound to proteins.

These techniques, based upon the ability of the metal ion to absorb circularly polarised radiation when the protein is placed in a strong magnetic field, were applied to metalloenzymes in a major way for the first time by the UEA group (see *SERC Bulletin*, Volume 3 No 3, Autumn 1985). The range of techniques available to the group has since been widened to include electron paramagnetic resonance spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, for both solid and solution phase studies of proteins, and Fourier transform-infrared spectroscopy.

Previous work has been concerned with respiratory chain metalloproteins from mammalian, bacterial and plant sources. Respiratory chains comprise a set of proteins, some membrane-bound and others water-soluble, which contain one or more transition-metal ions capable of cycling their oxidation states so that electrons can be passed from reduced organic compounds to a terminal oxidising agent such as molecular oxygen for aerobic species, or a hydrogen or nitrate ion in the case of certain anaerobically respiring organisms. The redox active centres in these cases are the haem group, iron sulphur clusters, and copper.

The new work to be carried out with the support of the Molecular Recognition Initiative is designed to elucidate the ways in which enzymes which contain iron can activate molecular oxygen and catalyse its reaction with a range of organic molecules, often in a stereo-specific way (figure 1). There are three broad classes of iron-containing proteins employing, respectively, a haem group (in cytochrome P-450), a dimer of iron atoms (in methane monooxygenase), or a single isolated iron centre (in benzene dioxygenase). In some instances a short electron transport chain is used to shuttle electrons from a reducing agent such as $NADH_2$ into the active site (figure 2). At the active site electrons, oxygen, protons and substrates are brought together in a complex and concerted reaction. The best characterised example is cytochrome P-450 used by a bacterium *Pseudomonas putida* which can degrade camphor as a carbon source. The first step is the hydroxylation of camphor stereo-specifically in the 5^{1}-position (figure 1). The X-ray crystal structure of the enzyme and the enzyme-substrate complex reveal that the camphor molecule is held close to the iron of the haem group (figure 3). Dioxygen is bound to the iron itself and activated in a process not yet understood. This enzyme receives electrons from an electron-transfer protein called putidaredoxin. Among the variety of reactions catalysed by cytochrome P-450 is the cleavage of the side-chain of cholesterol, important in the control of steroid levels in various glands. Figure 4 shows a model in this process involving the substrate and the enzyme embedded in a lipid membrane and a soluble protein, adrenodoxin, carrying electrons between a flavo-protein and cytochrome P-450. There is a range of haem-containing enzymes that carry out chemistry closely related to that of P-450 which are, as yet, poorly characterised. An example is the cleavage of the tryptophan ring to give formyl kynurenine, by tryptophan pyrrolase. Similar chemistry is involved in the enzyme prostaglandin H synthase, a haem enzyme that incorporates two molecules of oxygen into arachidonic acid converting it to prostaglandin G_2.

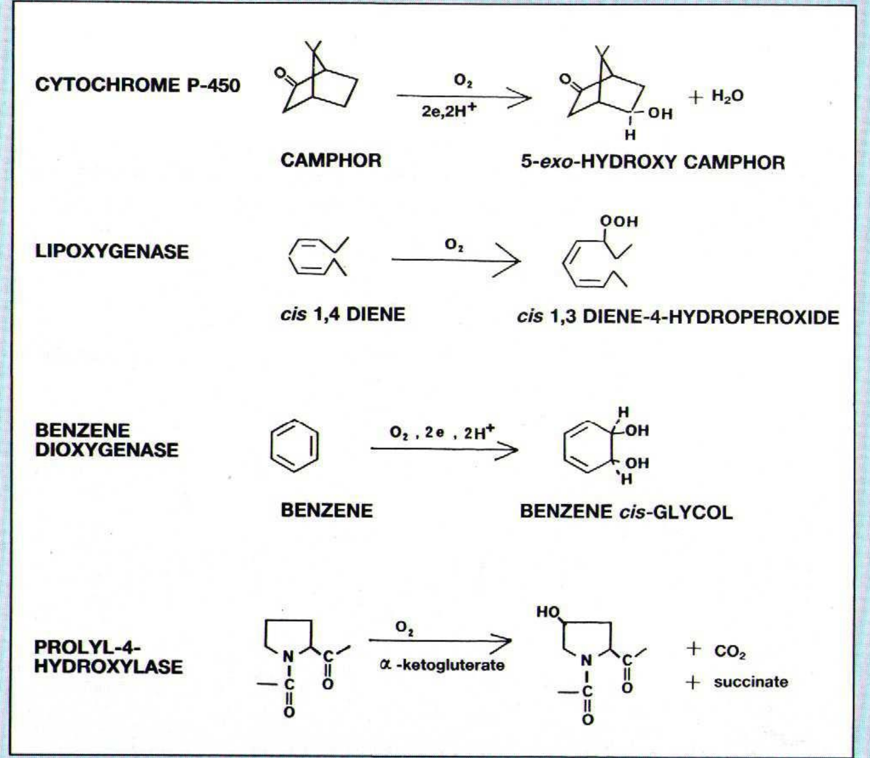

Figure 1: Examples of oxygen insertion reactions catalysed by different classes of iron-containing enzymes.

A second group of oxygen-activating enzymes, known as oxygenases, use a single iron site of, as yet, poorly defined structure. *Pseudomonas putida* can metabolise aromatic hydrocarbons including benzene, toluene and naphthalene. The initial step is the hydroxylation of the aromatic ring to form, in the case of benzene, a *cis*-glycol. The enzyme, benzene dioxygenase, contains an iron-sulphur cluster which passes electrons from a low molecular-weight electron carrier to the iron centre. There is a short electron transport chain to transfer reducing equivalents from $NADH_2$ to benzene, which in turn reacts with dioxygen. The industrial significances of this enzyme for biotransformations has been described (*SERC Bulletin* Volume 3 Number 6 Autumn 1986). Little is known of the structure of the active site of this enzyme. Spectroscopic methods can be used to define the site. First, the details of the state of ligation of the iron can be followed by optical and magnetic methods, including magnetic circular dichroism and electron paramagnetic resonance. FT–IR spectroscopy will enable the substrate binding to be monitored. NMR methodologies will permit the substrate binding site and its kinetics to be investigated. By use of a range of techniques, a map of the site can be built up and, importantly, a picture of the dynamics established.

There are examples of enzymes of potential pharmaceutical significance which may be related mechanistically to benzene dioxygenase. For example, prolyl-4 hydroxylase, which mono-hydroxylates certain proline groups of collagen, is an enzyme requiring iron, dioxygen, ascorbate and 2-oxoglutarate for this activity. This enzyme is a target for inhibition to prevent conditions in which excess collagen is deposited, such as fibrosis of the lung.

Another example is lipoxygenase, an enzyme containing non-haem, mono-meric iron that is present in plants, animals and fungi. Its function in mammalian biochemistry is as a catalyst in the pathway used for the production of leukotrienes, molecules implicated in the control of inflammation. This enzyme is also a target protein for inhibition by drugs. Collaborative work between the University of East Anglia group and research workers in the associated Agricultural and Food Research Council Plant Breeding Institute at Norwich on the molecular structure, function and genetics of the plant lipoxygenases is in progress.

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Dr G R Moore and
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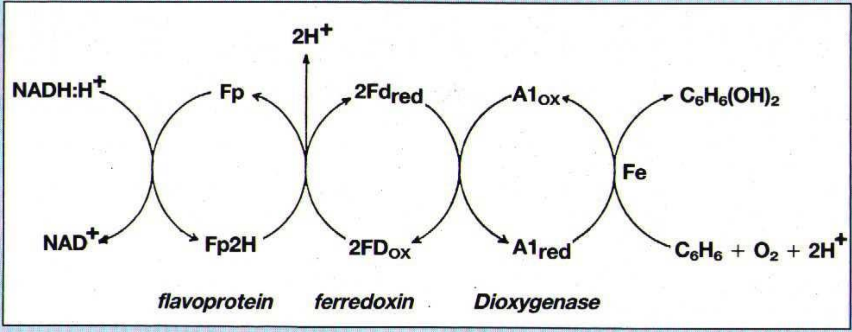


Figure 2: The electron transport chain consisting of three proteins: a flavoprotein, a ferredoxin and benzene dixoygenase, which carries electrons from reduced nicotinamide-adenine dinucleotide $NADH:H^+$ to benzene.

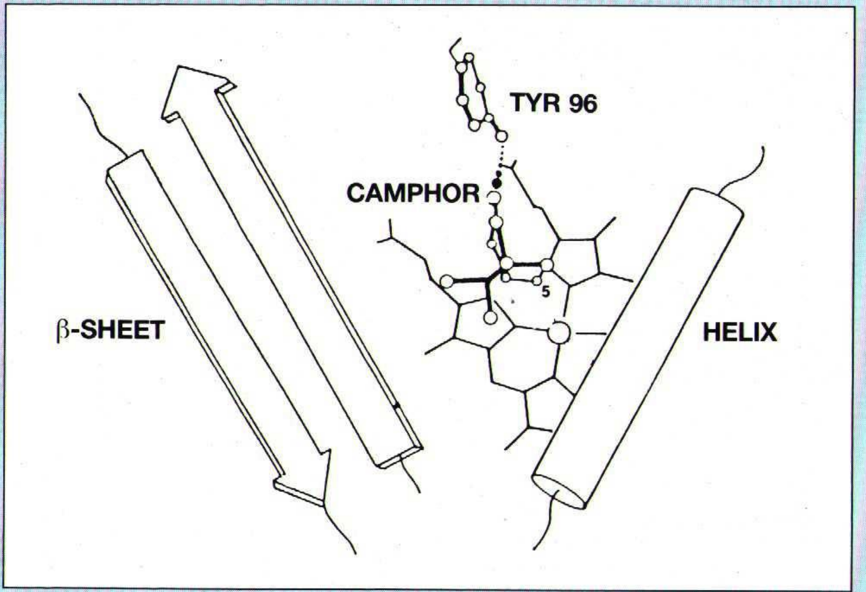


Figure 3: A representation of the active site of cytochrome P-450 CAM which shows the substrate camphor bound close to the haem group in a cleft in the protein and H-bonded to tyrosine 96.

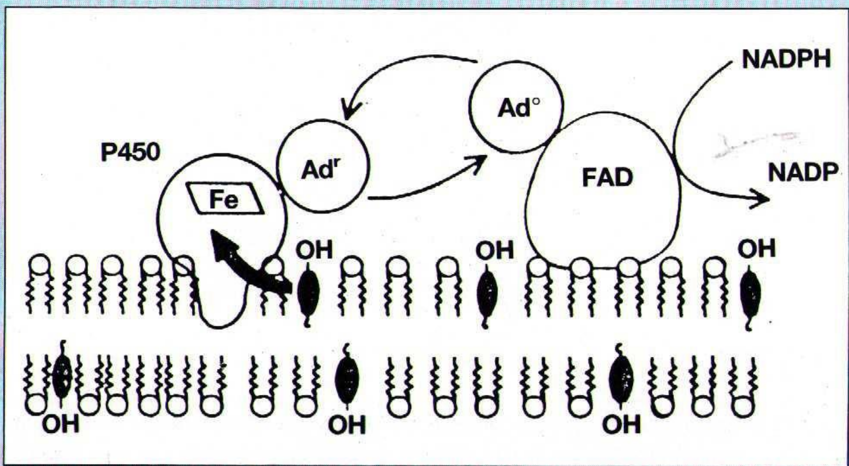


Figure 4: Side-chain cleavage of cholesterol by cytochrome P-450 with substrate and protein embedded in a phospholipid bilayer. Electrons are carried from NADPH by a flavoprotein, FAD, and a soluble electron carrier, adrenodoxin (Ad), an iron-sulphur protein.

The H1 experiment at HERA

In 1990, a new era of particle physics research will open in Hamburg, West Germany, when the electron-proton collider HERA will start operation. Although the new accelerator is being built at the West German National Laboratory, DESY, the facilities will be enjoyed by two large collaborations of physicists from many countries throughout the world. The two collaborations are called H1 (= HERA 1) and ZEUS and there are 200 to 300 physicists in each collaboration. In the last issue of the *SERC Bulletin* (Volume 3 No 11, Summer 1988), the background and description of the ZEUS experiment were presented and now the spotlight is turned on H1, by Dr Robin Marshall of Rutherford Appleton Laboratory.

The HERA accelerator itself is being constructed in a 6.3 kilometre tunnel which swings out from the DESY site, under a nearby trotting stadium, under the city suburbs of Hamburg and through the 'Volkspark' where it passes close to the city's main football and athletics stadium before rejoining the DESY site. The tunnel digging was finished last year and was constructed by what are now standard tunnelling techniques with a large drilling mole. Unlike the LEP tunnel at CERN, Geneva, which has to be bored through mountain rock, the DESY tunnel was bored through sand under the water table. Pieces of concrete tunnel lining were then carried to the head of the boring machine where they were joined together with a 5.5-metre diameter gasket. The subterranean caverns where the two experiments are to be housed have been excavated, lined and topped with service buildings. Already the first pieces of the equipment for H1 — iron for the magnet — have arrived from Leningrad and have been installed in the H1 hall. The pace of the installation will increase towards the end of 1988.

The H1 apparatus, like its international partner ZEUS, has been designed to detect the products of high-energy collisions between electrons and protons. Collisions between two such apparently simple objects as electrons and protons are far from simple and predictable, as indicated by the massive investment of science and technology in the HERA accelerator and the two experiments. At very low energies, as near the static limit as one can get in quantum mechanics, electrons and protons interact in a familiar and understood way; they form the stable pairing known as the hydrogen atom. In the HERA tunnel, 30 GeV electrons will be brought into head-on collisions with a beam of 820 GeV protons, these collisions taking place at the centre of the H1 and ZEUS apparatus. The two energies represent the current feasible technological limits in a ring the size of HERA. The limit is considerably lower for electrons than for protons because electrons radiate substantial amounts of synchrotron radiation as they are magnetically bent round the HERA curves.

The resolving power of an electron microscope is determined by the electron momentum measured in relation to the stationary sample. In HERA, the only sample to be used will be the protons themselves, and in their rest frame, the energy of the electrons corresponds to a spatial resolving power as small as 10^{-18} metres, some 1/1000th of the size of the proton. This represents the smallest scale at which the physical world can be studied at present. At these high energies and small distances, the form of the proton is revealed — three quark triplets and a variable swarm of 'gluons' — all confined in a fuzzy sphere approximately 10^{-15} metres in diameter, but all adding up to a unit of electric charge, half a unit of angular momentum and weighing an incomprehensible 938.3 MeV/c^2.

H1 has to be able to study the expected physics at these new energies and to be as versatile as possible in order to cope with the hoped for new physics. The strength of H1 lies in its ability to detect or observe the leptons (electrons, muons and neutrinos, for example) in the final state. Neutrinos are detected, if that is the right word, by the fact that the 2500 tonnes of the H1 apparatus look more or less like a vacuum to the very weakly interacting neutrinos which are deduced from the energy and momentum imbalance among the remaining observed particles. For this reason, good resolution of the observed particles is required and the designers of H1 have striven for optimum resolution in all the different, complex parts of the apparatus. An overall view of the H1 apparatus as it will appear in Spring 1990 is shown in figure 1. The equipment fits into a cube whose sides are about 10 metres, a far cry from the desk-top equipment of 75 years ago when Rutherford started his experiments.

Since its discovery in the nineteenth century, the electron has remained an apparently fundamental particle with no structure (point-like), a property which seems to be shared by its lepton relatives which have different masses. Almost all new particle physics discoveries in the last 20 years have involved the observation of energetic leptons in the final state and so it is a safe bet to incorporate the best possible electron detection in H1, to maximise new physics capability. This is done by combining an electromagnetic calorimeter with electron identification through transition radiation detection which is incorporated into the 'forward tracker'. Transition radiation occurs whenever a charged particle crosses an interface between two different dielectric media and it can be enhanced by using fibrous material which has many such interfaces.

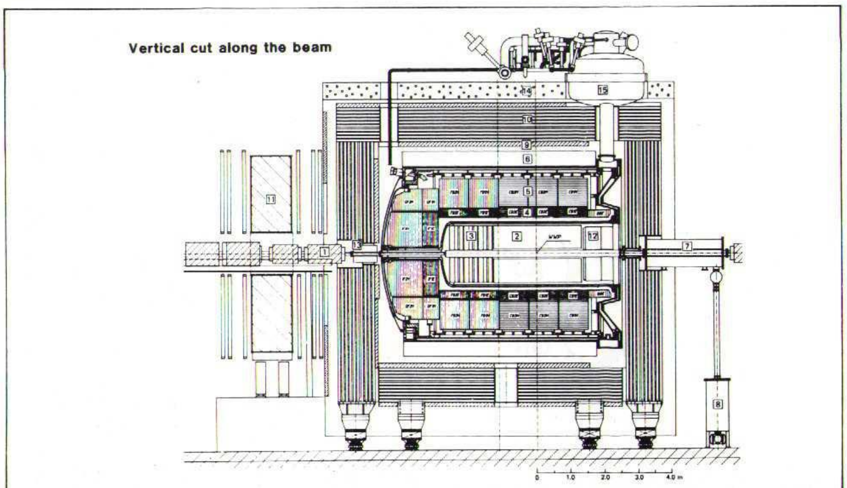


Figure 1: A general view of the H1 detector: 1: Beam pipe and beam magnets; 2: Central tracking chambers; 3: Forward tracking chambers and transition radiators; 4: Electromagnetic calorimeter (lead) and 5: Hadronic calorimeter (stainless steel) (both liquid argon); 6: Superconducting coil (1.2 T); 7: Compensation magnet; 8: Helium cryogenics; 9: Muon chambers; 10: Instrumented iron (iron slabs + streamer tube detectors); 11: Muon toroid magnet; 12: Warm electromagnetic calorimeter; 13: Plug calorimeter (Cu, Si); 14: Concrete shielding; 15: Liquid Argon cryostat. (Drawing: DESY).

The forward tracker is being built as part of the UK contribution to H1 together with Institutes at Orsay and Aachen. It is contained in a cylindrical module 1.8 metres diameter and 1.3 metres long, and will register the tracks of charged particles as they are bent by the axial magnetic field. The various parts of this module will be built and tested in the workshops of Lancaster, Liverpool and Manchester Universities, Rutherford Appleton Laboratory, Aachen and Orsay and then brought together for assembly into a lightweight aluminium and carbon fibre tank at RAL. Everything has to be mounted to a precision of a few microns and this has required many joint project and liaison meetings in order to achieve the stringent technical design requirements.

Figure 2 shows the components of part of the forward tracker being built in Liverpool. Extensive use is made of the new lightweight composite materials which provide strength and mechanical stability together with low atomic number. Walls and supports which are transparent to the particle radiation are impossible to make, but this technique is as close as one can come to such an ideal. The mechanical stability allows the holes shown in figure 2 to be drilled to a positional accuracy of better than 10 microns.

Figure 3 shows some large printed circuit boards at the stage of inspection using a three-dimensional position scanner in the RAL workshops. These printed circuit strips form the electric fields which drift the ionised electrons on to the sense wires in the detector.

The magnetic field itself in which the forward tracker is situated represents the limit of current technology. Producing a field of 1.2 Tesla over a cylindrical volume of 6 metres diameter by 6 metres length, constant to within ±3%, can only be achieved by superconducting technology. Such expertise is to be found at RAL where a similar magnet has already been fabricated and transported to CERN (*SERC Bulletin* Volume 3 No 11, Summer 1988). The H1 superconducting coil, which can be seen in its final planned position in figure 1 is now also nearing completion. It will be tested at a temperature of 4.2°K, prior to being shipped to DESY around the end of the year. Moving such bulky objects by road to Southampton has now become almost routine and the shipping lane to Hamburg also presents no problems. Plans for transporting the coil from the Hamburg docks through a few miles of streets to the DESY site has required research at the frontiers of logistics, but all planning problems now appear to have been solved.

The bunches of electrons and protons cross each other every 96 nanoseconds and there is a strong likelihood that some interaction, however trivial, will happen during these crossings. A non-trivial interaction can produce several megabytes of data from the apparatus and this has to be accepted and stored without losing too many subsequent valuable beam crossings due to dead-time. Consequently, there is the potential for massive and unprecedented data flow from the apparatus which requires intelligent on-line decision making if the recording equipment is not to be swamped. This problem has required fundamental research into this area of data acquisition (DAQ) and is solved in the case of H1 at HERA by what can be loosely described as pipelining the data, while a distributed array of small but fast computers decides the fate of the data in the memory pipeline — whether it should be accepted or discarded.

British scientists have traditionally been strong in this area of particle physics research and, in H1, they lead the DAQ project team. The UK DAQ team in Hamburg is being supported by the European Commission's Committee of Science and Technology as part of their programme to stimulate European scientific interchange.

The pedigree of the Manchester University research group in the H1 experiment can be traced back to Rutherford's team who carried out their studies into scattering of alpha particles by gold nuclei. Rutherford's discovery in the basement of the physics building in Manchester in 1912 arose from the unexpectedly high number of alpha particles scattered through wide angles. The H1 physicists will seek to follow Rutherford's example and will be ready to spot any deviation from the expected number of scattered electrons, which might indicate some small hard 'nucleus' deep within the quarks inside the proton. Other new physics possibilities, for which HERA is an eminently suitable tool for study, include leptoquarks, a hypothetical type of particle which could be produced by the fusion of the beam electrons with the quarks within the proton. These leptoquarks would then decay back into energetic leptons (again the lepton signature) and a quark jet.

The H1 project will form the main research effort from the UK for some 30 physicists and eight research students from four British Universities, (Glasgow, Lancaster, Liverpool and Manchester) and RAL through the 1990s into the next century. The investment so far in money and effort has been substantial and all the scientists involved look forward to reaping the reward of this investment by participating in the exciting physics that HERA will have to offer.

Dr Robin Marshall
Rutherford Appleton Laboratory

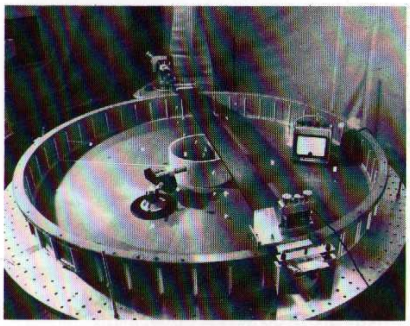


Figure 2: Part of the H1 apparatus under construction in the Liverpool University Physics Department workshops.

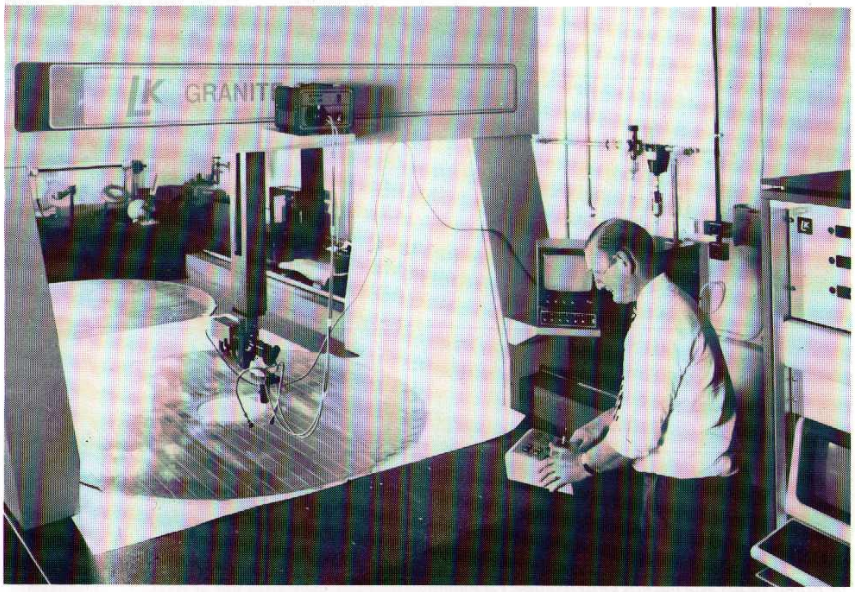


Figure 3: Large printed circuit boards being inspected at RAL.

Telescopes for the year 2000

A recently published report makes the case for UK involvement in two new international telescope facilities for the 21st century. The *Report of the Large Telescopes Panel* calls for access to a large-aperture (8 metres or more) optical/infrared telescope, and for new wide-field survey facilities. Dr Alf Game of SERC's Astronomy and Planetary Science Division assesses the implications of the Panel's recommendations.

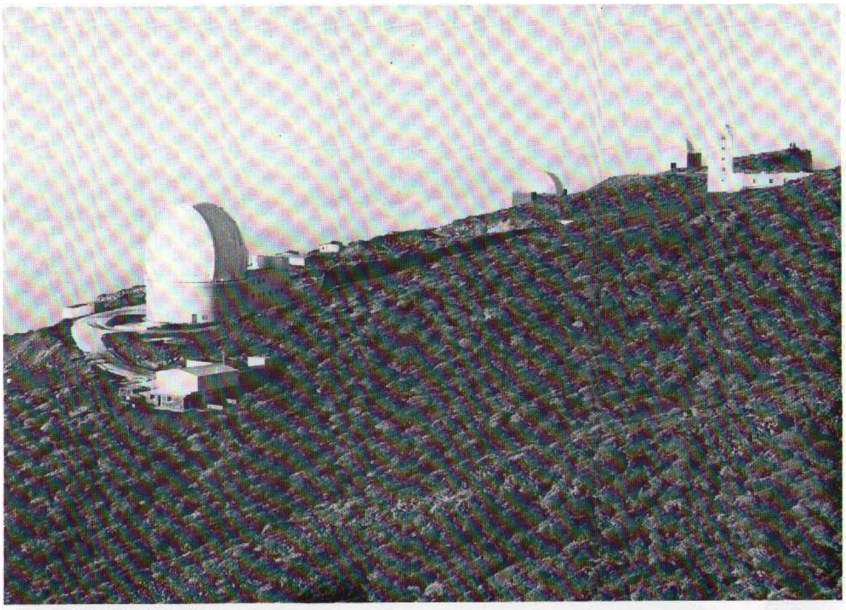
The success of UK optical and infrared astronomy rests in large part on the availability of well sited and well instrumented telescopes: the 3.9-metre Anglo-Australian Telescope (AAT) in Australia, the 3.8-metre United Kingdom Infrared Telescope (UKIRT) on Hawaii, and the Isaac Newton Group (ING) of telescopes in the Canary Islands. The completion in 1987 of the 4.2-metre William Herschel Telescope (WHT), largest telescope in the ING, has given the UK access to what is arguably the most powerful optical telescope currently available, and its exploitation can be expected to occupy the British astronomy community at the international forefront of research throughout the 1990s.

However, plans are well advanced in Europe and the United States for the construction of a new generation of optical/infrared telescopes, with apertures of 8-metres or more, which will become operational from the mid 1990s onwards. The scientific and technological challenges of designing, constructing and operating telescopes of this size are formidable, and such facilities will take ten years or more from the initial design phase to operation. Concern therefore began to grow in the UK community that work needed to be started on the next UK telescope projects if the impetus given by existing facilities was to be maintained. In 1986 the Royal Astronomical Society, in a report on the future of UK astronomy, called for UK involvement in an 8-metre class telescope and a wide-field survey facility.

The Astronomy and Planetary Science Board established a Panel, under the Chairmanship of Professor Richard Ellis of Durham University, to report on future requirements for telescope facilities. Throughout 1987 the Panel consulted extensively, nationally and world-wide, on the scientific priorities for the future and the technological advances possible with future generation telescopes. The Panel's report identifies what it believes will be important areas of scientific endeavour in optical and infrared astronomy in the next decade and considers the facilities needed to tackle them. It concludes that some needs will be met by existing ground-based facilities or by planned space missions, but major areas are identified where access to an 8-metre class telescope will be needed.

The case for an 8-metre telescope rests largely on the fact that progress in many of the important areas of astronomical interest, such as the large-scale structure and content of the Universe, the structure and evolution of galactic systems and physics of star-forming regions, is likely to be held back by the limiting performance of the 4-metre telescopes. An increased aperture naturally leads to an increased photon rate but significant gains are also expected from improvements in image quality. These arise from technological innovations in telescope design where the flexibility of a large primary mirror is controlled by elaborate support systems on short timescales which minimise image degradation from atmospheric turbulence. The Panel's report stresses that the combination of these two gains would lead to breakthroughs in two key growth areas in UK astronomy — high dispersion spectroscopy and infrared imaging. It also makes the more traditional arguments for large facilities based on faint object work.

The report recommends that the UK should seek a substantial share of an 8-metre+ telescope optimised for both optical and infrared astronomy. Infrared capability is essential to pursue important research areas such as star



The Roque de los Muchachos Observatory, La Palma

The Mauna Kea Observatory, Hawaii

The two international observatory sites in the northern hemisphere in which the UK is involved are probably the best in the world for an 8-metre class telescope.

formation processes, but it is financially unrealistic to consider separate dedicated optical and infrared 8-metre telescopes. This means that it is essential that the telescope be on a high, dry site suitable for infrared observations. Either of the current UK northern hemisphere sites — La Palma (Canary Islands) or Mauna Kea (Hawaii) — is appropriate for near-infrared work.

The report also calls for development of wide-field survey facilities. Two particular strengths in current UK astronomy are survey work, and the development of fibre-optic techniques for simultaneous study of multiple objects. Survey astronomy relies on the statistical study of many thousands of objects. The UK is in the vanguard of this field, thanks to the Schmidt Telescope at the Anglo-Australian Observatory, which provides highly detailed photographic plates of sections of the sky, together with high-speed plate measuring machines which extract statistical data from Schmidt plates. More recently, fibre optics has enabled both the Schmidt Telescope and the AAT to collect the spectra of a number of objects simultaneously across the telescope field. A wider-field facility would enable statistical studies of much rarer objects and a far larger number of fibres to be accommodated. There are two ways of achieving the wide field: a dedicated new telescope or, for much lower cost but with less gain, a modification of an existing telescope such as the Isaac Newton Telescope on La Palma or the AAT.

Astronomy is now an international endeavour, and all of SERC's current major telescope facilities are successful collaborations with one or more overseas partners. It is clear that any new facilities would also need to involve similar partnerships. The cost of an 8-metre telescope — upwards of £30 million — prohibits a facility for the UK alone. However, international partnerships in astronomy have scientific as well as financial benefits. The UK experience in the construction of major telescopes, our expertise in advanced optical and infrared instrumentation, and our management of overseas sites are all skills which are of interest to potential partners. In addition to access to the best sites, partnerships will bring the UK access to the latest in mirror and other technologies.

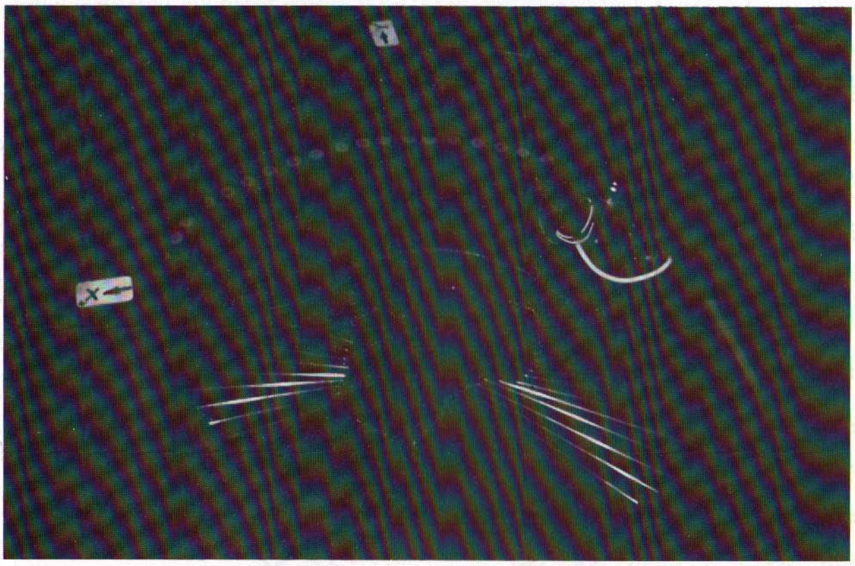
Although the construction and operation of new facilities will inevitably require substantial funds, but a large increase in the budget for ground-based astronomy is unlikely. In the absence of any increase, funds would need to be found by economies in existing activities. The current facilities are enormously productive and are all part of substantial international partnerships. Any proposal for new telescopes will therefore have to be developed in the context of the overall package of facilities.

The APS Board has been sufficiently convinced by the arguments in the Large Telescope Panel's report to provide funds to appoint a project scientist and set up a small project team, and appointments are in hand. Over the next one or two years the team will evaluate options, undertake design studies and assessments, and provide back-up for international discussions. It is intended to present to the APS Board a package of developments based around an 8-metre class optical/infrared telescope collaboration for consideration.

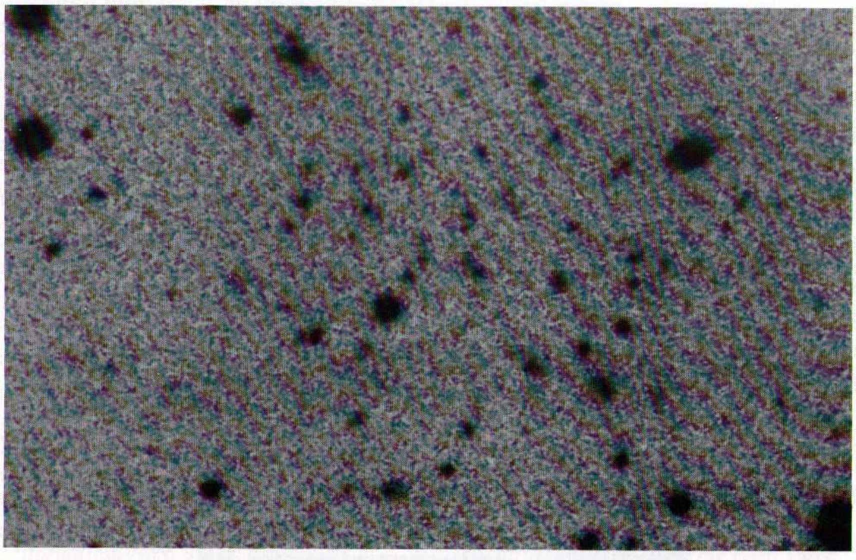
The next two years will be an exciting time in UK astronomy as proposals are formed for what may well prove to be the most significant development since the discussions in the late 1960s and early 1970s which led to the current facilities. It is hoped to involve as much of the astronomical community as possible in these discussions.

Dr A G Game
SERC Swindon Office

Copies of the *Report of the Large Telescope Panel* are available from Dr Game, SERC Swindon Office.



AUTOFIB. UK fibre-optic instrumentation, such as the Automated Fibre Positioning System (AUTOFIB) devised at Durham University and built in conjunction with the Anglo-Australian Observatory, forms the basis of the proposed participation in a wide-field spectroscopic survey facility. AUTOFIB simultaneously gathers the spectra of 50–100 objects in the focal plane of a large telescope.



A distant cluster of galaxies seen at an epoch corresponding to half the present age of the Universe. With current telescopes, only the brightest few galaxies can be studied in any detail; whether these are representative of others in the early Universe remains unclear. The larger aperture and improved image quality of an 8-metre telescope will allow systematic and thorough studies of the evolution and formation of galaxies of various types.

Infrared images from orbit

SERC has a crucial role in the development of ISOCAM, an infrared camera for the European Space Agency's Infrared Space Observatory (ISO) satellite. The satellite, which will be launched by an Ariane 4 rocket in 1993, will carry a 60-cm telescope and a suite of four scientific instruments cooled to a temperature close to absolute zero by liquid helium. ISO will be operated like the highly successful International Ultraviolet Explorer (*SERC Bulletin* Volume 3 No 10, Spring 1988) with the satellite under the supervision of astronomers at the ISO ground station. A large percentage of the available observing time will be open to individual astronomers who will propose observations on the basis of their research interests. The camera is described here by John Davies and Terry Purkins of the Royal Observatory, Edinburgh.

Although comparatively small, the camera will be a versatile scientific instrument which will operate in two overlapping wavelength ranges and provide a wide variety of image scales and spectral resolution. The beam from the telescope will enter the camera and then pass through a wheel which carries a set of polarising filters and an aperture. The beam is then directed, by a Fabry mirror on a second wheel, to one of two channels. The short wavelength channel will use a 32 × 32 element array of indium antimonide detectors and will operate between 3 and 5 microns; the long wavelength channel will use a similar-sized array of silicon:gallium detectors and operate between 5 and 17 microns. These arrays are being developed by French industry for the ISOCAM project. Each channel will be equipped with a wheel carrying four different lenses, each providing a different magnification, and a second wheel equipped with various filters (see figure 1). The camera will be an important part of the ISO mission and is capable of taking infrared images at wavelengths difficult from ground-based telescopes because of emission by the atmosphere. It will revolutionise studies of such diverse astronomical objects as comets, star formation regions and galaxies.

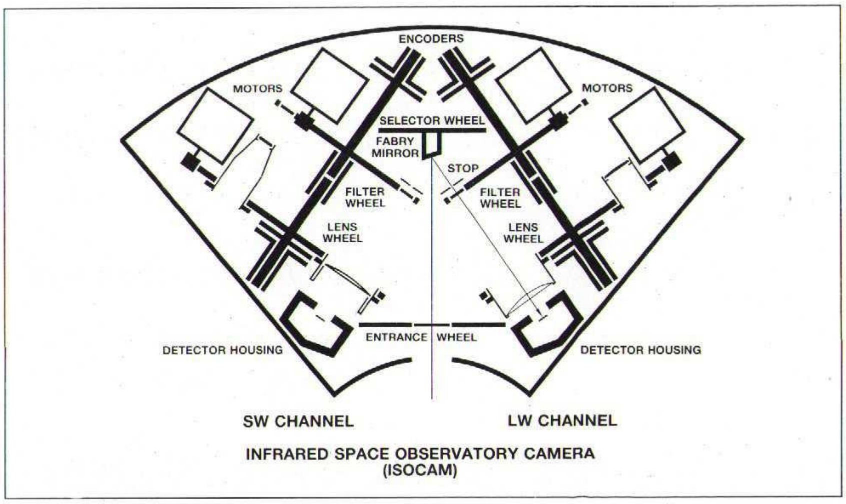


Figure 1: A schematic view of the ISOCAM instrument.

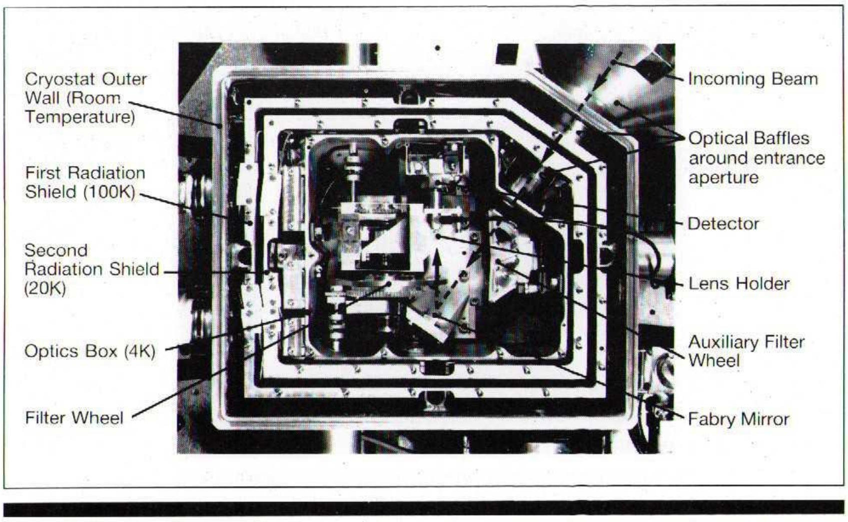


Figure 2: A view of the test facility cryostat showing the complex mechanisms which must operate at temperatures close to absolute zero. (Photo: ROE).

ISOCAM is being built by an international consortium consisting of institutions from France, the UK, Italy and Sweden. SERC, through the Royal Observatory, Edinburgh, and the Rutherford Appleton Laboratory, is responsible for the design, procurement and testing of the lenses, Fabry mirrors and circular variable filters and for the procurement of polarising filters. The Stockholm Observatory of Sweden is providing interference filters under a subcontract to ROE.

Since the optical components are critical to the success of the camera, ROE has worked hard to ensure they will meet the demanding requirements of a space experiment. The optical design was carried out using the 'Code V' computer ray tracing package and the required lenses, which feature complex aspheric surfaces, were diamond-machined from silicon and germanium by Scottish industry under ROE supervision. ROE has also developed a sophisticated facility to test the optics at cryogenic temperatures. The test facility is in two parts: a simulator used to produce an infrared signal which mimics the appearance of a star as seen by the main ISO telescope, and a cryogenically cooled camera simulator in which the optics are tested at four degrees above absolute zero (4 K).

The camera simulator is enclosed by a cryostat which uses two different cooling systems. Most of the heat is carried away by a two-stage closed cycle cooler which lowers parts of the cryostat to a temperature of approximately 20 K. The centre of the simulator is then cooled further by liquid helium. This arrangement economises on the amount of liquid helium required and allows the simulator to be kept cold for almost 24 hours without the need to top up the helium coolant: a vital advantage which allows long periods of automated testing. The cryostat is shown in figure 2.

In operation, the infrared beam enters the cryostat and, after being reflected from the Fabry mirror, passes through a filter before being focused on to a detector by the lens under test. Computer-controlled stepper motors outside the cryostat then move the lens backwards and forwards to preselected positions. During data processing the image of the simulated star can be examined to determine the position of best focus. Filters are tested by using a scanning monochromator which forms part of the telescope simulator.

The test facility is controlled by a mini-computer which can select various lens positions, rotate the filter wheel and so on and record data from each test. The computer can be programmed to carry out, unattended, a number of tests (which might involve different combinations of lens positions, filter selections and wavelengths), releasing manpower for the more difficult tasks of data analysis and interpretation.

One result from the test facility is shown in figure 3. This is a three-dimensional representation of a spot of infrared energy as seen by the camera simulator. The spot is sharply focused, confirming the optical quality of the test facility, and this quality can be appreciated when it is realised that the entire region covered by the figure would fit comfortably on the head of a pin. During tests of the real optics this data will be transferred to a VAX computer and analysed to determine the Point Spread Function of the lens, a numerical quantity which is a measure of the optical performance. ROE, through three co-investigators, also participates in the scientific management of the ISOCAM project, and ROE staff will assist in ISO operations after launch.

Dr J K Davies and
T E Purkins
Royal Observatory, Edinburgh

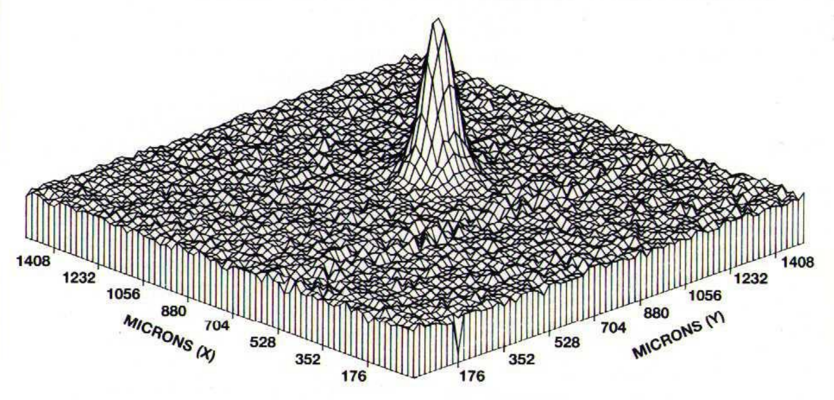


Figure 3: A three-dimensional representation of a spot of light imaged by the test facility.

UK Schmidt Telescope joins AAO

Professor E W J Mitchell CBE FRS, Chairman of SERC (right in picture) and the Chairman of the Anglo-Australian Telescope Board (AATB), Professor Robert Wilson CBE FRS, signing the agreement under which SERC's United Kingdom Schmidt Telescope (UKST) passed into the custody and management of the AATB to be operated on behalf of the UK and Australian astronomical communities. The Australian Consul in Edinburgh, Graeme South, attended the signing on 15 June as the representative of the Australian Government.

The UKST, a 1.2-metre survey telescope, is the finest of its type and is mainly used for taking photographic plates of the night sky. It is located on the same site as the AATB's Anglo-Australian Telescope (AAT) at Siding Spring Observatory, New South Wales. The operation of the Schmidt Telescope will pass from Royal Observatory, Edinburgh (ROE), and become part of the Anglo-Australian Observatory under its Director, Dr Russell Cannon. As part of the agreement, the Australian astronomical community will gain access to 50% of the time of the Schmidt Telescope.

The close association between ROE and the Schmidt Telescope will continue, as the ROE will provide the photographic plate archive and other support facilities for the telescope for both UK and Australian communities. Australian astronomers will have access to the high-speed plate measuring machines located at ROE and Cambridge University, which automatically extract statistical information from plates containing millions of astronomical objects.

The agreement follows an exchange of letters between the Rt Hon Mr Kenneth Baker MP, Secretary of State for Education and Science, and the Hon John Dawkins, Minister of Employment Education and Training, in which the opportunities and benefits of closer collaboration between the UK and Australia, building upon the great success of the AAT, were recognised.

The future plans for the telescope will be determined by the AAT Board, which has equal representation from the UK and Australia.

Coordinated observations of comet Halley

The cooperation of all cometary scientists in the UK during the 1986 appearance of comet Halley was highly successful and most productive, writes Dr Simon Green of Kent University.

Cooperation on Halley was first suggested during the Royal Astronomical Society (RAS) specialist discussion on comets in February 1983. The Comet Halley UK Coordinating Committee (CHUKCC) was immediately formed, to stimulate cooperative observing programmes for comet Halley using the world-class facilities available to UK astronomers; to support the considerable UK involvement in the Giotto and International Cometary Explorer (ICE) spacecraft; and to encourage submission of data to the International Halley Watch archive. The committee, supported by SERC and the RAS, consisted of representatives of the universities, the two Royal Observatories, Rutherford Appleton Laboratory, British Antarctic Survey and British Astronomical Association. Professor Jack Meadows (Leicester University) was its first chairman, with Professor Iwan Williams (Queen Mary College, London) later taking over from him.

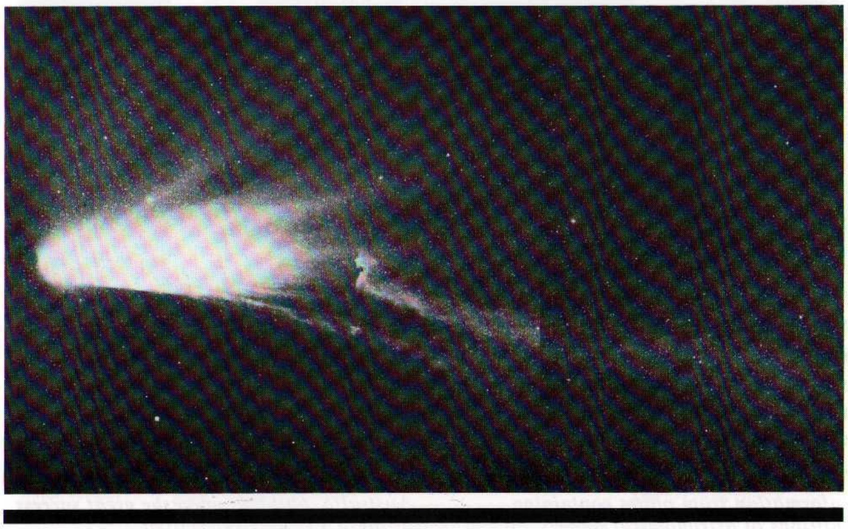
The major UK involvement in space activities centred on the Giotto mission, but a significant part was also played in the ICE (formerly International Sun-Earth Explorer-3) mission to comet Giacobini-Zinner. Activities ranged from instrument design and manufacture, to theoretical support studies and data analysis and interpretation. In addition, British Aerospace plc acted as prime industrial contractor for the entire Giotto spacecraft. Experiments led by UK principal investigators were the Johnstone Plasma Analyser (Dr A D Johnstone, Mullard Space Science Laboratory) and the Dust Impact Detection System (Professor J A M McDonnell, Kent University) on Giotto, and the Energetic Particle Anisotropy Spectrometer (Professor R J Hynds, Imperial College of Science and Technology) on ICE. In addition, several CHUKCC members were co-investigators on the Giotto Halley Multicolour Camera, Particle Impact Analyser and Magnetometer experiments.

Earth-based observations of comets Giacobini-Zinner and Halley were essential to provide a link with their changing global properties and to interpret the detailed spacecraft data. Collaborative UK programmes included astrometry, optical and infrared photometry, large-scale and near-nucleus imaging, spectral and polarimetric imaging, ultraviolet spectroscopy and radio observations.

Although visually disappointing from the UK, the cometary apparition produced spectacular scientific results from the combination of space and Earth based observations. The nucleus, the tiny source of a comet's activity, was directly observed for the first time, as an extremely dark, irregularly shaped body with a precessing axis of rotation and small, highly active areas on the illuminated hemisphere. Water proved to be the most abundant gas emitted into the coma. The composition, mass and spatial distribution of dust grains were measured, with a significant organic component, primitive elemental abundance and complex jet structure. Study of the distribution of ions and the interaction between the comet and the solar wind revealed a bow shock at 1.2×10^6 km, a contact surface at 5000 km, identified with the boundary of a magnetic cavity, and two unexpected structural features. A detailed study of the cold ion tail and magnetotail of comet Giacobini-Zinner was performed.

The success of CHUKCC and the collaborative programmes on comets Halley and Giacobini-Zinner bodes well for the future of cometary science, with the long-term goal of the return of a cometary nucleus sample to Earth now endorsed by the European Space Agency as a cornerstone mission in its Horizon 2000 plan.

Dr Simon Green
Physics Laboratory
Kent University



Comet Halley on 10 March 1986. This composite photograph, produced from two ten-minute exposures taken with the UK 1.2-metre Schmidt Telescope at Siding Spring, New South Wales, Australia, shows a prominent disconnection event in the ion tail caused by irregularities in the interplanetary magnetic field associated with the solar wind, and a number of striations in the dust tail due to outbursts of activity from the nucleus. The image covers an area of sky 3.6 × 1.9 million km at the comet. (Photo: ROE)

The nucleus of comet Halley: a composite of 60 images taken on 14 March 1986 by the Halley Multicolour Camera on the European Space Agency's Giotto spacecraft. The projected dimensions of the nucleus are 14.9 × 8.2 km; North is up and the Sun to the left and behind the image plane. Active areas and jets can be clearly seen, together with a 'crater' (due to outgassing rather than impact) and a 200-metre high 'mountain' beyond the dawn terminator with its summit illuminated. (Photo: Max-Planck-Institut für Aeronomie).

Pie in the sky

I sometimes like to think (writes Dr John Baruch of Leeds University) that the Teaching Company Scheme was initiated with university astronomy groups in mind and I marvel at those inscrutable mandarins at SERC central office: how did they realise that our experience in the Physics Department at Leeds, where we are developing instrumentation for astronomy, has so much in common with the problems faced by industry in generating new products for their markets?

In optical fibres and image processing and many other areas of technology, we have found that industry rarely wants the latest research results or embryonic technology: it wants to incorporate technology that shows every sign of maturing rapidly, or it wants to apply reasonably mature technology innovatively to its own products. This is the same technology brief that we have for generating new instruments in astronomy. This similarity has become increasingly apparent to us as we have broadened our industrial contacts to investigate the possibilities of Teaching Company Programmes. In our experience, it is not only academics developing astronomical instrumentation but also a significant sector of industry who need to work with technology that is sufficiently developed to facilitate accurate costing and time-tabling for effective planning. Industry — especially the smaller firms — also tend to have the problem of being familiar only with the technology relevant to their own programmes. Astronomy groups with their broad sweep of technology interests have a lot to offer.

Our own experiences crystallised as the first Teaching Company Programme for a Physics Department and the first Programme generated from the astrophysics community. Our industrial partner, Digisolve Ltd, is a small local company in the field of image processing. In the world of commerce, image processing is associated with cartoons, pop videos and the fancy television titles where images are shattered into fragments to fly around the screen and reassemble themselves into something completely new.

Many of the techniques used in image processing are also used and developed by astronomers to handle two-dimensional images from telescopes. These digital images are a jumble of stars, galaxies and glowing clouds of gas. Image processing allows us to separate out the different objects and precisely measure the light signal from each. The new instruments now employed in astronomy cover all wavebands from radio to gamma rays, both on the ground and in space. The instruments produce digital images of areas of the sky or spectra of particular objects. The astronomers developed the image processing techniques to look, for example, at the relative strengths of spectral lines against a background of noise or to manipulate dozens of images of the same portion of the sky to look for variable objects or abnormal colour indices.

Digisolve has produced a market leader in the image processing field, the IKON pixel engine. They have entered into a Teaching Company Programme with us to ensure that their next product maintains and extends that lead and to ensure that the company is reinforced financially in the process.

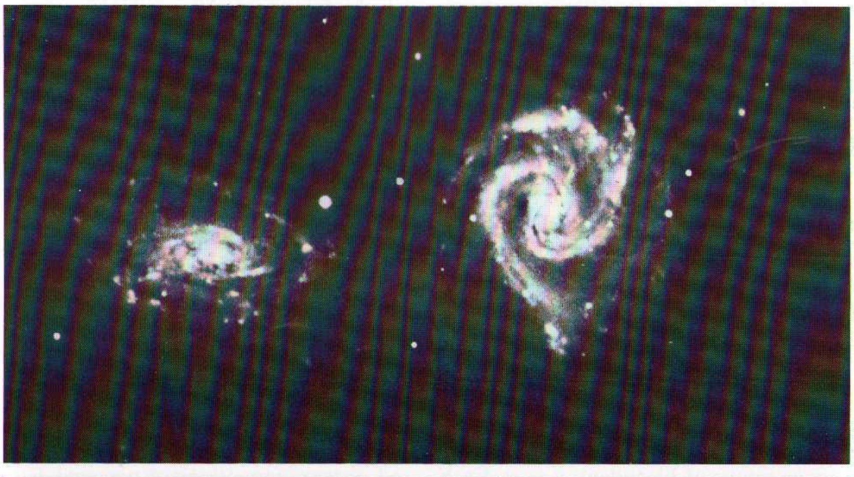
One of our PhD students, Richard Noble, became the first Teaching Company Associate. For his research, he had used the SERC Starlink image processing software and University hardware to determine the age of the oldest known stars in the southern hemisphere — globular cluster Omega Centauri — from images produced by the Anglo-Australian Telescope. His postgraduate experience in image processing, systems operation and networking are all basic skills for Starlink users. As a physics undergraduate he was familiar with the hardware of advanced computing systems and the lower levels of software. He was an ideal candidate for the first Associate with Digisolve.

We have found that the Teaching Company Scheme offers a package which enables industry to build new technology into its products. The industrial partners not only acquire ideas and expertise but new staff who are competent with new technology and opportunities for staff training in modern industrial methods. For our partners the scheme has generated a programme of development which covers all aspects of the successful launch of a new product including the planning, market research, prototyping, production, development and sales. For the University the scheme has extended our experience of the technology reinforcing instrument development. In teaching, the familiarity with the industrial environment enables us to tailor aspects of the courses to the needs of industry. This is particularly important for students where the possibility of a permanent post in astronomy is close to nil. The technologies used in astronomy extend over all the key information technologies of networking, image processing, data banks and computer mail as in Starlink. The telescopes and instruments are using fibre-optics, electro-optics and advanced computing systems, much of which forms the core of projects like EUREKA, ESPRIT and RACE.

Dynamic innovation on the widest technological base is the way forward for instrumentation in UK astronomy. Our funds are insufficient to buy instruments from industry, and so our projects list includes real-time computer modelling of standard engineering products to create inexpensive high-precision instruments, robotics and real-time expert systems.

Our interest in increasing the efficiency of telescopes by multiplexing the observations with fibre-optics is leading us into a second Teaching Company Programme with the possibility of others in the future.

John Baruch
Physics Department
Leeds University



Digisolve equipment helps to analyse images of phenomena such as this pair of interacting galaxies — themselves a symbol of the interaction between university and industry through the Teaching Company Scheme.

Integrated Graduated Development Scheme

Integrated graduate development is a relatively new concept in industrially oriented postgraduate training at the MSc level. The Integrated Graduate Development Scheme (IGDS) was set up by SERC on an experimental basis in 1980. It aims to attract recent graduates to enter key functions in industry; to improve the technical and managerial effectiveness of such graduates through the provision of part-time modular education specifically tailored to participating company needs; to increase the technical knowledge-base of UK industry, thus increasing its competitiveness; and to foster academic/industrial collaboration. Executive responsibility for IGDS currently resides with the Teaching Company Directorate, which can draw on past experience of promoting such collaboration.

Each IGDS programme is set up and run by a partnership of companies and one or more universities and polytechnics. A management committee is formed, which has responsibility for designing and developing short modular sources that are relevant to the particular industrial sector to be served by the programme. Graduates from the participating companies attend a coherent programme of these modular courses, which are interspersed with normal work periods at their parent company. A company-based project is undertaken, with the aid of both an industrial and academic supervisor. On successful completion of the programme, the graduate may qualify for an MSc or Diploma. Throughout the programme, graduates remain employees of their parent companies and the modular nature of the course ensures that there is minimum disruption to career progression.

Current IGDS programmes

Four IGDS programmes are currently in operation:

Warwick University — MSc in Manufacturing Systems Engineering (MSE). This is the largest programme, with an intake of approximately 90 students every year. Each student takes 16 one-week modules over a two and a half year period, together with a company-based project, leading to an MSc. A number of companies are involved, including Rolls-Royce plc, Austin Rover Group, Lucas Industries, Short Brothers and British Aerospace plc. In 1987, a sister programme which has some modules in common with the MSE programme, plus some specialised Design and Technology modules, was developed. The start-up costs were funded by the participating companies, the Department of Trade and Industry (DTI) and Warwick University (using some of the money it received as first prize in the 1986 DTI Industry Year Award, for the development of the MSE programme). This new programme, Design in Systems Production, was officially launched by Lord Young, the Secretary of State for Trade and Industry, in February 1988.

Glasgow University — MSc in Building Services Engineering. This programme has an intake of 20 students a year. Each student takes six two-week modules over two years, together with a company-based project, leading to an MSc. Recently, Glasgow has been increasing the interaction between students and the institution by developing computerised distance-learning modules and providing each student with a personal portable work-station.

Paisley College of Technology — Diploma in Process Plant Manufacture. This programme has an intake of approximately 20 students a year. Each student takes eight modules over one year and undertakes a company-based project, leading to a Diploma. One of the key features of this programme is the European module, where the students visit Process Plant Industries in Europe and gain an insight into European practices and possible trade and collaboration openings.

Kingston Polytechnic — MSc in Information Systems Design. This programme has an intake of about 30 students a year. Each student takes 16 one-week modules over two years, together with a company-based project, leading to an MSc. Like Glasgow, Kingston is developing distance-learning and systems-networking of personal work-stations.

Expansion of IGDS

Following a favourable review of the Scheme in 1986 by the Institute of Manpower Studies, the Department of Education and Science gave approval in 1987 for the expansion of the Scheme from its present level. In November 1987, universities and polytechnics were invited to submit outline proposals for IGDS programmes by 31 January 1988. Approximately 50 proposals were received. From these, half a dozen new programmes are due to start in October and a further group in 1989.

Future funding of IGDS programmes

The expansion of IGDS is being financed by an increase in the Council's budget for IGDS, rising to £1.1 million by 1990–91, and by the provision of additional funds from new co-sponsors.

A key feature of IGDS is that programmes should be market-led. Past experience has shown that good-quality programmes require a high level of commitment, both financial and managerial, from the participating companies. Thus, IGDS funding is seen primarily as a pump-priming exercise, with programmes expected to become self-supporting following a successful start-up period.

During the pump-priming period, up to 75% of central and tuition costs will initially be paid by SERC and other sponsors. Participating companies will provide the remaining 25% of these costs and all the travel and subsistence costs of the graduates. Industrial lecturers, managers' time, use of equipment and so on will also be provided by the companies. Following the pump-priming period (typically three years), company contributions will be rapidly increased until programmes become self-supporting.

Future of IGDS

It is hoped that IGDS will continue to expand, as new programmes join the scheme and established programmes become self-supporting. In this way, the calibre of young graduates and managers within UK industries should be raised, the efficiency and competitiveness of UK industries enhanced and the industrial awareness of academics and collaboration with industry improved.

Dr Lesley Shute
SERC Swindon Office

Regenerating the inner cities with 'space syntax'

Fundamental research funded by SERC has recently played a major role in one of the design proposals for the development of run-down railway goods yards behind King's Cross and St Pancras stations, write Bill Hillier and Alan Penn of University College London. The 35-hectare site (about 120 acres) is the largest inner city development in Europe at the moment with a total redevelopment cost placed at between £3 and £5 billion.

Foster Associates, the leading British architects, called in the Unit for Architectural Studies at University College London with their 'space syntax' computer modelling techniques after local community groups called for any development to be based on rigorous analysis of the area as it stands. The research was carried out in the six-week period before the final designs were presented to British Rail by the developers (a consortium including Rosenhaugh Stanhope and National Freight).

At this scale of design the problems that an architect is asked to resolve defy intuition: What will this place be like, not just to look at, but to use and live in? And it is precisely to help an architect's intuition at this level that the space syntax suite of programs has been developed. The problems the Unit were asked to help solve ran something like this: The site forms a large hole in the urban fabric of north London; any intervention is bound to make drastic changes to patterns of pedestrian use and movement, not only within the site itself, but also in the surrounding streets and housing estates. Past experience suggests that an essential component of successful and safe urban design lies in making sure that urban space is never empty of people — some of the major social disasters of the recent past lie in freezing out natural patterns of movement and leaving much space empty for most of the time. In the same way, too many people in the wrong places could cause problems. In a development of this scale it was essential to make sure that the patterns of use it generated would not conflict with the privacy of neighbouring residential streets, but would help to restore natural patterns of use to some of north London's most run-down areas.

The way that the UCL team is attacking this problem is by constructing a computer model of the area surrounding the site to a radius of about 1.5 kilometres. This model, which represents all space that can be used for pedestrian movement, consists of a series of individual spaces — recovered by a new suite of elegant pattern recognition algorithms from the ground plan of the area — and their connections to other spaces. The whole of a complex plan can thus be represented as a connectivity matrix and measures relating each space to all others in the network can be derived.

The team's research over the last few years, supported by the Building Subcommittee, has been mainly towards using these techniques of description and analysis to investigate patterns of use and movement by people in urban areas and inside buildings. The research has found one measure — called 'integration' — that consistently outperforms all others in predicting real patterns of use. Integration measures the average complexity of routes from any space to all other spaces in the network. Figure 1 shows the scattergram of integration (vertically) with numbers of moving adults per 100 metres (on a log scale horizontally) in some 239 observed sections of street and estate surrounding the King's Cross site. Considering that the observations of more than 25,000 people in about 500 miles of streets were carried out at different times of day and in all weather conditions, the correlation is remarkably good and provides strong confirmation of previous findings of this sort.

The importance of these findings for the designers and developers is that they give us at least a 'weather forecasting' basis on which the effects of new designs on patterns of use can be assessed. By looking in detail at the way the pattern of integration values in the area change when the proposed new development is included in the computer model, we can forecast its likely effects on surrounding communities: will the resulting pattern of use tend to integrate the whole development into a piece of continuously used urban fabric, or will it effectively segregate it into a modern ghetto? For the developer, more detailed questions can begin to be answered: are the proposed shopping areas located to take advantage of the natural passing trade? Will sufficient levels of use and movement be attained in the housing areas to keep them safe?

In the future, detailed and subtle design at the urban level, to regenerate run-down areas and avoid the disastrous planning of the recent past, may depend on this type of high-powered computer modelling. Figure 2 shows the large area of north London studied by the Unit and the design layout for the site with its oval park and network of streets designed using the 'space syntax' techniques. The techniques however have a far wider application in any discipline in which spatial layout is of interest. They allow the study of archaeological data to retrieve likely patterns of use from ground plans, and the detailed study of patterns of use in today's large and complex buildings: the team is currently studying office buildings and has recently secured funding from the Department of Education and Science and the Nuffield Foundation to study research laboratories to try and detect the effect of building design on patterns of use by workers. First findings suggest that the spatial layout of buildings may be a major factor dictating the degree of interaction among different groups in an organisation. The scope for 'intelligent' design is obvious.

W R G Hillier and A R Penn
Bartlett School of Architecture
University College London

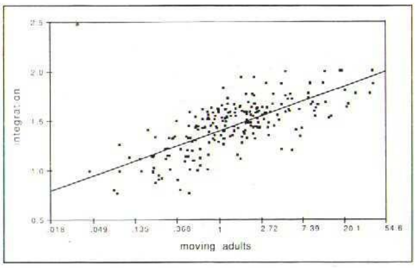


Figure 1: Relation between moving adults and spatial integration (r = .744).

Figure 2: Layout for the north London site, showing network of streets and oval park, designed using 'space syntax' techniques.

Boost for Joint Academic Network

The UK academic community's computer network infrastructure is currently undergoing a major performance upgrade and, as part of this initiative, a significant enhancement of JANET (the Joint Academic NETwork) has recently entered service.

The principal reason for the network performance upgrade is to support the demanding networking requirements of the supercomputer users who require access to the centrally funded supercomputing facilities at London and Manchester Universities and at the Atlas Computer Centre at Rutherford Appleton Laboratory. This includes the rapid transmission of large amounts of data and advanced styles of access based on the use of workstations. The trunk connections which link four of JANET's eight switching centres — those at London, Manchester, the Atlas Centre and the Daresbury Laboratory — have been upgraded from 48 kilobits per second (kbps) to 256 kbps or 512 kbps.

The four sites are connected in a box configuration by British Telecom Megastream circuits, and GDC multiplexers at each site are used to subdivide the Megastream bandwidth into 256 kbps or 512 kbps channels which provide a fully interconnected configuration with fallback channels which are configured automatically if one of the Megastream connections fails.

A complementary programme of upgrading the site links and local area networks (LANs) is in progress with the intention that all large sites will be connected at 48 kbps or 64 kbps, and smaller sites at 9.6 kbps. The upgrade was introduced with the minimum disruption of service.

At present JANET handles about 1000 Mbytes of traffic each day, equivalent to about half a million sides of A4 typescript, and the traffic is doubling each year. This makes JANET one of the most heavily used academic networks in the world and, combined with the fact that it interlinks computers from some 25 different manufacturers, provides the UK academic community with a unique facility to support its research, teaching and administrative activities.

The JANET network links more than 100 sites, including all the universities, the majority of the polytechnics and many research council sites, as well as institutions such as the British, Welsh and Scottish national libraries. At most of the sites, one or more LANs are connected to JANET providing wider access for computers, workstations and terminals connected to the LANs, enabling them to communicate with both on-site and off-site computers and networked services.

A total of more than 1000 computers and 20,000 terminals have access to the network. All computer systems, regardless of type or operating system, use a standard set of non-proprietary protocols called the Coloured Books (soon to be replaced by equivalent ISO standards) and can thus interwork with each other. The Coloured Book protocol architecture has been developed in the UK and supports interactive terminal connections, file transfer, electronic mail and job transfer over interconnected LANs and wide area networks (WANs). The infrastructure is recognised worldwide as a pioneering initiative in open systems communication.

Dr R Cooper
Director of Networking
Computer Board for Universities and Research Councils

IBM supercomputing initiative

In February this year, the Council approved the replacement of two ageing IBM-compatible computers at the Rutherford Appleton Laboratory by a new IBM 3090-200E computer. The main roles of the computer are to meet the continuing needs of mainframe computing of the Boards and other SERC users and to front-end the Joint Research Council's Cray X-MP/48 supercomputer.

The new computer has about the same aggregate conventional computing power as the two older machines but it has a new feature, known as a Vector Facility, which can boost the power of certain types of work. The size of the boost depends on the exact nature of the work; typically a factor two to three might be expected, or more in some circumstances.

The 3090-200E was delivered to the Atlas Centre at RAL in April and came into service within a few days.

In May there was an announcement by IBM that the Atlas Centre had been selected to be a participant in the Company's European Supercomputing Initiative. This initiative was launched in November 1987 and its objective is to establish a number of IBM supercomputing facilities in Europe to further the use of supercomputing in the academic sector. Each facility will have an IBM 3090-600E with six Vector Facilities. The supercomputers will be linked to each other and to an equivalent facility in the USA at the Theory Center at Cornell University. The facilities will work with each other, with IBM, and with industrial partners where appropriate to look at potential new supercomputing applications, parallel processing and visualisation techniques. As well as contributing towards equipment, IBM will provide expertise to work in collaboration with staff at the supercomputer facilities on projects of mutual benefit.

It is expected that the 3090-200E at the Atlas Centre will be upgraded to a 3090-600E with six Vector Facilities by Summer 1989. Such a machine will have scalar power greater than the Cray X-MP/48 and peak vector performance of about 70% of the Cray. It will have huge memory facilities which could open up new avenues of research that have been difficult to attempt in the past. It is therefore expected that the enhanced computer will provide a valuable complementary facility to the Cray for the UK academic community. Further information on the services that will be available and the conditions under which they may be used will be announced as the details are settled.

Dr B W Davies
SERC Director of Computing

Fellowships 1988

Allocation, applications and awards in 1988 for the various Fellowship Schemes

Type	Allocation	Applications	Awards
Senior	2	23	2
Advanced	18	68	18
SERC/NATO Postdoctoral	65	172	62*
RS/SERC Industrial	10	12	10
IT Fellowships	–	27	18†

* 31 of the postdoctoral fellowships 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.

† four at senior level, four advanced and ten postdoctoral.

Industrial fellowships

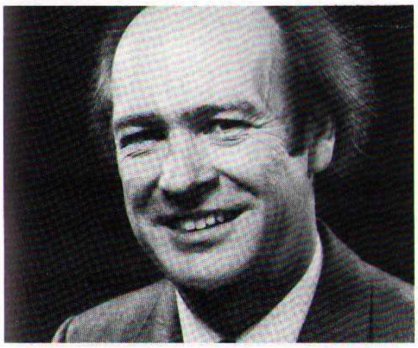
For 1988, Royal Society/SERC Industrial Fellowships have been awarded to:

Dr K Baines (Aston University) to GKN Technology Ltd;
Dr S C J Garth (Texas Instruments Ltd) to Strathclyde University;
C Gray (Reading University) to Rosehaugh Stanhope plc;
Dr C A Heaton (Liverpool Polytechnic) to ICI Chemicals and Polymer Group;
Dr D Holmes (Liverpool Polytechnic) to Mullard Southport;
Professor L F Lind (Essex University) to British Telecom;
Dr B T Meggitt (SIRA Ltd) to King's College, London.
Dr J L Nicklin (Birkbeck College) to ICI Agrochemicals;
Dr G J Rees (Plessey Research) to Oxford University;
J H Rieger (GEC) to Warwick University.

Senior fellowships

Senior Fellowships have been awarded to **Professor J M T Thompson** of University College London and **Professor P Whittle** of Cambridge University.

Professor Michael Thompson graduated from Cambridge University, where he was awarded a PhD in 1962 and an ScD in 1977. He joined the Department of Civil Engineering at University College London as a lecturer in 1964, and was appointed Professor in 1977. He has held visiting appointments at the Université Libre de Bruxelles and the Brookhaven National Laboratory in New York. He was elected a Fellow of the Royal Society in 1985.



Professor Michael Thompson

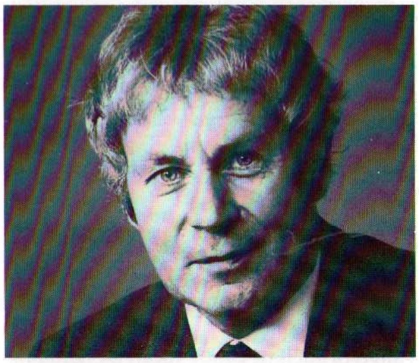
Professor Thompson has a distinguished record of research in nonlinear dynamical systems, and is a world leader in the field. His four books range from the elastic stability of thin-walled structures to chaotic dynamics of mechanical oscillators. These are areas of vital concern to modern engineering, involving the application of new mathematics to problems of great relevance to practising engineers in many fields including civil and mechanical engineering, aerospace and marine technology.

During his five year fellowship he will study the global dynamics of carefully chosen archetypal models of nonlinear engineering systems using novel phase-space techniques of both interactive and automated computing. The results will offer guidance to industrial designers and analysts on new phenomena and on unexpected and potentially dangerous modes of instability and failure.

Professor Thompson's links with the London Centre for Marine Technology and his collaboration with engineering firms should provide a clear path to channel the results of his research back into industry. His strong links with research groups in the USA and Japan will ensure wide international recognition of the progress made.

Professor Peter Whittle graduated from the University of New Zealand and took his PhD at the University of Uppsala in Sweden. After working in New Zealand and lecturing in Mathematics at Cambridge University, he became Professor of Mathematical Statistics at Manchester University in 1961. He took up his present appointment as Churchill Professor of the Mathematics of Operational Research at Cambridge in 1967 and was Director of the Cambridge Statistical Laboratory from 1973–1986. He was elected a fellow of the Royal Society in 1978.

Professor Whittle is one of the world's leading stochastic mathematicians, with interests covering a number of fundamental areas of concern to applied probabilists, statisticians, control engineers, physical scientists and operational researchers. In the field of time series analysis, he was one of the first to provide a rigorous treatment of inference problems and to make systematic use of linear space ideas, and he was an early contributor to the study of spatial processes and to the unified treatment of interpolation and data smoothing problems. He has contributed to static and dynamic optimisation theory and to statistical theory in the areas of sequential analysis and design of experiments.



Professor Peter Whittle

During his three-year fellowship he will be working on the provision of a mathematical setting within which the behaviour of complex neural and processing networks can be studied. This is in an area of great scientific importance to the development of computers which can operate in a truly intelligent and damage-tolerant fashion.

Wearing four hats

The Royal Society/SERC Industrial Fellowship Scheme is intended to enhance communication on science and technology between industry and the academic community and is designed to suit a variety of needs. University lecturer, wife, new mother — and Industrial Fellow, Dr Janet Efstathiou, formerly of Queen Mary College, London, gives a personal account of her experiences of working with a small company, Analysys Ltd, in Cambridge.

Dr Janet Efstathiou

Reaching the critical age of 30 meant that many unpredictable changes were about to happen in my life. Fortunately, it also meant that I would be eligible to apply for a Royal Society/SERC Industrial Fellowship.

By the end of May 1986, I had been lecturing in the Department of Electrical and Electronic Engineering at Queen Mary College for four years. I was living in Cambridge, where my husband worked, and commuting daily to London . . . and I was about to start maternity leave for my first child. I had been happy at QMC, but felt in need of a change. There was a heavy load of teaching and administration, leaving little time for the research work and reading that I needed to do, so I had been thinking about taking a sabbatical for some time. Also, before the baby was born, I could not be certain how I would feel about continuing my career afterwards. Would I come over all domestic, would the child be difficult and demanding? Anyway, I knew I did not want to commute any more, for a while at least. A period of leave would give me a chance to review my future and decide what to do next. And so, while on maternity leave, I applied for a RS/SERC Industrial Fellowship and was delighted to be awarded one.

The choice of company was easy. I had done a little consultancy work for a small telecommunications company, Analysys, located in Cambridge. The company had started on the Cambridge Science Park a few years before and was growing quickly. The founder and managing director, David Cleevely, used to commute too and we had met when his briefcase had spilled my coffee over his clothes on the train. The company began by providing economic analyses of the telecommunication market to organisations in the UK and Europe. Recently, they had begun to extend the range of facilities they offered clients by expanding their software group and developing packages for the clients to use. It was in this area that I hoped to contribute.

What I stood to gain from the Fellowship was more knowledge about telecommunications itself and the application of my knowledge and experience in this area. Also, I hoped to learn more about how a small company behaves in the market. The project title was *The application of intelligent knowledge-based techniques to telecommunications.* Artificial intelligence and intelligent knowledge-based systems (IKBS) were my main areas of research at QMC, but I had also been teaching software engineering, algorithms and basic programming for some time.

One of the first things I learnt at Analysys was that, in a small market-driven company, it is difficult to plan more than a few months ahead. Of the three areas where I had expected to spend my time, two saw appropriate effort and the third was only pursued indirectly by my research students at QMC. However, three or four different projects emerged as time went on.

The most substantial of these was in collaboration with a member of Cambridge University's Department of Pure Mathematics and Mathematical Statistics, Dr Frank Kelly. The project began with David Cleevely asking me to look into Analysys' programming language requirements. Their main software package had been written in Pascal, but the language was imposing constraints on the flexibility of use of the package. Tailoring the package to the needs of each client was becoming time-consuming. The package was to be upgraded for sale to clients, so were there any useful languages that could be used in the re-write to satisfy these needs?

The package had originally been designed using an object-oriented style with strictly hierarchical data structures This had not translated easily into Pascal. A new, low-cost object-oriented language, Actor, had come on the market and so I was given the job of trying it out.

At the same time, Frank Kelly had been working on how to allocate circuits on telecommunication networks and calculate the probability that calls between nodes of the network would be blocked because all the available circuits were busy. We decided that I should prototype a new version of his software in Actor. This exercise would test Actor as a usable language and yield a version of the program that could be demonstrated to test the market.

It had been a long time since I had been able to concentrate on a large program and here was the chance to try out a new language with a programming paradigm of which I had no experience but was keen to learn. There was the fun of designing and demonstrating a new user interface, and the intellectual kick of tidying up the algorithms and data structures presented to me by the mathematicians. The Fellowship would have been worth it for that alone.

Meanwhile, at the personal level, things progressed. My daughter was spending her days happily with a childminder. Before taking up the Fellowship, I had applied for a lectureship at Cambridge University in artificial intelligence and had been offered it a few days before starting work at Analysys. Then a few months later, I fell pregnant again. Life was getting complex indeed. I was wearing four hats, as a Fellow at Analysys, as an entering lecturer at Cambridge, as a departing lecturer at QMC and as a wife and mother. I gave in and bought a Filofax.

At the end of February 1988, I resigned the Fellowship after 10 months and resigned from QMC on the same day. I took up the lectureship at Cambridge and immediately began my second spell of maternity leave. My son was born at the end of March, and I returned to full-time work at the end of June.

Overall, my impression of the Fellowship scheme is very positive. I broadened my technical expertise in the area of telecommunications in a way that would have been impossible given the day-to-day pressures and interruptions of normal academic life. I learnt a great deal about the sociology of a small company and how their size and proximity to the market exaggerates the impact of a few individuals.

For anyone taking up such a Fellowship, it is important to realise that at the start it may not be possible to predict how the Fellow will fit in and what niche he or she will fill. I would advise, therefore, that the Fellow and the host organisation agree at the beginning some guidelines on the Fellow's role and how far the

Some new publications from SERC

Cooperative research grants
Copies of the *SERC Cooperative Research Grants Scheme* are available from Geoff Strange, SERC Swindon Office, ext 2405*.

Astronomy
Copies of *The ground-based plan: a plan for astronomy and planetary science research by ground-based techniques* are available from Paul Cass, SERC Swindon Office, ext 2266*.

Science
Copies of *Low dimensional structures and devices*, an account of achievements and plans in this field of research, are available from Jacqui Williams, SERC Swindon Office, ext 2435*.

Copies of the *Synchrotron Radiation Facility Committee annual report 1986–87* are available from Carol Simmons, SERC Swindon Office, ext 2217*.

Engineering
Copies of *Strategy of the Environment Committee* and the *Environment Committee Information Pack* are both available from Steve Cann, SERC Swindon Office, ext 2493*.

Copies of *Materials Committee reports on projects, August 1987* are available from Joe McIlherron, SERC Swindon Office, ext 2277*.

Three new publications have been issued by the Electro Mechanical Engineering Committee. They are: the Committee's *Information Pack, Grants current at 1 August 1988* and *Reports on projects, August 1988.* All are available from Natalie Barnett, SERC Swindon Office, ext 2200*.

ACME Directorate
Copies of the following are available from Terry Keaney, SERC Swindon Office, ext 2106*: *ACME annual report 1986–87; Research project status reports, June 1988;* and *1988 Research conference proceedings, Nottingham University.*

Biotechnology Directorate
Copies of the following are available from Sue Cooper, SERC Swindon Office, ext 2495*: *The Biotechnology Directorate of the SERC: report and evaluation of achievements 1981–1987; SERC biotechnology support 1980–2000* (report and leaflet pack); *The Protein Engineering Club: the first two years;* and *Biobulletin* (the Directorate's newsletter).

Polymer Engineering Group
Polymer research projects in the UK is a consolidated analysis of plastic, rubber, polymeric composite and structural adhesive research projects in the UK funded by SERC, DTI, MoD, the European Commission and AIRTO. It is published by the Polymer Engineering Group, 5 Belgrave Square, London SW1 8PD (telephone 01–235 7286), price £50 a copy.

* *See page 2: Swindon Office telephone*

Wearing four hats: continued

Fellow will participate in the company, whether as a detached visitor, as an ordinary employee or somewhere in between the two. This agreed role should be reviewed from time to time to see whether everyone's expectations are being met, in much to same way as many organisations give their employees regular job reviews.

I would strongly recommend the Industrial Fellowship scheme to other people, although it is most likely to appeal to those who want to bring about a change in their lives and so do not feel it a career risk to leave their home department for a while. For me, it was a godsend, giving me the chance to review my career, maintain contacts with my research students, ease gently in to my new job at Cambridge and gain experience in technical areas that were new to me or a bit rusty. I would like to think that Analysys gained something too. Few Industrial Fellowships after all can have ended with the managing director giving the departing Fellow a peck on the cheek.

Dr J Efstathiou
Computer Laboratory
Cambridge University

Holmes-Hines support for conference

A practical session in the undergraduate laboratories at University College London. A three-day residential Sixth Form Conference held in July at UCL's Department of Physics and Astronomy was attended by 120 girls from all over England and Wales. The conference received a grant of £750 from the Holmes-Hines Memorial Fund, which is administered by SERC.

The 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.

Fission fragments in a spin

Research on heavy-ion reactions is a lively feature of the experimental programme at Daresbury and other laboratories worldwide. Recent work done at the Nuclear Structure Facility shows great promise and anticipates future progress when the new post-accelerator comes into use. In this article, Dr John Durell of Manchester University explains why and how heavy-ion reactions are studied.

Nuclear fragments resulting from fission induced by heavy-ion reactions are rich in neutrons and are emitted in a state of high excitation ('hot'). This phenomenon is being used by a group from Manchester University working at Daresbury Laboratory to obtain information on the shapes and properties of hot nuclei which are inaccessible by other nuclear processes.

The physics of fission is now well understood. At a basic level the splitting of a single, heavy nucleus into two lighter nuclei can be explained by considering the nucleus as a charged liquid drop. As the drop changes from spherical to dumb-bell shaped, competition between Coulomb (electrostatic) and surface energies leads to the formation of an energy barrier to fission at the 'saddle point' (figure 1). It is this barrier which makes spontaneous fission half-lives so long, explains why neutrons must be used to give a fast reaction rate in fission reactors and why the saddle point is so important in determining the subsequent properties of the fissioning system.

Heavy-ion reactions can however produce fissioning systems at excitation energies much higher than the theoretical fission barrier. The path to fission is then dominated by the nuclear properties at scission (the later point at which the fission fragments separate). Can observed features be related to the properties of the fission fragments at or near scission? If so, then the angular momentum of the fission fragments would depend largely on their excitation energy and shape, and measuring it would tell us a lot about the shapes of 'hot' nuclei. This would complement recent studies of gamma-rays emitted from heavy-ion fusion-evaporation reactions which have already provided a wealth of information about the shapes of 'cold' nuclei.

How can we determine the angular momentum of the fission fragments? After their formation, the fragments rapidly emit neutrons, which cool them but do not carry away much angular momentum. The remaining energy and most of the angular momentum are then carried away by gamma-rays and, by measuring in some detail the gamma-ray decay pathways in a particular fragment, its average angular momentum can be determined. An extra bonus is that the fission process produces neutron-rich nuclei whose structure can be studied by means of their gamma-ray spectroscopy.

During the Summer of 1987, a unique gamma-ray detection array was assembled at Daresbury, in collaboration with several other European laboratories. This ESSA30 (European Suppressed Spectrometer Array) comprised 30 high resolution gamma-ray detectors. It was used to study gamma-rays emitted from the fission fragments produced by the fusion of the nuclei oxygen-18 (^{18}O) and thorium-232 (^{232}Th). Using coincidence techniques, the gamma-ray decay schemes of many fragments ranging from krypton-84 (^{84}Kr) to neodymium-148 (^{148}Nd) were established. The intensities of the gamma-rays provide information on the population of excited states of different angular momentum which can be used to determine the average angular momentum of the fission fragments.

Figure 2 shows the average angular momentum of fission fragments determined in the Daresbury experiment, together with data from an earlier experiment performed by the Manchester group using the fluorine-19 + gold-197 (^{19}F + ^{197}Au) reaction. These results show that the average angular momenta depend on the fission fragment mass to the power 5/6 — just what would be expected if angular momentum was distributed between the fragments according to their excitation energy at the scission point. Any variations from the average trend can be interpreted in terms of nuclear shapes. Interestingly, those fragments with larger-than-average angular momentum are known to be nuclei which have deformed shapes in their ground-state configuration.

These experiments provide support for the idea that, for heavy-ion induced fission, it is the properties of the fragments at scission which determine some observable features. More detailed analysis and understanding will, it is hoped, lead to the exciting possibility of measuring the shapes of hot nuclei.

Dr John Durell
Manchester University.

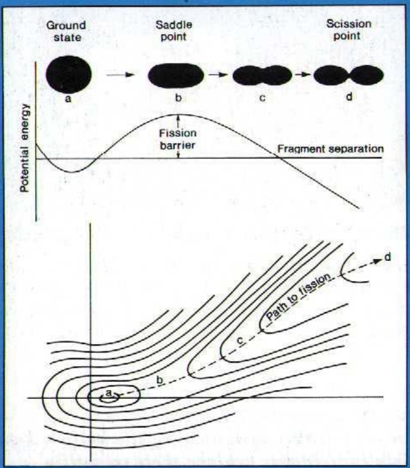


Figure 1: A simple picture of fission (above) showing the nuclear shapes at points on the path to fission, and (below) the more complex nature of the fission path.

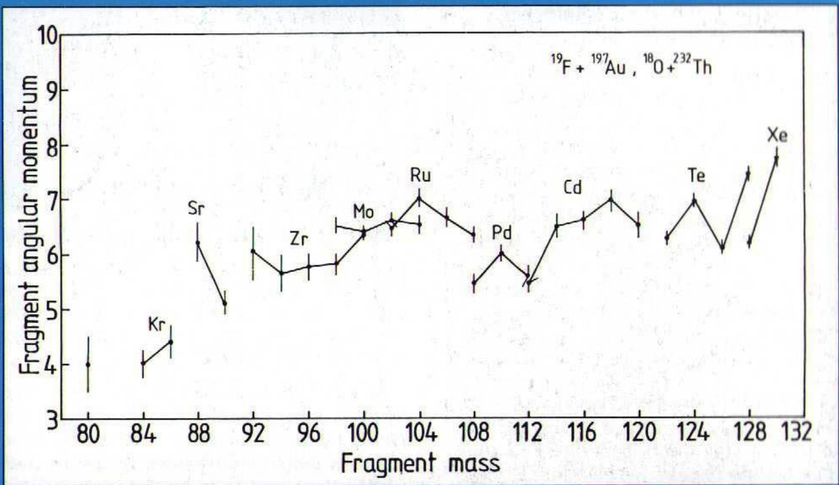


Figure 2: Variation of fission-fragment angular momentum with mass. An increase in angular momentum with mass is expected if momentum is determined by the internal energy of the fragments. Are the variations related to fragment shapes?