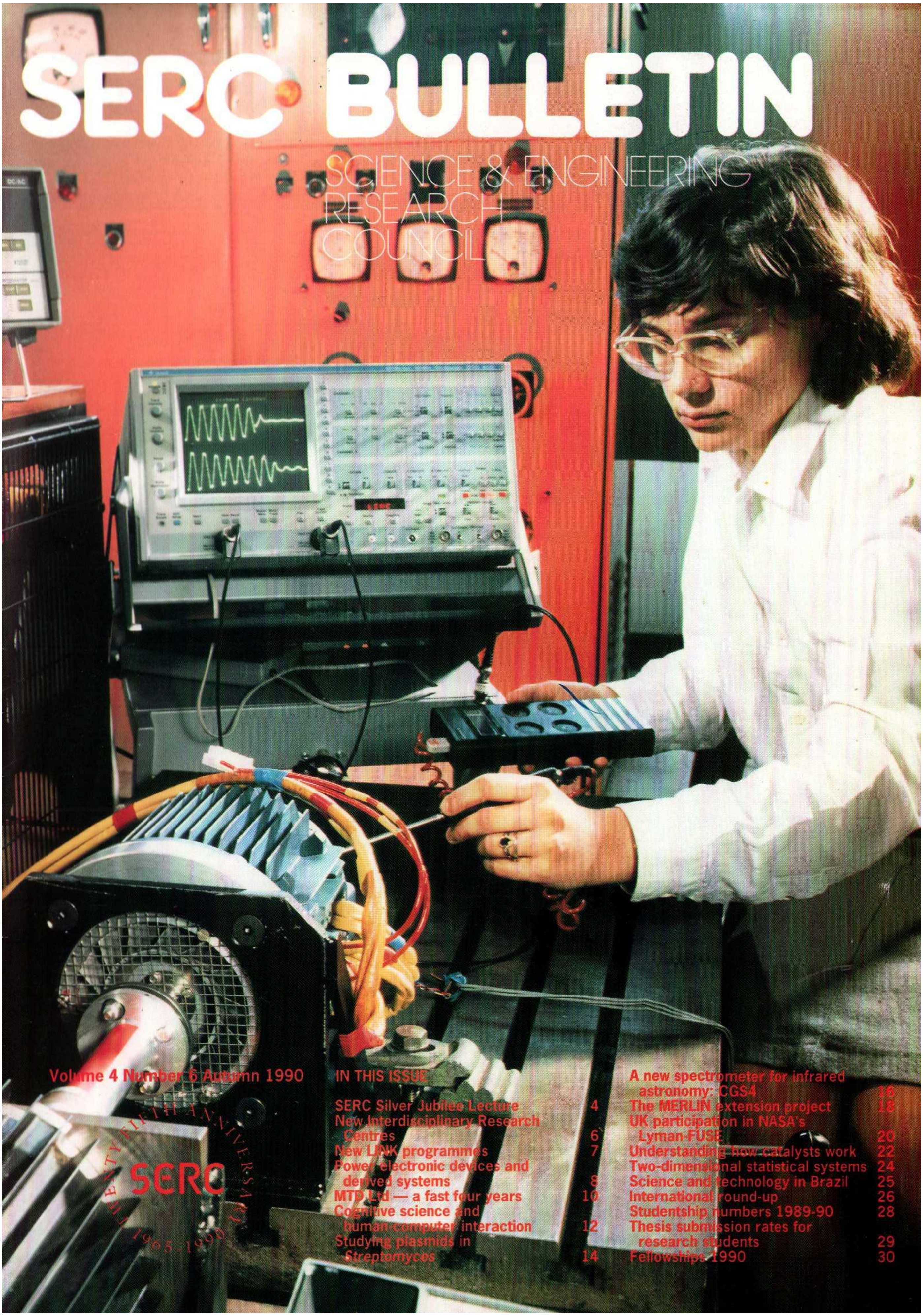

SERC BULLETIN

SCIENCE & ENGINEERING RESEARCH COUNCIL

Volume 4 Number 6 Autumn 1990

IN THIS ISSUE

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

Establishments of the Science and Engineering Research Council

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

SERC London Office
22 Henrietta Street, London WC2E 8NA
Telephone 071-836 6676

Rutherford Appleton Laboratory (RAL)
Chilton, Didcot, Oxon OX11 0QX
Director Dr P R Williams.
Telephone Abingdon (0235) 821900

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

Royal Greenwich Observatory (RGO)
Madingley Road, Cambridge CB3 0EZ
Director Professor A Boksenberg FRS
Telephone Cambridge (0223) 374000

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

UK Research Councils' European Office
BP 2, Rue de la Loi 83
1040 Brussels, Belgium
Telephone 010-322-230-5275
Telex 21525 ENVRE B
Fax 010-322-230-4803

SERC *Annual Report* (available from PRU, SERC Swindon Office) 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.

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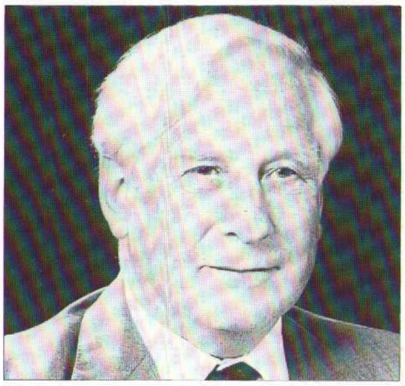
Front cover picture

Mary Tolikas, a first-class Honours graduate from Glasgow University, tests an electronically controlled motor designed in collaboration between Lucas Automotive and the University's industrial SPEED consortium. SPEED works closely with SERC on a range of projects in the motion control industry and power electronics.
See page 8.

A welcome to our new Chairman Sir Mark Richmond



Sir Mark Richmond

Professor Sir Mark Richmond FRS took up his appointment as Chairman of SERC on 1 October 1990, on the retirement of Professor Sir William Mitchell. He was Vice Chancellor of Manchester University from 1981 until then, and Chairman of the Committee of Vice Chancellors and Principals from 1987 to 1989.

Mark Richmond was born in Sydney, Australia, in February 1931 but moved to the UK at the age of 18 months. Following schools in Surrey and degrees at Cambridge (his PhD in 1958 was taken in Microbial Biochemistry), his first job was as a research scientist at the Medical Research Council's National Institute for Medical Research, Mill Hill. He was appointed senior lecturer in the Department of Molecular Biology at Edinburgh University in 1965, setting up the new department.

In 1968 Professor Richmond became head of the Department of Bacteriology at Bristol University. His varied activities while at Bristol (apart from his research programme) included being head of the University Safety Group, union negotiations, consultancy work for the pharmaceutical industry, and involvement in government committees on genetic engineering.

During his Vice Chancellorship at Manchester, Sir Mark also served on the Council for SERC, the Jarrett Committee for University Efficiency and as Chairman of the Food Safety Committee, which is shortly to product its second report. Among his international distinctions, he was elected a Fellow of the Royal Society in 1980 and honoured with a knighthood in 1986.

Of his appointment to the Chairmanship of SERC, Sir Mark said:

"We are in times of change and there are enormous challenges to overcome if Britain is to remain at the forefront of international research. The next five years will certainly be interesting and I very much look forward to the task."

New Council members

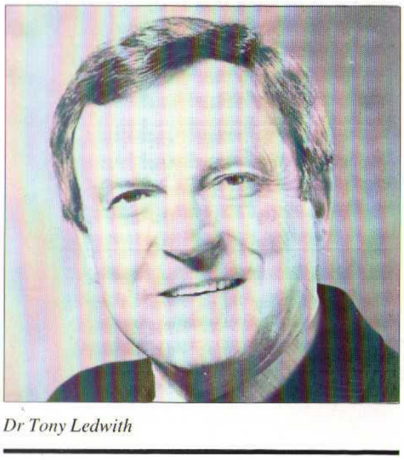
Secretary of State for Education and Science John MacGregor appointed **Dr Tony Ledwith**, Director of Research, Pilkington plc, to the Science and Engineering Research Council in February.

Dr Ledwith has been a member of SERC's Science and Engineering Boards, is currently a member of the Materials Science and Engineering Commission and Chairman of the Molecular Electronics Committee.

Tony Ledwith was appointed to the academic staff at Liverpool University in 1958 and, when recruited by Pilkington in 1983, held the Campbell Brown Chair of Industrial Chemistry and was Dean of the Faculty of Science.

STOP PRESS:

Five new Council members have just been announced: **Professor R E Hester** (York University), **Dr N W Horne** (Peat Marwick, McLintock), **Dr J S Mason** (Glasgow College of Technology), **Dr J O Thomas** (Cambridge University) and **Professor D J Wallace** (Edinburgh University).



Dr Tony Ledwith

Council commentary March – July 1990

Project approvals

Approval was given by the Council during this period for the following:

- Participation in the European Space Agency's High Throughput X-ray Spectroscopy mission (XMM) — the second cornerstone of ESA's Horizon 2000 programme — to be launched in 1998. The estimated cost is £11 million.
- Provision of a second Along Track Scanning Radiometer (ATSR-2) for ESA's second Earth resources satellite mission ERS-2. Cost to SERC will be about £8 million with further contributions from the Department of Trade and Industry and other partners in ESA's science programme.
- UK contribution of £5.5 million towards the capital costs of building a gravitational wave detector as a German-British collaborative project involving the Glasgow University, University of Wales College of Cardiff, Rutherford Appleton Laboratory and four groups from Garching, Hanover and Braunschweig.

Plasma physics and fusion

Dr Carol Jordan FRS presented the report of the Council's Plasma Physics and Fusion Panel that she had chaired to advise on SERC's future support of research into plasma physics and related subjects. The fusion programme has fostered and influenced areas of research in basic plasma physics in universities that the Panel felt needed to be continued and consolidated so as to ensure an adequate science base and training dimension for the future.

Review of ACME Directorate

Philip Warner, formerly Director of Corporate Engineering at NEI plc, presented to the Council the report of a review committee on SERC's Applications of Computers to Manufacturing Engineering (ACME) Directorate. Among its recommendations were:

- That the Directorate should continue at least for another five years;
- Because of the important interfaces between ACME and the Electro Mechanical Engineering Committee (EMEC), there should be arrangements to make collaboration smoother;
- That ACME should create a strategy and also a long-term policy for publicising its activities;
- That a consultant should be appointed to take on its education and training strategies.

Neutron Review Panel

The Neutron Review Panel, chaired by Professor P H Fowler FRS of the Department of Physics, Bristol University, reviewed the current UK programme and future needs of research using neutron beams at the Institut Laue-Langevin (ILL) and the Isis spallation neutron source at RAL. The report was presented by Science Board Chairman Professor Brian Fender.

The Council agreed that the UK should seek to continue its membership of ILL beyond 1992 on equal terms with France and Germany, while encouraging new contributing member states.

The report recommended that Isis should raise its reliability from 70% to at least 90%; that overseas income should be increased; and that industrial participation in both ILL and Isis should also be increased.

The 8-metre telescope

In July, the Council discussed the two options before it — a Spanish-UK partnership to build a telescope on La Palma, and a US-Canada-UK partnership to build two 8-metre telescopes, one on Mauna Kea, Hawaii and the other in Chile — and agreed to continue negotiations with both potential partners.

Major new grants

Engineering
Sheffield University: £1.5 million for a research programme on structural integrity covering materials (metals, life evaluation, fracture, corrosion, fatigue and stress).

A Scottish Universities Consortium (Heriot-Watt, Glasgow, Edinburgh, St Andrews and Strathclyde): £1.2 million for optoelectronic research ranging from work on high-quality optical devices to lasers and holographic optics.

Information Technology
Edinburgh University: an interim renewal of support of £1.3 million for the Microfabrication Facility pending a review of all microfabrication facilities.

Particle physics
Rolling grants of more than £1 million each, over four years, to the Nuclear Physics Board's eight largest research centres in universities and colleges; similar smaller grants to a further nine centres.

Science Board
Instrumentation Fund: In May the first 15 grants, totalling £3 million, were made under the Science Board's Instrumentation Development Fund, for scientific research programmes involving the development of novel and innovative instrumentation.

York University: £700,000 to continue work in safety critical systems.

IRCs
Surface Science IRC, Liverpool: £965,000 enhancement.
Superconductivity IRC, Cambridge: £2 million enhancement.

Congratulations to . . .

. . .the following on their recent honours:

Retiring Chairman of SERC **Professor Sir William Mitchell CBE FRS**, on his knighthood awarded in the Queen's Birthday Honours List;

Retiring Council member **Professor J M Thomas FRS** on his election as Honorary Foreign Member of the American Academy of Arts and Sciences;

Council member **Gerard Fairtlough CBE** on his honorary doctorate from the Council for National Academic Awards.

Director, ROE

Professor Malcolm Longair, Director of the Royal Observatory, Edinburgh, Astronomer Royal for Scotland and Regius Professor of Astronomy in Edinburgh University, has accepted the position of Jacksonian Professor of Natural Philosophy at Cambridge. He expects to take up his new post in January 1991.

Professor Sir William Mitchell, Chairman of SERC said: "Professor Longair has made an outstanding contribution to astronomy as Director of the Royal Observatory Edinburgh, including the development of the UK's telescopes on Mauna Kea in Hawaii. It is a tribute to Professor Longair's ability and his work with SERC that he has been offered this prestigious chair at Cambridge. All those associated with the Council and its programmes will want to wish him well for the future."

SERC Silver Jubilee Lecture

To commemorate the 25th year of the Science and Engineering Research Council, Lord Flowers FRS, then Vice-Chancellor of London University and past Chairman of SERC, presented a lecture on 11 June, reviewing the Council's achievements. The event, at the Queen Elizabeth II Conference Centre in Westminster, had an audience of 180 representatives from both Houses of Parliament, industry, the academic world, press and past and present staff, and was followed by a dinner attended by Robert Jackson, Parliamentary Under Secretary of State for Education and Science.

Lord Flowers delivering his SERC Silver Jubilee Lecture.

Lord Flowers, who is Chairman of the House of Lords Select Committee on Science and Technology, recalled that Lord Champion (Minister without Portfolio in 1965) had said in the House of Lords when introducing the Bill for the then SRC:

"The Science Research Council will take over the present responsibilities of the Department of Scientific and Industrial Research (DSIR) for giving research grants to universities and postgraduate training awards. Grants for the support of applied as well as pure science in universities are to be the responsibility of the Science Research Council, although the Ministry of Technology will undoubtedly want, on occasion, to meet its own particular needs with university work, which it would normally do by placing contracts."

Referring to the birth of the Council's Board structure he said:

"I well remember the heated discussions in 1964 about whether, and if so how, the particle physics of NIRNS and the UK responsibility for CERN were to be joined with the university nuclear physics responsibilities of the DSIR without, on the one hand, destroying the delicate balance of subjects and budgets so carefully devised by DSIR, and on the other, diluting the 'big science' competence so necessary for the prosecution of particle physics .... And, of course, there were similar discussions about space research and astronomy. The eventual outcome was the board structure of the SRC, with a Nuclear Physics Board of which I became a member; an Astronomy, Space and Radio Board; and a University Science and Technology Board to handle all that was not then big science."

The growing difficulty of matching research funds to demand in the 1960s was highlighted:

"In 1967, when I became Chairman, the Council announced that it had initiated 'a major review of its whole scientific programme and policy' to see how best to judge priorities between selected projects of equal intrinsic merit. Of course, that is now the normal way of life, but in those days when most university scientists had reasonable expectations of their proposal being funded, the situation seemed paradoxical. How could you choose between different proposals, except on the grounds of the quality of applications, when you could not know the outcome of the research and therefore could not judge its importance?"

Quoting from a contemporary pamphlet of the Council's he said:

"The Council exists primarily to enable good scientists and technologists ... to do significant research.... This essential function aims to create cultural, scientific and technological assets through the training of highly skilled manpower and through the support of research which leads to the discovery of new knowledge and techniques. The assets so created are of value in their own right ... but they can only be generally seen to benefit the community after they have been applied to immediate aims by other organisations in industry, commerce and the public services. The Council will therefore continue to support both postgraduate training and research proposals of high quality over the broadest front. However, within each area of activity resources will be concentrated on schemes which seem likely to yield significant scientific advance or the basis for economic or social benefit or both."

Noting that the underlying philosophy had not changed, he picked out how the response had shifted:

"Scientific research grows more expensive each year owing to its increasing sophistication. Assuming that the proportion of Gross Domestic Product devoted to research does not increase, the volume of activity will therefore tend to decrease, and the proportion of grant applications which can be funded tends to shrink. In response to these trends the first SERC Corporate Plan was published in 1985. It saw the way forward as through greater effort in seeking partners for new ventures, improvement in the efficiency of operations, and specific redistribution of resources."

Commenting on the growing 'selectivity' of research expenditure, Lord Flowers asked whether there were:

"significant areas of research for which funds are being unreasonably withheld? I have to say that within the limit of available funds I doubt whether there are, in those subjects for which SERC is responsible. I cannot say the same more broadly, because I believe, for example, following a report on priorities in medical research of the Select Committee on Science and Technology of the House of Lords, that health service research is not at present receiving anything like the attention it deserves. And I also suspect that there are areas which lie on the borders of responsibility between research councils where all is not entirely well. An example suggested by another Select Committee report might be those aspects of atmospheric chemistry which are important for a full understanding of the greenhouse effect and its consequences for global climate change."

The emergence of the Council's Engineering Board — putting the 'E' in SERC — was described, with the result that:

"engineering in universities does now get a fairer share of the cake and, compared with my day, many engineering departments hum with research activity of a very high quality and interest. Moreover, collaboration with industry, and sometimes joint funding, have made it more likely that engineering research will result in economic benefit."

Reviewing the process of concentration of resources in selected areas he saw serious problems:

"In some cases, like radioastronomy, where the subject is dominated by very few, very large pieces of equipment of relatively long useful life, it has been possible so far to keep lively university teams in existence. The experience in nuclear physics in this country has not been so encouraging, however. Perhaps there were too many university centres, most of them underfunded. Our best work has been done in national and international laboratories, inevitably at great cost. The university departments that make effective use of these laboratories, however, still tend to be large and expensive in their own right, so their number has to be limited.... With concentration there comes the inertia of well established permanent teams and the likelihood of eventual stagnation."

One effect of current funding policy he saw was that:

"the effect on research will be that existing projects, existing centres of excellence, may be better funded for a while, but fewer spontaneous initiatives will be possible. Research councils are good at dealing with subjects of proven worth; they are not so good at recognising the unorthodox idea of a hitherto unknown academic. It is significant, I think, that they have often been content to leave highly speculative proposals, and the support of newly appointed young academic staff, to the charitable foundations. The problem I describe is not just a British one. I have recently returned from a short visit to the USA where I was able to enquire about the effect of selective research grant policy upon university faculty. There too there is concern about the support of promising young research workers whose only refuge is to join an established team with a settled programme."

Science Minister Robert Jackson chats with the team from the Centre for Speech Recognition Technology, Edinburgh University. Left to right: Professor John Laver, Professor Mervyn Jack, the Minister, and Gordon Watson.

In reviewing the growth of international collaborative science he sketched the story of the European Science Foundation and exemplified some major achievements:

"In the physical sciences, the ESF's most obvious success is the European Synchrotron Radiation Facility at present under construction at Grenoble, having been sponsored for many difficult and sometimes disheartening years by the ESF. Another is the current geological traverse of Europe from north to south. There have been distinguished achievements in the humanities also, such as the study of human migration in Europe and the problems of second language acquisition. In every case, however, the most significant result of ESF's initiative has been the recognition of a community of scholars willing to devote themselves to their field in a European context."

He also highlighted the importance of the Academia Europaea, the membership of which covers both science and humanities and is drawn from Eastern as well as Western Europe.

"There are no quotas, either of subject or of nationality, although the Council is endeavouring to maintain an approximate balance in both respects. It held its first plenary meeting in London last year; this year it meets in Strasbourg. The emphasis is on problems with a European dimension and the links between humanities and science.

"Its finances are its weakness. There has been short-term government assistance from several countries, not least from the United Kingdom through ABRC (the Advisory Board for the Research Councils), and generous grants from a number of charitable foundations, but its long-term future is not yet secure. Already there are alternative proposals for an academy of academies, and for an organisation more closely modelled on the French Academy. The Academia Europaea has made an encouraging start, but if it is to survive it will need additional recurrent income for at least seven years at the level of about £100,000 a year. For the whole of Europe that does not seem excessive."

Looking at the future of British science in the context of international comparisons of expenditure on civil research and development he concluded:

"I believe that on the grounds of international comparison there is a case for increasing expenditure on civil R&D on the part of both Government and industry, and that Government should particularly concern itself with increasing expenditure on basic research and with the support of promising young scientists. That is the only way to overcome the impending stagnation of university research."

Lord Flowers rounded up his lecture with a view of SERC in the context of a fast-changing world:

"Confrontation between East and West is giving way to cooperation, and our future now lies in a greater Europe. The global climate may be changing faster than we can know. The gap between rich and poor grows amongst the nations. Population has to be controlled. The diversity of living things is in peril. In every case new science is needed, and more appropriate technology.... There is much to do, and SERC will be busy at least for another quarter century. Of course, the emphasis will change with perceptions of national and global need. But the concept of 'timeliness and promise' is permanent, and must continue to guide your affairs."

New Interdisciplinary Research Centres

SERC has set up a further three Interdisciplinary Research Centres (IRCs). They are in Cellular and Molecular Studies of Simpler Nervous Systems; Biomedical Materials; and Biochemical Engineering. They will be based at Sussex University, Queen Mary and Westfield College London, and University College London respectively and are supported by six-year grants totalling about £18 million.

These three new Centres, which were announced following the Council meeting on 20 June, join the 10 existing IRCs which the SERC has established since 1988. All 13 Centres concentrate on research in areas of basic and strategic science which require the application of several disciplines. The three latest Centres have been chosen from 23 submitted bids in strategic areas of science and engineering.

Cellular and Molecular Studies of Simpler Nervous Systems

(Director: Professor Michael O'Shea)

Based on Sussex University's School of Biological Sciences, this IRC will have two broad scientific goals:

- to identify the linkage at all levels between the behavioural output of the nervous system and the cellular and molecular mechanisms which generate it
- to identify strategic and completely novel targets within the invertebrate nervous system for the next generation of control methods against invertebrate pests and/or parasites and to explore other (medical and machine intelligence) applications of the work.

The IRC will be served by a number of in-house facilities: protein chemistry (automated sequencing facilities, mass spectrometry, nmr); molecular genetics (cloning/PCR, DNA sequencing and *Drosophila* and *C elegans* genetics); expression systems (oocyte, *E coli*, etc); molecular physiology (primarily patch clamp). These services would be run very much on an interdisciplinary basis, and would each link in with the integrated themes of the IRC programme.

Interdisciplinary themes:

- Protein structure and function.
- Determination of neuronal phenotypes and expression of genetic information.

SERC contact: Alyson Thomas, telephone (0793) 411491.

Biomedical Materials

(Director: Professor William Bonfield)

The IRC comprises a consortium of Queen Mary and Westfield College (QMWC), the London Hospital Medical College (LHMC), the Royal Free Hospital School of Medicine and the Institute of Orthopaedics. The IRC will be principally located in the Nuclear Physics Building at the QMWC/LHMC campus.

The primary objectives of the proposal are:

- to establish a recognised national focus for the future development of biomedical materials in the UK
- to coordinate and integrate work in a wide subject range (from cell biology through to clinical practice)
- to establish a second generation of implant materials with enhanced lifetimes for use in orthopaedic, cardiovascular and dental applications
- to produce an effective interface between the IRC and industry, the Department of Health and other IRCs
- to provide education and training in biomedical materials.

Interdisciplinary themes:

- Bone and joint replacement materials
- Orthopaedic systems
- Cardiovascular devices
- Dental applications.

SERC contact: Alan Thomas, telephone (0793) 411108.

Biochemical Engineering

(Director: Professor Peter Dunnill)

This IRC will be based at University College London (UCL) and bring together a consortium of collaborating departments within UCL as well as groups at Oxford and Kent Universities. The principal location of the IRC will be in the Advanced Centre for Biochemical Engineering at UCL to be completed in 1991.

The primary objectives of the Centre are:

- The identification of general principles for processing of biological materials to accelerate the rate of definition and design of process operations
- Examination of specific problems associated with the production and recovery of high value products, an area where the technological leverage to UK industry is felt to be particularly high
- To understand the scale-up of operations involving recombinant materials
- To explore the implications of molecular biology for bioprocessing.

The total process capability provided by existing facilities will be extended on completion of the advanced centre which will house a unique large-scale category II biocontainment facility, the only university-based amenity of its type in the world. This will allow a thorough exploration of the interaction between molecular biology and recombinant techniques with bioprocessing.

Research themes:

- Biocatalysis
- Downstream processing
- Bioprocess design and operation.

SERC contact: Neil Viner, telephone (0793) 411279.

Sale of Herstmonceux Castle

The sale by the Council of Herstmonceux Castle and estate has attracted much interest and comment. A National Audit Office (NAO) report on the sale has been published (No 341) and it is expected that the House of Commons Public Accounts Committee will discuss the matter with the Accounting Officers of Council and the Department of Education and Science in the Autumn. Protocol demands that the Council cannot respond publicly in advance of a PAC hearing and so it is a matter of particular regret when any related media reporting is inaccurate or ill informed. One magazine article on the sale reported an NAO spokesman as having said: "Basically, we're saying that SERC were sloppy about it." The Chairman of Council Sir William Mitchell subsequently received a letter from Mr John Bourn, the Comptroller and Auditor General in which he says: "I can personally assure you that both I and the staff of the National Audit Office directly and indirectly concerned with this matter fully disassociate ourselves from the comments made." Sir William said: "I was gratified to get at least this part of the record straight. I am personally fully aware and appreciative of the care and attention that the staff involved in this difficult sale paid to their work."

New LINK programmes

Two new programmes have recently been approved under the LINK Initiative. This brings the total number of programmes within the scheme to 24, all of which are listed in the panel. Three more are in the immediate pipeline. The new programmes are:

Asymmetric Synthesis

Many organic compounds are chiral, that is they exist as two 'mirror image' species, termed enantiomers. The ability to produce such compounds in entantiomerically pure form is increasingly important. This £7 million programme supported by SERC, Department of Trade and Industry and industry aims to advance the understanding and development of methodologies for the synthesis of such optically pure compounds. The programme will support projects in which organic synthesis is the key component, but will focus on reactions where (a) the reactant contains a covalently bound chiral auxiliary which is itself a product of organic synthesis; (b) the reaction is driven by a chiral promoter which associates with reactants; (c) the reaction is driven by a chiral reagent; or (d) a chiral catalyst is employed, again the product of organic synthesis. The development of new resolving agents is not a priority, but novel methods such as catalytic kinetic resolution may be supported.

For further information contact Ann-Marie Hilder, SERC Swindon Office; telephone (0793) 411305, or the LINK Asymmetric Synthesis Programme Secretariat, Department of Trade and Industry, Ashdown House, Victoria Street, London SW1E 6RB; telephone 071-215 6042.

Crops for Industrial Use

British farmers face difficulties of overproduction while industry depends upon foreign suppliers for expensive feedstocks. This £6.2 million programme seeks to stimulate research which will enable greater use to be made of British-grown crops for industrial processes. Primary topics include production and processing of plant fibre, mechanical fractionating of plant parts, chemical and enzymatic treatment of crop materials to improve nutritional value as animal feed, strategies for producing and manipulating the structure of crop-derived polysaccharides and other chemicals, and the genetics and biochemistry of oil-seed crops. It is led by the Agricultural and Food Research Council with the support of the Department of Trade and Industry, Ministry of Agriculture Fisheries and Food, Department of Agriculture and Food for Scotland, and industry. SERC is also a partner in the programme and has agreed to fund £100,000 a year from 1991-92 onwards, particularly to support the process engineering aspects of the programme expected in its later stages.

For further information contact M D P Matthews, Crops for Industrial Use Programme Secretariat, AFRC Institute of Engineering Research, Wrest Park, Silsoe, Bedford, MK45 4HS; telephone (0525) 60000, extension 2512.

For information regarding the LINK Initiative in general contact:
Tony Medland
LINK Unit, SERC Swindon Office
Telephone (0793) 411162.

LINK is a national initiative which aims to encourage strategic research of medium-term industrial significance and, by strengthening the links between industry and the science base, improve the transfer of new technology into industry. LINK consists of a series of programmes, each reflecting a priority topic. It operates by supporting, within these programmes, pre-competitive research projects involving industry and the scientific community, with up to 50% of the cost of the projects available from Government. Current programmes are:

Programme	Sponsors	£ million
Molecular Electronics	SERC/DTI	20
Advanced Semiconductor Materials	SERC/DTI	24
Industrial Measurement Systems	SERC/DTI	22
Eukariotic Genetic Engineering	DTI/SERC	5
Nanotechnology	DTI/SERC	15
Biotransformations	SERC/DTI	4
Personal Communications	DTI/SERC	13
Selective Drug Delivery & Targeting	SERC/DTI/MRC	3
Construction Maintenance & Refurbishment	SERC/DOE	3
Food Processing Sciences	DTI/MAFF	14
Ventilation, Air Conditioning & Refrigeration	SERC/DTI	3
Optoelectronic Systems	DTI/SERC	30
Design of High Speed Machinery	SERC/DTI/AFRC	21
Structural Composites	DTI/SERC/MoD	40
Protein Engineering	DTI/SERC/MoD/AFRC/MRC	10
Biochemical Engineering	DTI/SERC	15
New Catalysts and Catalytic Processes	SERC/DTI	5
Power Electronic Devices & Derived Systems	DTI/SERC	14
Control of Plant Metabolism	SERC/DTI/AFRC	3
Molecular Sensors	DTI/SERC/DH/AFRC	11
Technology for Analytical & Physical Measurement	DTI/SERC	16
Transport Infrastructure & Operations	DTp/SERC	12
Asymmetric Synthesis	DTI/SERC	7
Crops for Industrial Use	DTI/MAFF/DAFS/SERC	6

New Director Teaching Company Scheme

Dr E H Robson has been appointed Director of the Teaching Company Directorate (TCD) from 1 October 1990. He came to TCD from Sunderland Polytechnic where he was Dean of the Faculty of Technology and, before that, Head of Mathematics and Computer Studies. His major interests have been the use of information technology to solve business, educational and industrial problems and he has developed degree courses in technology and its management.

Ed Robson will be based at the TCD headquarters at Sudbury House, London Road, Faringdon, Oxon SN7 8AA; telephone (0367) 242822.

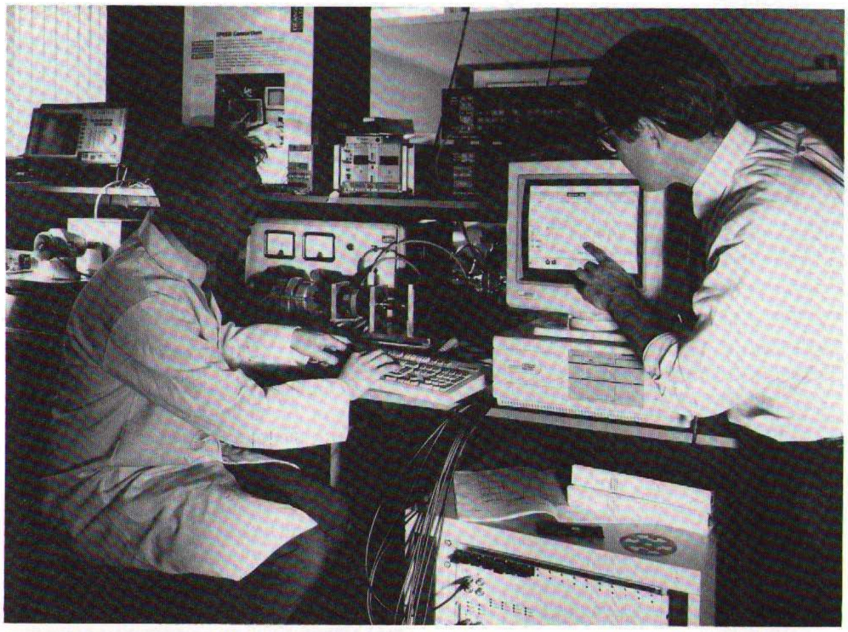
Power electronic devices and derived systems

The announcement of the 21st LINK programme established by the Department of Trade and Industry (DTI) and SERC could be taken to celebrate the 21st birthday of power electronics, since by 1969 it was clear that a new technology had made its way into the world. The LINK programme is the Power Electronics and Derived Systems Programme (PEDDS). This £14 million collaborative programme designed to facilitate the exploitation of new power electronics technology by British industry is outlined here by Professor Tim Miller, a member of the PEDDS Programme Management Committee.

Power electronics has been heralded as the 'second electronics revolution': in the same way that the invention of the transistor and the subsequent development of integrated circuits transformed the world of information processing, so the invention of the thyristor and the subsequent development of power transistors and converter technology are steadily transforming the world of energy processing. The rectifier/inverter stations at each end of the cross-channel DC link convert 2000 MW of power — equivalent to the output of a very large power station — showing that electronics has muscle as well as intelligence. In the next few years the proportion of all generated electricity that passes through power semiconductors may rise to over 50%. This proportion tends to rise when traditional AC power supplies fail and uninterruptible power supplies take over with battery-supplied inverters. And if alternative energy sources are to make any contribution to our need for electricity, it can only be through power electronic converters that 'condition' the power to make it useable and controllable.

Still greater changes are taking place at lower power levels. Coupled with microelectronic controls, power electronics has finally brought adjustable-frequency speed control to the induction motor; this development, awaited for decades, has opened up vast opportunities for energy-saving in process industries. The same technology has enabled the development and widespread application of improved servo-motor drives for accurate and automatic motion control in industrial and commercial machines ranging from numerically controlled machine tools to computer disk drives. Domestic appliances and even automotive auxiliaries are also increasing their use of power electronics, with many revolutionary new products projected for the future.

Few electronic products are immune from the impact of power electronics technology, yet the subject remains hidden. The market for switchmode power supplies, for example, has grown from nothing to a multi-million-pound industry in just a few years; but because these black boxes are tucked away inside computers, or perhaps because they deliver nothing more interesting than plain 5 or 12 volts DC, they are easily forgotten. Much of the potential for power electronics therefore remains untapped.



Precision dynamometer installed at Glasgow University's SPEED Laboratory in Power Electronics for studying loss mechanisms in AC motor drives and PWM inverters

The PEDDS Programme is designed to help industry exploit this opportunity through technology transfer from the 'science base' into the factory. In common with other LINK programmes, the strategy is based on collaboration: funding will be available to individual companies or to groupings of two or more companies who join their efforts with those of a university, polytechnic, or other research organisation to produce a 'critical mass' that could not be developed within one of the participating organisations acting alone in a reasonable timescale. The objective is to put in place the enabling technology that will lead to commercial exploitation through new products. This is illustrated in our front cover picture.

The scope of PEDDS is focused on four main topics:

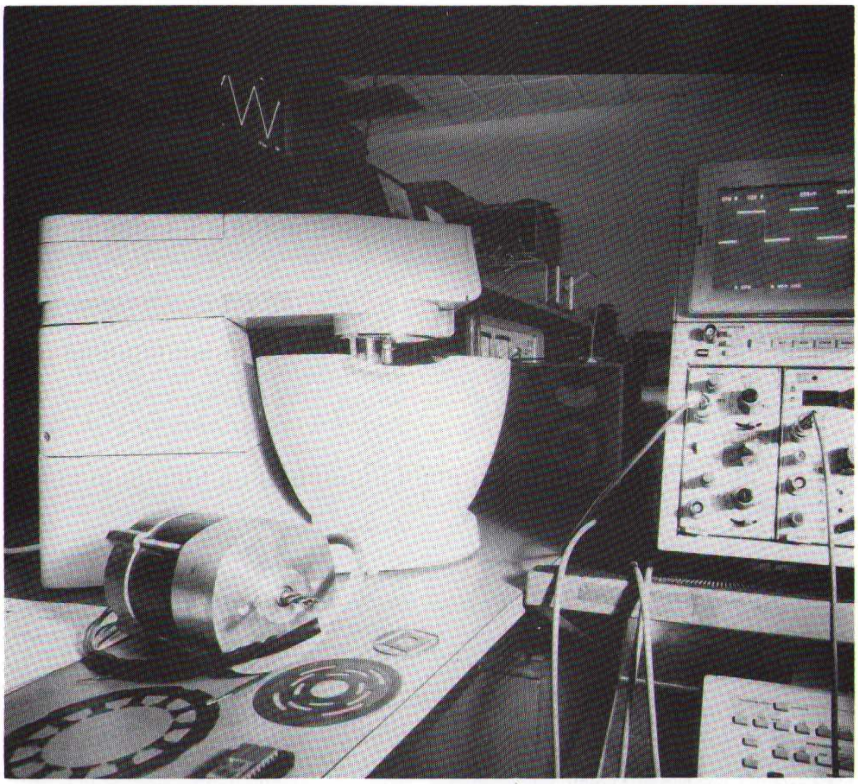
- discrete power semiconductor devices, including novel designs and applications, thermal problems and device protection
- electric drive systems including the reduction of disturbances to the mains, control strategies and hardware, integration of control electronics and power handling devices, improved devices for drives, and improved reliability
- power conversion, conditioning and control, including harmonic and other supply distortion, higher frequency operation, static VAR compensation, systems modelling and simulation
- uninterruptible power supplies including control and monitoring systems and advanced battery charging methods.

The funding is split between the DTI (£3.2 million) and SERC (£3.8 million) over four years, reflecting the central principle of facilitating the transfer of technology from science-base partners (such as universities), whose funding for their contribution to a collaborative project will follow the same principles as for ordinary SERC-funded research. This means that the scientific criteria applied to proposals will be consistent with those already established for research in higher education establishments, encouraging the maintenance of high standards of originality while providing a direct route for commercial exploitation. (Responsibility for the contractual assignment of intellectual property rights rests with the individual partners to a proposal.)

In line with other LINK programmes, PEDDS should be attractive to small and medium-sized enterprises, not only because of the financial support but also by facilitating collaborative research that is often difficult for them to resource on their own. To help expedite proposals and to receive guidance on the formation of the necessary partnerships, a Programme Coordinator will be appointed to help with all stages of a proposal from the initial concept through to final submission.

Professor T J E Miller
Department of Electronic and Electrical Engineering
Glasgow University
Telephone: 041-330 4922

Further details are available from:
Dr Lesley Thompson
(0793 411350), SERC
Fergus Morley
(071-215 6741), DTI



Much of SERC-funded research in motor control has application in domestic appliances. This food mixer was used for demonstration in a Royal Society lecture on BBC 2 by Professor Gareth Roberts of Thorn EMI.

Cofunding research agreement

By signing a new Cofunding Research Agreement with the four new companies to be formed from the Central Electricity Generating Board, SERC has demonstrated its determination to continue its good working relationship with the electrical supply industry when it is eventually privatised. The agreement was signed on 9 April, only two weeks after 'vesting day' for the new companies. Signatories to the agreement were (shown left to right): Dr John Baylis (National Grid Co plc), Dr Eric Carpenter (Nuclear Electric plc), Tony Egginton (SERC Director Programmes), Dr Chris Lawn (PowerGen plc) and Dr Ian Mogford (National Power plc).

This agreement provides up to £750,000 a year for sponsored research at universities and other higher education establishments, the costs to be covered on a 50:50 basis by SERC and the new companies. A wide-ranging research programme will be supported, with particular attention to be paid to research in: heavy current electricity, computational flow dynamics, integrity of power plant materials and non-destructive testing.

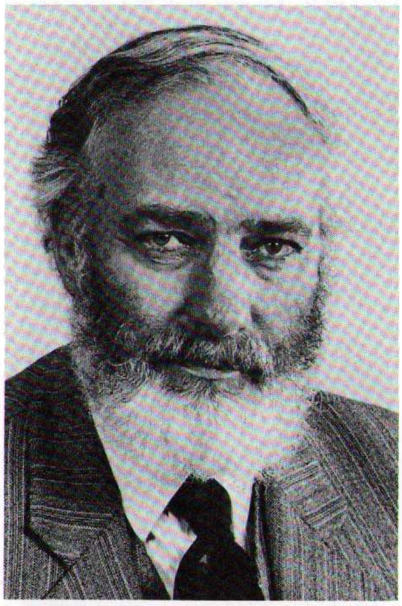
For further information contact Dr Lesley Thompson, SERC Swindon Office; telephone (0793) 411350.

MTD Ltd — a fast four years

The Marine Technology Directorate Limited (MTD Ltd) is now over four years old. It was incorporated as a company limited by guarantee in May 1986, officially launched by Kenneth Baker (then Secretary of State for Education and Science) on 20 October 1986, and registered as a charity in December 1986. It was the first of SERC's Directorates to be privatised. This article, by MTD Ltd's George Richardson, traces the company's development since then, and its current relationship with SERC.

The Marine Technology Directorate was launched in 1977, as the focus for SERC's ocean-related research and training activities, and to forge links between academic researchers, industry, and government. One of its first tasks was to set up the Marine Technology Centres: Cranfield, Glasgow, Heriot-Watt, London, Marinetech NorthWest (a consortium of six universities), Newcastle and Strathclyde. (The eighth Centre, Southampton, was set up in autumn 1989.)

During its nine-year life, the Directorate handled a total investment of around £40 million, and by 1988, the research programme consisted of more than 100 individual projects and 14 managed programmes in more than 30 academic institutions. This work concentrated on offshore oil and gas related work. SERC's financial commitment was £4.5 million a year, industry's was £1.35 million, and funding from government departments was £0.75 million.



Don Lennard, MTD Ltd's Director and Chief Executive

At the time of its launch in 1986, MTD Ltd funds were supplied by seven industrial companies (BP, Britoil, John Brown, Conoco, Esso, Shell and Wimpey), three government departments (Departments of Energy and Trade and Industry, and Ministry of Defence), and SERC. Patronage, then and now, was given by the Fellowship of Engineering.

MTD Ltd's first Director and Chief Executive, Mike Adye, had previously run the Directorate within SERC, and his death in October 1987 came as a shock to all his associates. His achievements and memory are being preserved in the Mike Adye Trust and in the annual Mike Adye Memorial Lecture. The first lecture was presented by Professor Tom Patten in January 1990.

After acting as Temporary Director and Chief Executive for six months, Don Lennard took over as Director and Chief Executive in June 1988. Since his appointment, the company has laid firm foundations for its future. The Corporate Plan and Strategy sets out its aims and aspirations until 1995. Initially, this was to concentrate on the renewal and development of the academic base for research and training in marine technology.

Education and training

Internationally, MTD Ltd is making its mark in education and training. The company has established a sectoral University Enterprise Training Partnership in marine science and technology in conjunction with five European partners, and MTD Ltd holds the secretariat of the West European Graduate Education Marine Technology foundation. This foundation currently has a membership of 25 universities from 12 West European countries. It provides a series of short intensive training courses, typically one to three weeks long.

MTD Ltd also provides one of the two contacts for the European Community's Marine Science and Technology programme. This programme initially runs for three years to mid 1992, and it aims to contribute to establishing a scientific and technological basis for exploration, exploitation, management, and protection of European coastal and regional seas.

Research activities

SERC-supported research through MTD has been in five fields: marine resources, physical ocean environment, ocean structures and materials, ships and floating structures, and underwater working.

Current MTD Ltd research supported by SERC in these areas totals more than 200 projects, in 70 departments in 37 universities and polytechnics. Of these, 75 are individual projects, the remainder being within 11 managed programmes. The latter attract about 60% of the £5.7 million expenditure.

A major addition to the company's research activities occurred with the acquisition in July 1989 of the Underwater Engineering Group (UEG) from the Construction Industry Research and Information Association. UEG's joint industry-funded projects provided a ready-made springboard for MTD Ltd's plans in this area of research.

Newer areas of research which MTD Ltd seeks to develop, in line with its Corporate Plan, include: behaviour of materials in ocean environments, surface tasks automation, subsea technology, and ocean exploration technologies. Six other proposed areas are: environmental protection and waste management, leisure activities, mariculture, measurement techniques (ocean instrumentation), mineral resources, and ocean renewable energies. Research into oil and gas is being fully maintained at the same time.

Information

The absorption of UEG has another benefit for MTD Ltd's members: an existing publications list, to which results of the UEG projects then current, and other joint industry projects started since then, are being added in the MTD Ltd publication series. The company also has an agreement with a commercial publisher. This agreement has already been the route used for publishing the results of the *Exclusive economic zones* report, and where suitable material results, it will be used for other mainstream and joint industry projects. The members now receive a *Members bulletin*, which gives company news (particularly the major decisions taken at Board meetings), and *Marine technology research news*, published quarterly and at present distributed to more than 900 addresses.

CCMST report and MTD Ltd

The Coordinating Committee on Marine Science and Technology was set up under the chairmanship of Sir John Mason, and its report was published in March 1990. Committee members included the Chairman of MTD Ltd, Admiral Sir Lindsay Bryson, four other Board members, and the Director and Chief Executive.

Among the report's findings are:
"The effective dissemination of knowledge is greatly aided by routine contact between researchers in academia, government laboratories and industry. MTD Ltd provides one such channel of communication. It funds national research in marine technology with active involvement of its industrial members. Communication and collaboration are achieved both by publishing reports and by developing training programmes.

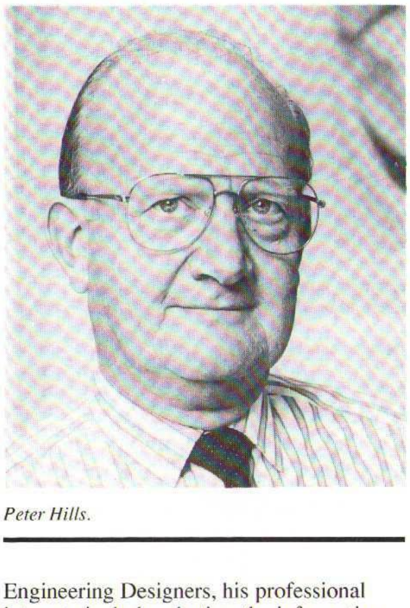
"DTI and MTD Ltd (SERC) have a joint panel to advise on project proposals submitted to the DTI Wealth from the Oceans Programme. CCMST endorses this arrangement, which should encourage the transfer of ideas from academia to industry and ensure cohesion between the DTI and SERC programmes."

In four short years, MTD Ltd has changed its spots considerably. It has industrial links, it has taken over another organisation, it has increased its funding from SERC by an equal amount from government and industry, and it is diversifying from predominantly oil- and gas-related work into a broadly-based ocean technology organisation.

George Richardson
MTD Ltd

Design Coordinator

Peter Hills took over as SERC Engineering Design Coordinator on 1 September 1989. Previously he was Head of Design Group in the School of Mechanical, Materials and Civil Engineering at the Royal Military College of Science (Cranfield).



Peter Hills.

He has been in engineering since 1952 when he began a five-year apprenticeship at Pressed Steel Co Ltd, after which he moved on to the design of tooling and special-purpose production equipment at Morris Motors (Radiators). He then joined Oxford College of Technology (which shortly after became Oxford Polytechnic) where he set up the engineering design teaching activity. In 1978 he was appointed Principal Lecturer in Engineering Design at the Royal Military College of Science, becoming Head of Design Group when the college became a Faculty of Cranfield Institute of Technology in 1984.

He has experience of design consultancy across a broad range of topics including concept and detail design, product evaluation and technical risk assessment, and has lectured for British and American universities. A Chartered Engineer and Fellow of the Institution of Mechanical Engineers and the Institution of Engineering Designers, his professional interests include robotics, the information needs of designers and 'simply designing'.

Key changes

SERC Swindon Office has had several changes in senior staff recently:

Dr Barry Martin has moved from Head of Astronomy and Planetary Science (APS) Division to Head of Engineering Division, on the transfer of Dr Bob Voss CBE FEng to become Associate Director, Science, at Rutherford Appleton Laboratory;

Dr David Jones becomes Deputy Head of Engineering Division;

Dr Nick Lawrence has been appointed Head of the new Clean Technology Unit;

Dr Ian Corbett has transferred from RAL to take over as Head of APS Division;

Dr Geoffrey Findlay moves to APS Division as Deputy Head with responsibility for the British National Space Centre;

Dr Doug Yarrow has been appointed Head of Nuclear Physics Division, on the retirement of Dr David Thomas;

Stuart Ward becomes Head of the Materials Science and Engineering Commission; and

Peter Maxwell takes over as Head of Finance Division on the retirement of Lewes Addison.

Cognitive science and human-computer interaction

Increasingly the application of information technology is meeting a bottleneck in the problem of designing the dialogue or interaction between the machine and the person. A major difficulty has been the lack of general principles that designers might use, or of sustained basic research targeted at finding such principles. Such research would lie at the edge of SERC interests, since it may well involve medical or social science techniques. Dr Donald Broadbent of Oxford University describes the broad-based research initiative which he chairs and which draws together these diverse techniques.

As well as the practical aspects of human-computer interaction, medical and social scientists are increasingly intrigued by the theoretical possibilities of the concepts devised for studying computers. There are many alternative ways in which machines can solve problems, set up their own goals and achieve them, learn from experience, store and retrieve information, and act on the world. The methods of describing and comparing these processes can also be applied to describing or improving the ways in which human individuals and groups undertake the same functions. Despite its importance, however, there is a danger that such 'cognitive science' will be neglected, because it lies at the edge of medical and social science interests just as it does of those of SERC.

Initiative launched

The three Research Councils most concerned have recognised this problem for some years; and in the Spring of 1989 they obtained from the Advisory Board for the Research Councils a special allocation of funds to support an initiative in this area. The programme was based on a portfolio of 11 themes (see panel), chosen and shaped from 160 suggestions coming from the research community; so far 31 grants have been awarded.

Unlike some other priority areas, this needs simultaneous advance on at least four fronts rather than the achievement of one single goal. On one front, we need good models of the interaction between the user and the machine (Themes 2.1-2.3). To achieve such a model however we also need ways of modelling the events within the individual person; or, as we are using similar concepts for person and machine, the individual system (Themes 4.1-4.3). An important characteristic of people, and of the complex man-made devices we are considering, is that they learn from experience; so we also need to understand the learning process and the best ways of improving it (Themes 3.1-3.3). All this information is in the end intended to affect the design of new systems; so such design itself needs study and the provision of techniques that might make it more effective(Themes 1.1-1.2).

Thus far the distribution of projects across themes is uneven. This is because the various themes have attracted unequal numbers of proposals, and unequal success in avoiding technical criticisms. As the initiative moves into its second and third years, it hopes to correct the inequality.

Themes of the Cognitive/Human-Computer Interaction Initiative

1. **System design**
   - 1.1 Tools, methods, and the design process
   - 1.2 Linking language to image
2. **Principles of interaction**
   - 2.1 Models of users in interaction with the system
   - 2.2 Modelling of communication and collaboration among active agents (including discourse)
   - 2.3 Representation of organisational knowledge
3. **Computational learning environments**
   - 3.1 Effects on learning of the forms of presentation, action, and feedback
   - 3.2 Intelligent tutoring (the choice of learning material in the light of a model of the learner)
   - 3.3 Support of programming
4. **Computational modelling of cognition**
   - 4.1 Models of cognition and learning
   - 4.2 General theoretical principles of network models
   - 4.3 Psychophysics and modelling of neutral phenomena (including low-level vision and speech)

Dr Elizabeth Pollitzer has been appointed Coordinator of the Cognitive Science/Human-Computer Interaction Initiative, a major SERC – Medical Research Council – Economic and Social Research Council undertaking.
Dr Pollitzer can be contacted at:
The Management School
Imperial College of Science, Technology and Medicine
Exhibition Road, London SW7 2PG
Telephone 071-589 5111
e-mail UMTSK 30@ UK.AC.IC.CC.VAX A

Some examples

Let us take some sample projects. If some problem requires a solution slightly more complex than a single action, then the person (or the machine) must plan a whole sequence of actions before launching the first. But the process must be flexible, dropping a faulty plan and changing its direction during execution if things seem to be going wrong. An interesting case is that of the human teacher (or mother) trying to improve the problem-solving performance of a child: one can see that the adult is constantly modifying the way the child is informed, verbally, by demonstration, by specific hints, in a way that depends systematically on the child's own behaviour. The strategy of the interaction is related to the success of the child. But measurement shows that human teachers cannot deliberately follow instructions to produce a perfect strategy of this kind, because it is too hard to analyse what the child has just done, change the plan, and construct the next sentence in the time available. In principle, however, a computer can do this; and so one of the initiative's projects is attempting to solve the 'artificial intelligence' problems of devising such flexible plans, while at the same time using the developed system to teach real children and get still more information about the way they can best learn.

In addition to rules of action, both mechanical and human systems must of course develop a symbolic model of the world, on which their actions are based. The interpretation of electrocardiograms is a task that must involve some mental model of the body, but it is obscure exactly what features of that model are critical to successful diagnosis. Another project is systematically observing the performance of human diagnosticians, and at the same time comparing it to an intelligent mechanical system that has been developed for a different medical field; to see not merely whether the program has advantages over the person, but how far each is using the same or some different method.

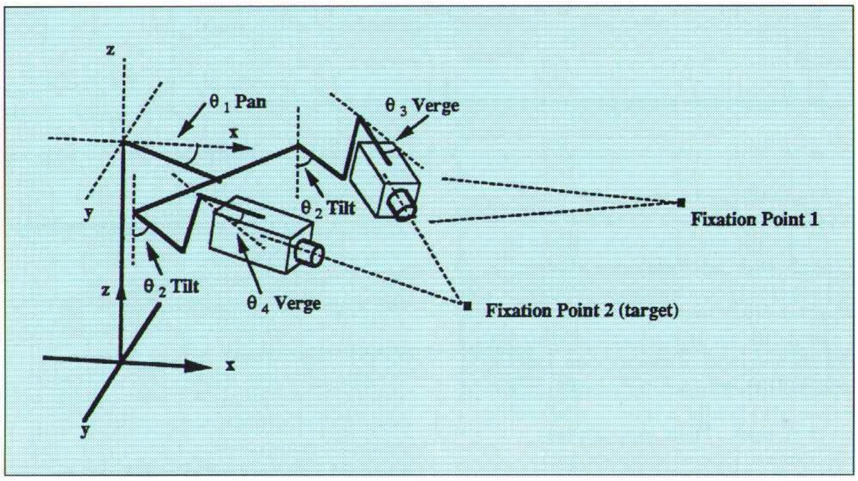
These tasks are manifestly 'intellectual'; but understanding a spoken sequence, or correctly locating the objects in a visual scene, are challenging problems for a machine despite their apparent simplicity. Yet mechanising such functions would in turn make machines much easier to use; the computer that will understand spoken instructions is a kind of crock of gold that will certainly be very useful but needs long programmes of basic research to achieve. For example, the sounds of words do not have convenient silent intervals between them as words have spaces on this page. Accordingly, the initiative has a project on the way speech is 'segmented' by human beings, since that may help to solve the problem for machines.

Each of these projects displays a welding together of the tools of separate disciplines. Perhaps one of the clearest examples is a study in which a stereo camera mounted on a robot is being used to locate and track objects. To do this, a network of interconnected units adapts to the structure of the environment by changing the weight of the interconnections. This architecture is one that is highly probable in biological systems, and the same team is using information on the firing rates of the neurons involved in the movement of real eyes, to construct a computational model of the system used by mammals to perform similar functions. Thus computing, physiology, engineering, and psychology, are closely integrated in a fashion that should lend strength to each of them.

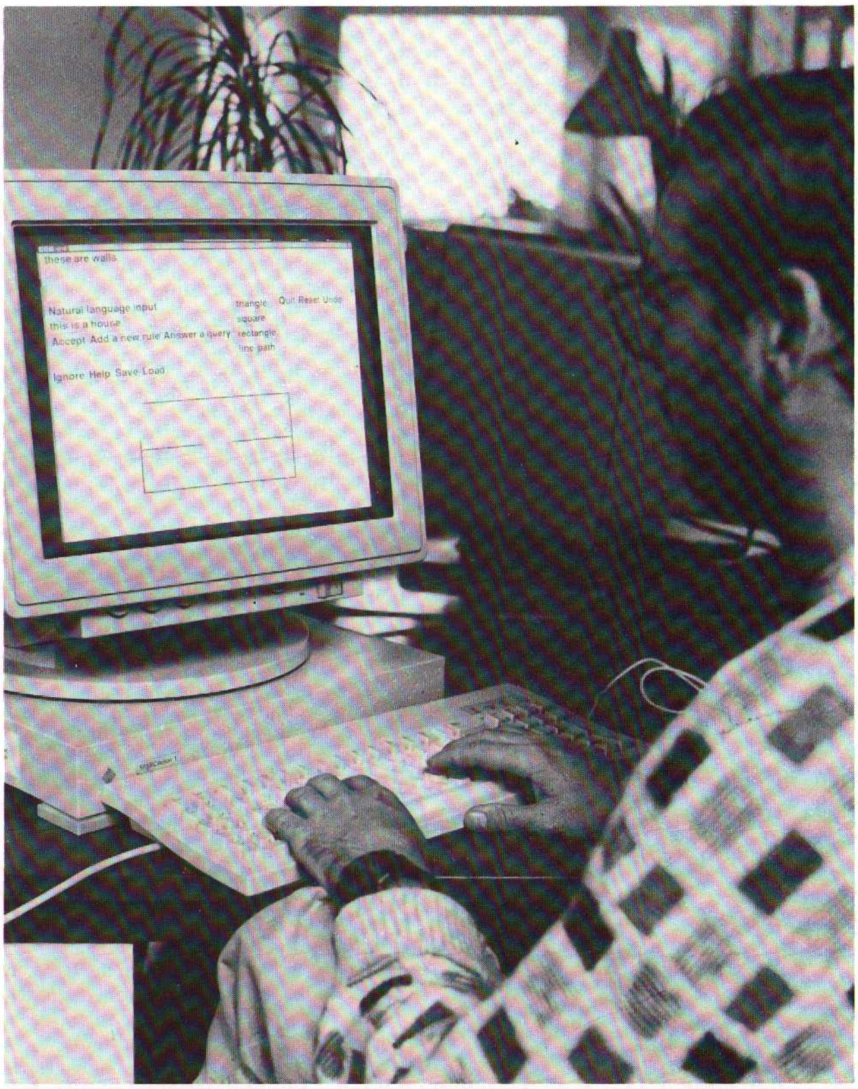
National network

It is difficult to assemble in one place suitable expertise in all the disciplines; one location may have facilities in linguistics and computing, another in physiology and engineering, a third in robotics and psychology. It is also important that each investigation should meet standards at least as high as those in longer-established fields. The initiative has therefore been cautious about concentrating resources in a single centre and has rather favoured a national network of projects individually assessed and directed, with a large number of collaborations. So far four principal centres have emerged each having several projects; and each with an important surrounding structure of smaller specialised institutions. The pattern may change as the themes develop; but it is hoped that this network will make an increasing contribution both to IT design and to our understanding of intelligent behaviour.

Dr D E Broadbent
Department of Experimental Psychology
Oxford University.



The problem of locating objects, as faced by the camera of a robot or the eyes of a person. Fixing the target requires movement of the two eyes together both horizontally (θ_1 pan) and vertically (θ_2 tilt) as well as each eye converging (θ_3 and θ_4 verge). (Sheffield University)



Neil Leslie operating a graphics/natural language interface developed at EdCad and the Centre for Cognitive Science at Edinburgh University.

Studying plasmids in *Streptomyces*

Plasmids are DNA molecules which replicate independently of the host chromosome and are wide-spread in prokaryotes (bacteria) and lower eukaryotes (yeast and fungi). The functions they encode are usually dispensable for the growth of their host but they provide a mechanism for the acquisition and transfer of new genes which may confer a selective advantage on their host. Their independent replication, ease of isolation and manipulation makes them essential tools for genetic engineers and biotechnologists. They are used in the cloning and analysis of genes and for the expression of single genes for the production of proteins (especially therapeutic proteins such as tPA) and the expression of blocks of genes (such as an antibiotic biosynthetic pathway). Hilary Richards and John Ward of University College London have been working on *Streptomyces* plasmids and in this article describe some of their work.

It is important to understand the biology of plasmids, their replication, maintenance, stability and transfer functions for the logical development of plasmids as cloning vectors.

E coli plasmids have been the most extensively studied, in particular the ColE1 plasmid which is the parent of may cloning vectors used in *E coli* such as the pUC vectors. However, *E coli* plasmids cannot replicate in many industrially important bacteria such as *Streptomyces*. For the successful genetic engineering of *Streptomyces* we need to understand the biology of their indigenous plasmids and to exploit these as cloning vectors.

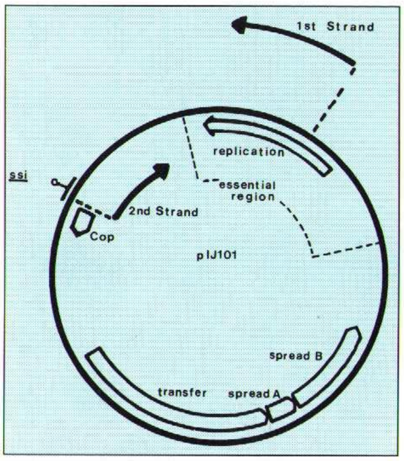


Figure 1: Map of plasmid pIJ101 showing functions required for replication, inter-mycelial transfer and intra-mycelial spread.

Streptomyces and antibiotic production

Streptomyces are a diverse group of Gram-positive bacteria which inhabit soils and composts. They are of tremendous commercial importance as they produce the majority of antibiotics used in clinical and veterinary medicine, such as tetracycline, erythromycin and tylosin. The pioneering work of David Hopwood at the John Innes Institute in Norwich, on the cloning of antibiotic biosynthetic pathway genes and the production of hybrid antibiotics via recombinant DNA methods, demonstrated the potential of genetic engineering in these organisms.

The Biotechnology Directorate and Biological Sciences Committee of SERC, together with the Department of Trade and Industry and a consortium of four companies — Smith Kline Beecham Pharmaceuticals, Celltech, Glaxo and ICI — created the Antibiotics and Recombinant DNA Club to fund fundamental research into antibiotic producing organisms. The club funded research by 13 academic groups and was coordinated by Dr Iain Hunter of Glasgow University.

The work funded by the Club at University College London was to study the biology of two *Streptomyces* plasmids, pIJ101 and SCP2* which are the parents of many commonly used vectors in *Streptomyces*. pIJ101 is a small, 8.9 kilobase (kb) plasmid which has a high copy number of approximately 300 copies per host chromosome. Plasmid vectors derived from pIJ101 are useful for initial cloning and analysis of *Streptomyces* genes and for the over-expression of a gene product. SCP2* is a much larger plasmid of 31 kb and has a low copy number of only one to two copies per host chromosome. Its use is in the expression of single copy genes such as a gene to modify an antibiotic produced by the host *Streptomyces*.

Replication and maintenance of pIJ101

Most of the cloning vectors based on pIJ101 contained only the essential replication region (2kb) of this plasmid (see figure 1) and it was known that these vectors were often unstable, particularly when carrying inserted DNA fragments. We have determined the DNA sequence of a region outside the essential replication region which encodes two functions necessary for the stable replication and maintenance of pIJ101. Within the DNA which was sequenced is an inverted repeat which can form a stable hairpin loop (see figure 2). The marked hexanucleotide sequence within the loop is homologous to sequences found in several other plasmids and such loop structures containing this particular sequence act as sites for second strand synthesis (*ssi*) during plasmid DNA replication.

It is likely that replication in pIJ101 initiates in the essential region in an anti-clockwise direction (figure 1) using only one of the DNA strands as a template. The hairpin loop structure forms in the other DNA strand and acts as the site for the initiation of lagging, or second strand synthesis. Vectors lacking *ssi* have to rely on weaker sites for second strand synthesis and have a pool of single stranded replication intermediates within the cell which leads to instability.

Immediately adjacent to *ssi* is a gene encoding a small protein known as Cop. We have recently shown that both the Cop protein and the *ssi* sequence are necessary for the efficient conversion of single

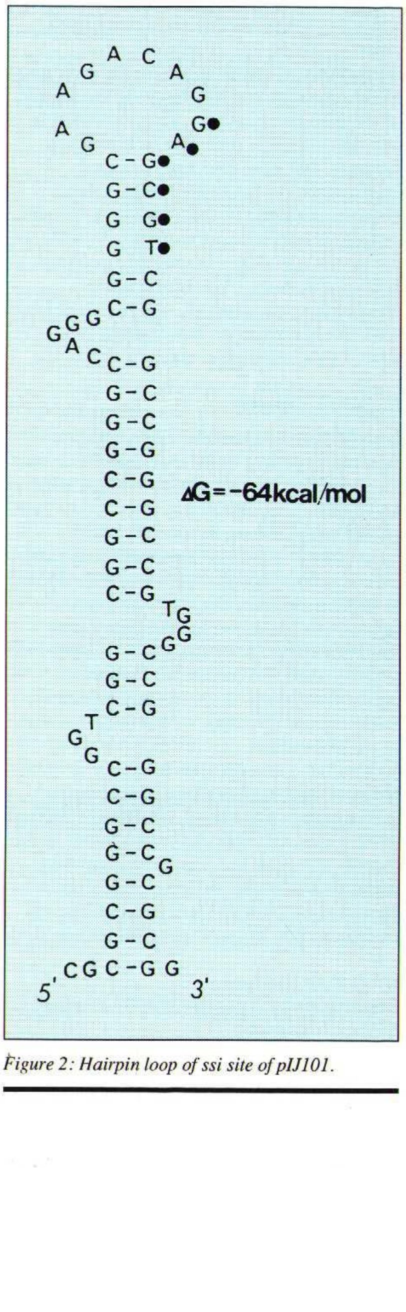


Figure 2: Hairpin loop of ssi site of pIJ101.

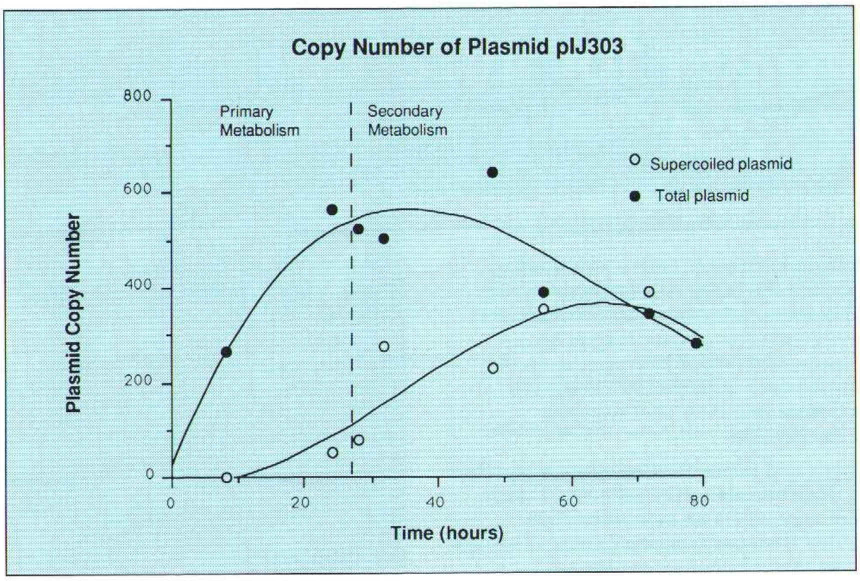


Figure 3: Copy number of pIJ303 during fermentation.

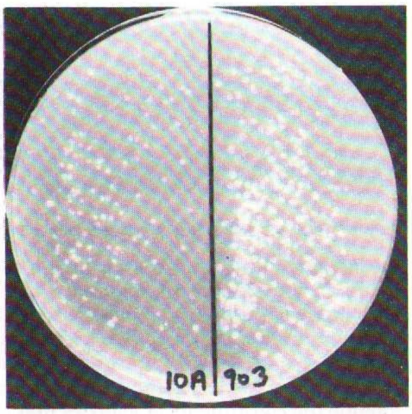


Figure 4: Wild type colonies of pIJ903 (right side) and a transfer mutant, 10A (left side) replica plated from the centre of 'pocks'.

stranded replication intermediates into double stranded plasmid molecules. The inclusion of the Cop and *ssi* functions into plasmid vectors would increase the stability of recombinant plasmids in *Streptomyces*.

Plasmid copy number in *Streptomyces* fermentations

If *Streptomyces* containing recombinant plasmids are going to be grown in industrial fermenters, we need to understand plasmid copy number changes during batch fermentation. Because *Streptomyces* are filamentous and not unicellular organisms, the common methods devised for *E coli* copy number determinations do not work. We have developed methods for measuring plasmid copy number in *Streptomyces* and the results of a fermentation of *Streptomyces lividans* carrying plasmid pIJ303 (a pIJ101 derivative) are shown in figure 3. Plasmids exist in different physical forms and previous methods only measured the supercoiled form. Our data show that this underestimates the plasmid copy number during the early, rapid growth phase of the culture and that the peak of plasmid copy number occurs after the transition from primary to secondary metabolism. It is during secondary metabolism that the majority of antibiotics are synthesised.

SCP2* plasmid transfer

Plasmid transfer is a common property of *Streptomyces* plasmids. Not only do plasmids transfer themselves between *Streptomyces* species but there are plasmid encoded functions which are needed for the spread of the plasmid throughout the mycelial network of filaments. Transfer of the plasmid to a recipient *Streptomyces* leads to a transient suppression of growth of the recipient. This can be seen as 'pocks' on mating plates. Also many plasmids such as SCP2* have fertility functions which enable chromosomal genes to be transferred between *Streptomyces* species. We are currently sequencing the DNA of the transfer region of SCP2*. We are also making transfer defective mutants using a specially designed mutagenic cassette which contains a selectable gene and other sequences which aid the characterisation of the mutation. We have now identified several classes of mutations including transfer deficient and spread deficient mutants. Figure 4 shows normal, pIJ903 colony type morphology on the right side of the plate and a spread deficient mutant which produces a smaller colony form on the left side of the plate. These mutants have enabled us to map where the transfer and spread genes lie within SCP2*.

The understanding of streptomycete plasmid biology has already revealed many interesting features and some of these may be commercially significant when recombinant *Streptomyces* are used in industry.

Dr Hilary Richards and Dr John Ward
University College London.

Global environmental research

David Brown of the Natural Environment Research Council has been appointed head of the Joint Research Council Global Environmental Research (GER) Coordination Office which will be based at Polaris House, Swindon. He has both a biological background, nurtured at NERC's Institute of Virology, and administrative experience within NERC and at the Department of the Environment.

As well as providing an information base for UK research in this field, and the Secretariat for the Inter-Agency Committee on Global Environmental Change, the Office will help to involve British research groups in international initiatives.

David Brown may be contacted at:
Joint Research Council Global Environmental Research, NERC, Polaris House, North Star Avenue, Swindon SN2 1EU; telephone (0793) 411734.

Built environment

A major review of civil engineering has been undertaken by a panel chaired by Professor G S Littlejohn of Bradford University. A significant increase in the level of support is recommended especially in environmentally sensitive areas such as integrated pollution control, coastal engineering and water quality.

A new structure and titles are recommended to effect strategic planning.

The Environment Committee will become the Built Environment Committee with five subcommittees covering:

- performance of structures and materials;
- geotechnics and pavement engineering;
- water environmental and coastal engineering;
- building design, technology and management; and
- transportation.

A new spectrometer for infrared astronomy — CGS4

The infrared region of the electromagnetic spectrum has always been a rich hunting ground for physicists and chemists. For astronomers this is the region where we can study many of the simplest, most obscured, and in some cases, most distant molecules and atoms in the Universe. By observing at wavelengths that are too long to be obscured by dust we can measure the rotations and vibrations of hydrogen molecules that have been excited in the stellar nurseries buried deep in molecular clouds. Or examine the constituents of galaxies that are so distant that their characteristic emission lines have been redshifted to infrared wavelengths.

The problem with infrared spectroscopy of galactic and extragalactic objects is that the line fluxes detected here on Earth are very low. Instruments on the 3.8 metre United Kingdom Infrared Telescope (UKIRT) in Hawaii may collect no more than 1000 photons a second from molecular hydrogen emitted from our Galactic Centre. The same lines from other galaxies can have fluxes less than 10 photons per second.

To detect and measure these fluxes, a new cooled grating spectrometer (CGS4) for infrared astronomy has been designed and built at the Royal Observatory, Edinburgh, and is described here by Dr Matt Mountain and David Robertson of ROE.

CGS4 has been designed to operate in the 1-5 μm region and to provide wavelength resolutions ranging from 300 to 40,000. By using two-dimensional arrays, astronomers will get both spatial and spectral information so making it possible to map the velocity fields of gas swirling near the embedded nuclei of active galaxies.

At the heart of the instrument are two back-to-back 150 mm x 300 mm gratings that disperse the infrared wavelengths collected by the telescope across the detector. The optical layout is shown in figure 1.

The difference between CGS4 and an optical or laboratory spectrometer is that, to avoid the weak astrophysical signals being swamped by the radiation from room temperature objects, the entire instrument has to operate in a vacuum at cryogenic temperatures. This presented a number of technical problems.

Optics at liquid nitrogen temperatures

To accommodate our infrared arrays, the optics had to be designed to give aberrations of no more than 30 μm at all wavelengths.

Diamond-turning was used to achieve this 'optical' performance at cryogenic temperatures to cut near-optical quality surfaces on to aluminium substrates (figure 2). Alignment pads and the optical surfaces were cut at the same time with the same precision so that the mirrors, machined to fit the optical support structures, required no further alignment. (Figure 3 shows the assembled collimator camera module). The use of aluminium for both the mirrors and support structures avoided any degradation in image quality from differential contraction or de-focusing when the optics were cooled to below 80K.

Cryogenic mechanics

To cool such a large instrument and maintain temperatures around 80K for several weeks, a hybrid cryogenic system was developed (figure 4). The main optical structure (85 kg) is cooled with liquid nitrogen with the surrounding radiation shield maintained below 80K by the first stage of a commercial closed cycle cooler. The array is cooled separately by the second stage of the cooler motor to 35K.

Within the cryostat there are eight drives at cryogenic temperatures all operated by modified commercial stepper motors. These are used to focus the detector, move gratings, select filters and orientate the image rotator. Unnecessary heat loading inside the cryostat is prevented by depowering the motors when not in use.

Detecting low photon rates

Our present detector is a hybridised InSb array with a silicon multiplexer. The current format of 58 x 62 pixels will eventually be replaced by a 256 x 256 device. With these arrays the infrared photo-generated charge is usually accumulated on each pixel before being

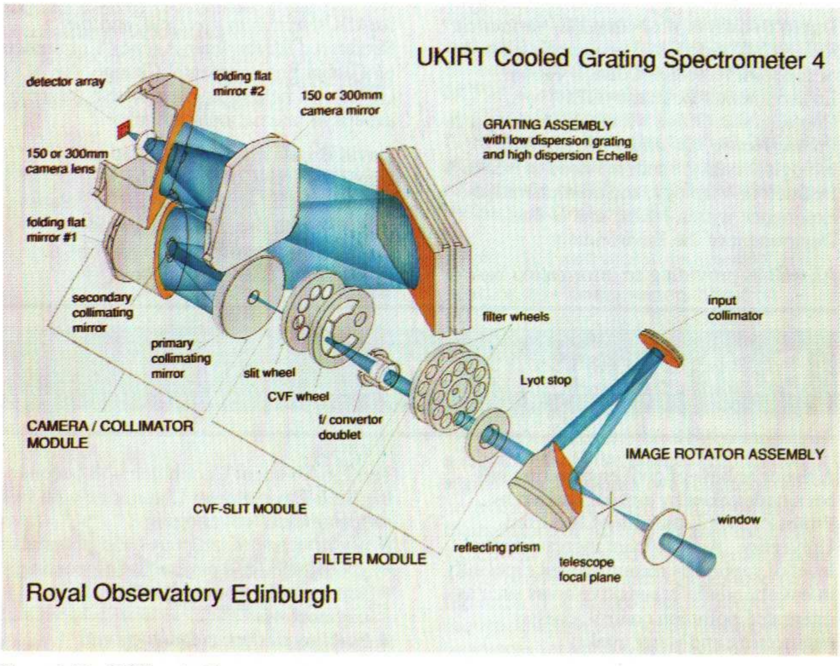


Figure 1: The CGS4 optical layout.

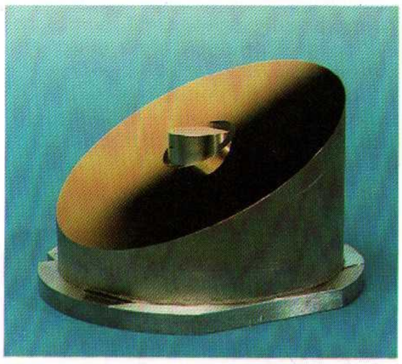


Figure 2: One of the diamond-turned optical assemblies showing an ellipsoidal collimating mirror mounted in the centre of a larger folding mirror. These mirrors are aligned using pads machined to the same precision as the optical surfaces.

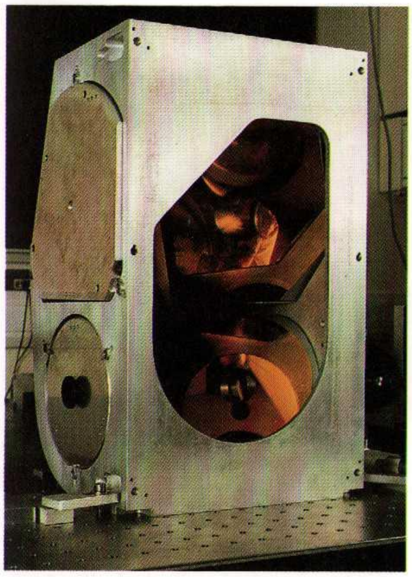


Figure 3: The complete collimator camera module on the optical bench during initial testing.

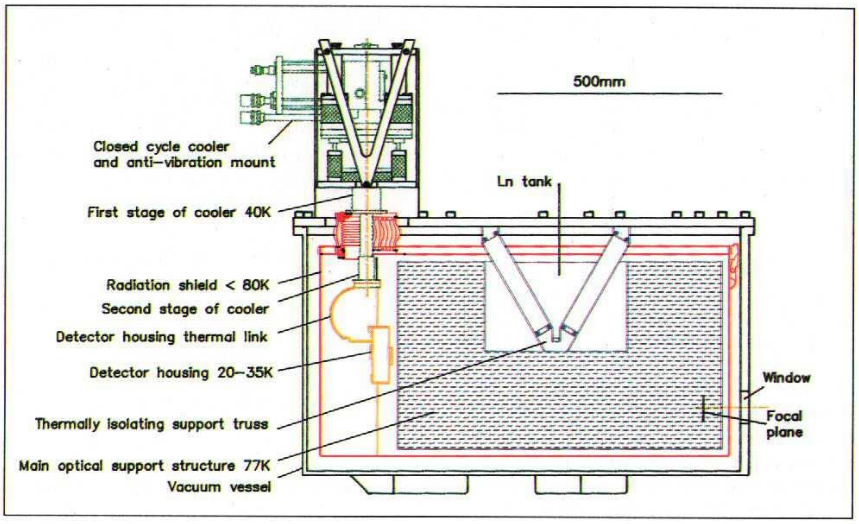


Figure 4: CGS4 cryogenic system.

read out by the multiplexer at the end of an integration. Unfortunately, the read-out process contributes approximately 400 electrons noise to our accumulated astrophysical signal. To detect and measure infrared signals as low as 1-10 electrons a second required a new readout strategy.

Using our Infrared Array Control System, we can now periodically sample the accumulating charge on each detector during an integration (figure 5). These samples are used to calculate the best fit to the slope of the integrating signal so reducing the uncertainty (or read noise) in the measurement. With this novel strategy we will obtain read noises as low as 30-40 electrons per integration.

Common user software

By its very design, with the entire spectrometer enclosed in a vacuum jacket, the operation has to be 'hands off'. Therefore, for a visiting astronomer to UKIRT to get the best science out of CGS4 a comprehensive 'common user' software system had to be developed. This system will deliver automatically reduced data minutes after observation (figure 6).

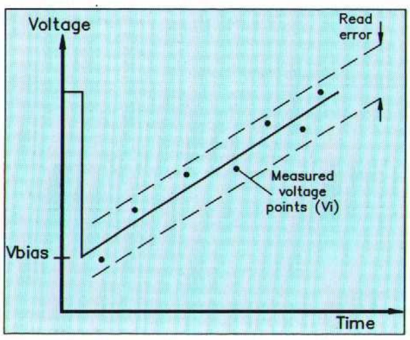


Figure 5: Illustration of noise reduction due to straight line fit through n points.

CGS4 commissioning

First light was obtained with the instrument at ROE on 25 April and shipment to UKIRT is scheduled for mid-December this year. Telescope commissioning will start early in 1991 and will initially be on a 'shared risks' basis. This will allow for a full evaluation of the spectrometer using the wide experience within the astronomical community and get some science done.

Dr C M Mountain
Dr D J Robertson
Royal Observatory, Edinburgh

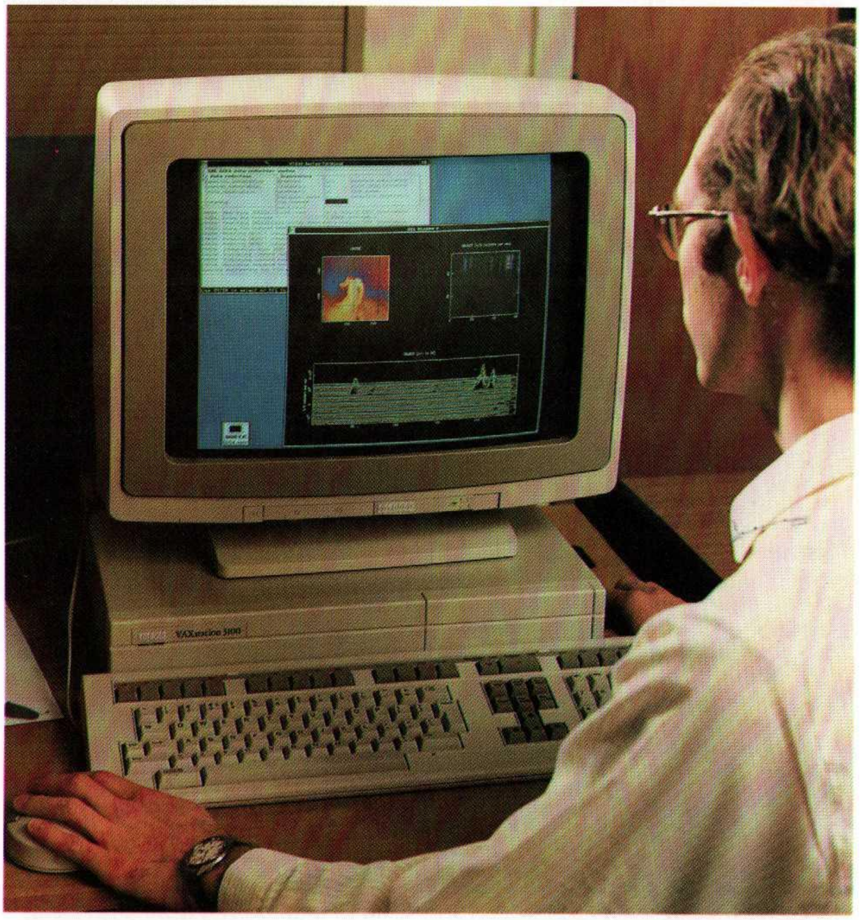


Figure 6: Automatic data reduction.

The MERLIN extension project

Figure 1: Map of the MERLIN array of radio telescopes linked to Jodrell Bank. The addition of the 32-metre telescope at Cambridge increases the maximum baseline to 230 km. The telescopes are shown by circles. The microwave link sites bringing the astronomy signals back to Jodrell Bank are shown by crosses.

The MERLIN extension project is at a significant stage in its construction. The 32-metre radio telescope which forms the central element of the £5 million grant to Manchester University has now reached the commissioning phase and has demonstrated the high quality of its design concept. The 32-metre diameter bowl was lifted into place at the Mullard Radio Astronomy Observatory in Cambridge on 8 December 1989. Since then, crucial fitting out has taken place including setting the surface panels and measuring the change of shape with elevation angle. Professor Rod Davies of Jodrell Bank believes it is clearly a first class telescope.

The aim of the Multi-Element Radio Linked Interferometer Network (MERLIN) extension project was to make a major increase in the resolution and sensitivity of the MERLIN array of telescopes linked to Jodrell Bank by the addition of a 32-metre telescope at Cambridge, which increases the available baselines to 230 km (see figure 1). The telescope would also be linked into the European Very Long Baseline Interferometry Network (EVN) and the worldwide Very Long Baseline Interferometry (VLBI) network.

Figure 2: The assembled 32-metre radio telescope at the MRAO site in Cambridge. The 216 surface panels have been set to an accuracy of 0.2 mm.

MERLIN will soon take its place among the international facilities for high angular resolution studies in astronomy, the most recent of which is the Hubble Space Telescope. MERLIN operating at 5 GHz and Hubble both have angular resolutions of 0.050 arcseconds. The 32-metre telescope achieved 'first light' in August; the full MERLIN extension will be operational by the end of 1990. Applications have already been received for the first observing session. Apart from Jodrell Bank staff, proposers come from 33 institutions in the UK and overseas.

The new 32-metre telescope

A unique high-efficiency design was developed by the West German contractors MAN and Jodrell Bank staff. The design efficiency of 80% instead of the more usual 60-65% was achieved by special shaping of the main reflector and subreflector.

A precision surface ensures fully efficient operation at frequencies up to 22 GHz. Adjustments to the 216 panels of the surface of the completed telescope (figure 2) give a surface setting accuracy of 0.2 mm. The novel support system of the telescope keeps the figure of the telescope close to this accuracy as the telescope is moved in elevation.

MERLIN technology advances

A feature of the MERLIN concept is the radio frequency phase control at each telescope site necessary for real-time interferometry. This involves the measurement and subsequent correction of the path length to each telescope to an accuracy of 1 picosecond, equivalent to 0.3 mm in path length. This path to Cambridge takes the signal via link towers at Camp Hill, Clee Hill, Charwelton, Sandy Heath and Madingley (see figure 1).

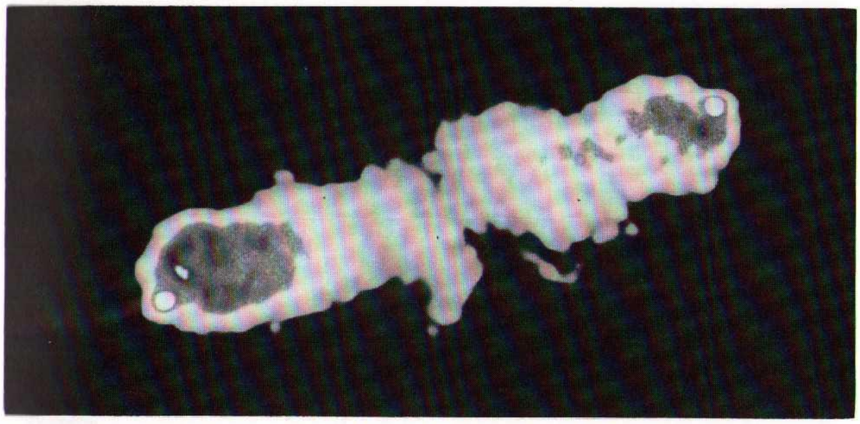


Figure 3: The powerful radio source Cygnus A mapped with MERLIN at 151 MHz. The bright structure at the outer edges of the lobes is being activated by jets from the central object (not seen at 151MHz).

A major improvement in the sensitivity of MERLIN is being achieved by advances on two fronts. In the first, high performance receivers cryogenically cooled to 14K are being installed on all MERLIN telescopes. In the second, the bandwidth of the astronomy signals being transmitted back to Jodrell Bank over the microwave link is being increased three-fold. The resulting five-fold increase in sensitivity of MERLIN opens up new areas of research in high angular resolution astronomy.

New science with MERLIN

The launch of the Hubble Space Telescope has highlighted the potential of high angular resolution optical and ultraviolet astronomy. A similar range of fascinating possibilities is available in the radio spectrum with the MERLIN extension covering stellar, galactic and extragalactic astronomy. Some areas of particular interest where significant new areas will be opened up are:

Stars from birth to death. The first signs of stellar birth have a radio signature — intense small diameter hydroxil (OH) ion maser beams from the gas cocoon around the new born star. The OH spectral line emissions delineate the gas clouds and give a direct measure of the high magnetic fields, velocities and densities in the collapsing gas clouds.

The exciting prospect of directly imaging the disk of a star is within the grasp of the MERLIN extension. The best example is the first magnitude red giant Betelgeuse which has a photospheric diameter of 0.08 arcsecond and an intensity of 2000 micro Janskys (μJy). MERLIN with its 0.05 arcsecond beam can 'map' Betelgeuse with a sensitivity of 40 μJy with 12 hours of observation.

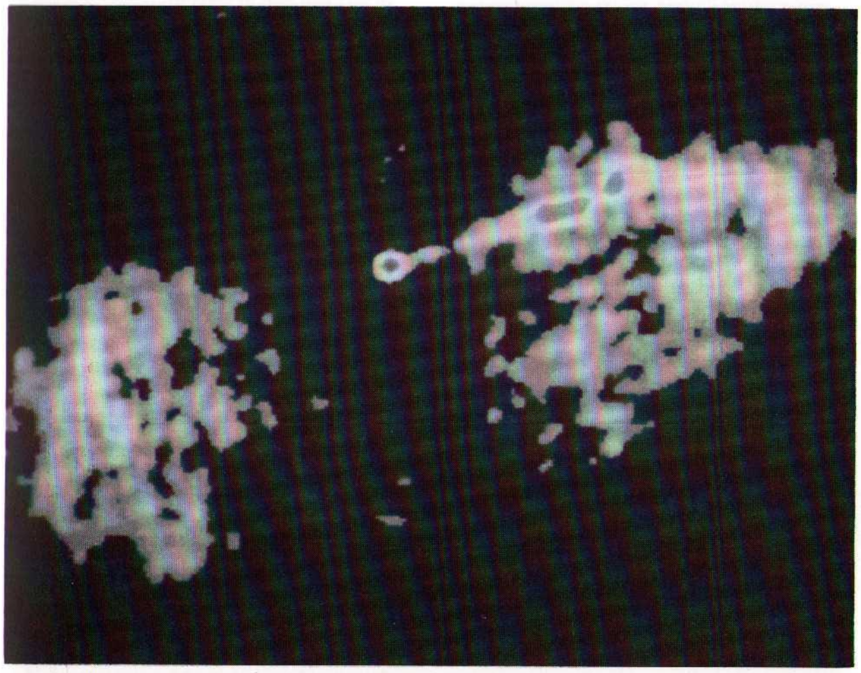


Figure 4: The Virgo A radio source mapped by MERLIN at 408 MHz. The structure is typical of active radio galaxies. The central source powers jets of relativistic particles which pass through the parent galaxy and eventually diffuse into intergalactic space.

Many types of interesting active stars often in binary systems have been identified at X-ray wavelengths. Although relatively weak at radio wavelengths, these can now be mapped with MERLIN. The radio emission is associated with mass transfer between components of double systems or from instabilities in the stellar envelopes.

During the death throes of stars, shells of processed matter rich in 'metals' are ejected from the surface. These form copious amounts of dust and produce molecular radio masers of OH, SiO and H_2O which are resolved into shells of emission by MERLIN. By solving the dynamics the distances of these systems are evaluated. Distances can be determined in this way for the masers in the dust-enshrouded centre of our Galaxy to give a galactic centre distance important for understanding the dynamics of our Galaxy.

Active galactic nuclei. The most powerful radio galaxies and quasars present fascinating problems for the astrophysicist, including the question of the source of power in the central engine and the mechanisms by which the energy is transferred to the extended outer lobes many times the optical galaxy in size (figure 3). MERLIN can map the jet as it leaves the central object and funnels its way through the parent galaxy into the intergalactic medium (figure 4 and on the back page). VLBI probes the innermost regions of the active galaxy where the jet first forms. Nearby mildly active galaxies with active nuclei or more widespread starbursts also hold clues to the origin of the activity. These are important areas of study where radio (MERLIN and EVN) and complementary optical studies (Hubble) can focus on important astrophysical problems.

Gravitational lenses. Einstein predicted the gravitational bending of light in his 1916 General Theory and extended the work to predict that a foreground massive object would produce 'images' of a background object on an adjacent line of sight. This effect was first actually observed on an object 0957+56 discovered in a Jodrell Bank survey of northern radio sources. Some dozen or so candidate gravitational lenses have been identified but have not yet been observed with sufficient angular resolution. The high sensitivity and high resolution of MERLIN is ideal for this purpose. A major outcome of these observations will be the measurement of the mass of the lensing galaxy and the accurate estimation of the hidden (dark) matter in these massive objects. Such dark matter is the subject of much speculation in modern astronomy and particle physics.

Professor R D Davies
Manchester University Nuffield Radio Astronomy Laboratories, Jodrell Bank.

UK participation in NASA's Lyman-FUSE

NASA, SERC and the Canadian Space Agency have agreed to collaborate in providing a major new space observatory, Lyman-FUSE, to study a wide variety of astronomical sources in a region of the electromagnetic spectrum which is largely unexplored, yet contains the bulk of the most important spectral lines of common elements in the Universe. The mission is described here by Dr Allan Willis of University College London.

In October 1989 NASA selected the Lyman Far-Ultraviolet Spectroscopic Explorer mission for launch in 1997 to study the far-ultraviolet (FUV) spectra of astronomical sources from planets to quasars at unparalleled sensitivity. Lyman-FUSE will open up the largely unexplored region of the spectrum between 900-1250Å which contains sensitive spectral line diagnostics of plasmas in the Universe spanning temperatures somewhere between 10 and 10^7 K. Its scientific mission will cover topics in planetary, interstellar, stellar and extragalactic astronomy and cosmology. In March this year SERC gave financial approval for British hardware participation in this mission, in return for which the whole UK astronomy community will be able to apply for observing time on the satellite, operated as a guest observer facility.

Lyman-FUSE is part of the future NASA explorer satellite programme, and will provide an observatory for spectroscopy of astronomical objects in the FUV spectral range from 900 to 1250 Å, at a very high spectral resolution of $\lambda/\delta\lambda = 30000$. Space-based instruments are required to observe in this spectral region since the atmosphere of the Earth strongly absorbs radiation at wavelengths shorter than 3000Å. Only the NASA Copernicus satellite, in operation from 1973 to 79, has observed the FUV region before, but was limited to looking at bright 'naked-eye' stars. By comparison, Lyman-FUSE has a sensitivity 100,000 times that of Copernicus and will measure — for the first time — sources both throughout our own galaxy and at very large extra-galactic distances. In addition to the high-resolution FUV capability, Lyman-FUSE will also carry a medium-resolution spectrograph ($\lambda/\delta\lambda = 300\text{-}600$) covering the extreme-ultraviolet (EUV) range from 100 to 900Å. This instrument will provide detailed spectroscopy of sources discovered in the first photometric EUV sky survey to be carried out by the British wide-field camera on the ROSAT satellite, launched in May this year.

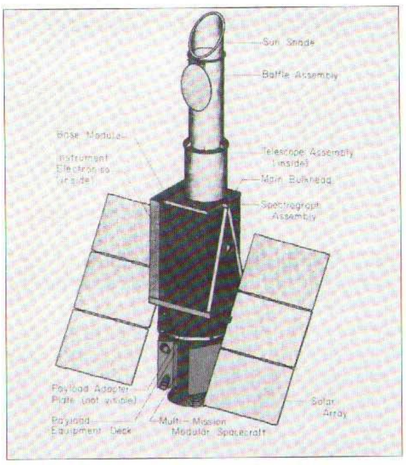


Figure 1: The Lyman-FUSE instrument mounted on the Multi-Mission Modular Spacecraft. (Picture: NASA)

The FUV region is inaccessible to the International Ultraviolet Explorer and the Hubble Space Telescope because their telescope mirrors and spectrometer optics, operated at normal incidence, are coated with materials which have a very low reflectance below 1200Å. However, recent advances in the technological development of glancing-incidence telescope mirrors (often employed for X-ray astronomy) now allow for both high throughput and the good image quality needed to match the high spectral resolution required for FUV spectroscopy. The high FUV sensitivity of Lyman-FUSE is achieved with a 70-cm glancing incidence Wolter-II telescope, providing about 1 arcsec image quality, feeding efficient FUV and EUV spectrometers both employing photon counting electronic detectors.

The overall system throughput in the FUV will be around 50-100 cm^2 allowing observations of unreddened hot sources as faint as 18th magnitude. In the EUV the system throughput will be about 5-20 cm^2. The instrumentation will be placed on the NASA Explorer Bus using a Shuttle launch, and operated in a low 28 degree orbit, with a minimum operational lifetime of three years (figure 1). Lyman-FUSE will provide the first detailed astronomical spectroscopy in these FUV and EUV wavelength ranges at high sensitivity, filling the gap in the electromagnetic spectrum between the HST and the future major NASA and ESA X-ray missions, AXAF and XMM (figure 2).

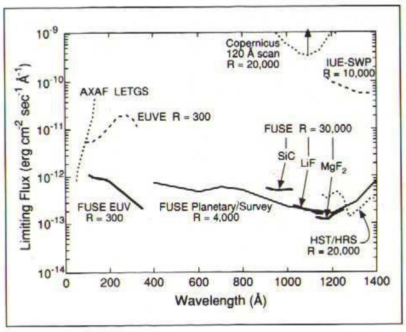


Figure 2: The sensitivity of Lyman-FUSE compared to other UV and EUV missions — the most sensitive instruments are at the bottom of the graph. Lyman-FUSE will fill the gap in spectral coverage between the HST and AXAF/XMM at comparable sensitivity. (Picture: NASA)

FUV and EUV spectroscopy

The FUV and EUV spectral windows to be opened up by Lyman-FUSE will provide a unique access at unparalleled sensitivity to many critically important atomic and molecular species for astrophysics. These include the resonance lines of atomic and molecular hydrogen, and its isotope deuterium which was formed in the furnace of the Big Bang. In addition, most of the resonance lines of the most chemically abundant species in a wide range of ionisation states fall into Lyman's window, providing measurements of gas and plasma in the Universe at temperatures spanning a few tens of degrees to more than ten million degrees (figure 3).

Important spectral diagnostics in the Lyman-FUSE wavebands include:

- resonance lines of atomic and molecular hydrogen and deuterium
- the Lyman and Werner bands of molecular H_2 and HD
- the resonance lines of HE I and HE II
- resonance lines of many ionisation stages of common species, like N I-V, P II-V, S III-VI, C I-III, O II-VI
- the resonance lines of the noble elements argon and neon
- strong lines of highly ionised plasmas, up to 2 x 10^7 K.

Scientific mission

The Lyman-FUSE scientific mission will be broad and fundamental, providing crucial observations of objects as diverse as planetary magnetospheres, the interstellar medium, stars of all types, active galaxies and quasars, and the inter-galactic medium. For example it will be able to:

- measure the deuterium abundance in a wide variety of environments throughout our galaxy, in other galaxies and in the intergalactic medium to provide an unambiguous determination of the primordial D/H value and a crucial test of models of the Big Bang cosmology;

- observe the resonance lines of neutral and ionised helium in high red-shift objects to determine the temperature and density of the intergalactic medium;
- characterise the temperature, density and velocity structure and ionisation mechanisms in active galactic nuclei and quasars;
- study the hot interstellar gas in the disks and halos of galaxies to determine the physical and dynamical structure and origin of this plasma;
- study the gas and dust in cold interstellar clouds in the Galaxy and metal-poor Magellanic Clouds, and the interface regions between the hot and cold phases of the inter-stellar medium;
- measure the detailed ionisation and velocity structure of the stellar winds associated with the ubiquitous phenomenon of mass loss across the H-R diagram;
- investigate the hottest remnants of advanced stellar evolution (hot subdwarfs, planetary nebulae nuclei, white dwarfs);
- provide detailed studies of accretion phenomena and interaction processes in X-ray binary systems, cataclysmic variables and symbiotic stars, where the bulk of the accretion emission occurs in the FUV and EUV;
- provide detailed studies of the FUV and EUV emission lines of the chromospheres, transition regions and coronae of cool stars and in stellar flares, to determine the structure and energy-balance of these outer heated regions;
- contribute to an understanding of the magnetospheres of the outer planets, plasma sources, sinks, rotation rates and energetics, together with measurements of primordial abundances in the Solar System, particularly of the noble elements.

UK participation

In addition to the launch and Explorer Platform, NASA will provide the instrument structure, telescope and spectrometers, together with the ground-station and Science Operations Centre; the UK will provide the Fine Error Sensors (jointly with Canada), the Slit-Wheel Assembly and the instrument module main electronics and low voltage power supply (figure 4). Canada will also provide the telescope baffle system. The British hardware will be provided by the Mullard Space Science Laboratory (MSSL) of University College London, the Department of Space Research at Birmingham University, the Rutherford Appleton Laboratory and British industry. Overall management of the UK programme will be provided by the Space Science Department at RAL.

The Fine Error Sensor (FES) images the telescope field of view and is used for object acquisition, tracking and guidance, and diverting light from the telescope to the spectrographs, via the slit-wheel. The FES will be provided jointly with Canada, with RAL, the Space Research Group at Birmingham University and British industry playing leading roles.

The Slit-Wheel Assembly will be built by MSSL and is the central instrument diverting the telescope image through slits to the FUV and EUV spectrographs.

The main instrument electronics, memory and power supply will be developed by RAL and British industry, and provides the central electronic processing unit for all the experiment functions including the main memory, involving the FUV and EUV detectors, the FES and slit-wheel.

In return for this hardware, the whole UK astronomical community will be able to apply for viewing time on Lyman-FUSE which, like IUE, will be operated as a guest observer facility. Observing proposals generated by the astronomers from the three participating countries will be assessed on scientific merit by a single Time Allocation Committee, with British, US and Canadian membership, which will allocate time on the satellite. The scope and breadth of the scientific mission is such that we expect the British user community to be large, embracing most groups in the country, reflecting past IUE usage and ROSAT involvement.

The UK has been at the forefront of ultraviolet astronomy since its inception in the mid-1960s. Initially rocket- and balloon-borne observations were carried out by several dedicated instrumentation teams. In more recent years, however, the whole astronomical community has been able to use the highly successful International Ultraviolet Explorer, a joint NASA/ESA/UK satellite, launched in 1978 and still operational. In 1988 the British IUE project team, together with NASA and ESA, were honoured by US President Ronald Reagan with the Presidential Award for Design Excellence (see *SERC Bulletin* Volume 4 No 1, Spring 1989). The British participation in Lyman-FUSE will maintain this country's strength in this important field of modern astronomy into the next century.

Dr A J Willis
Department of Physics and Astronomy
University College London.

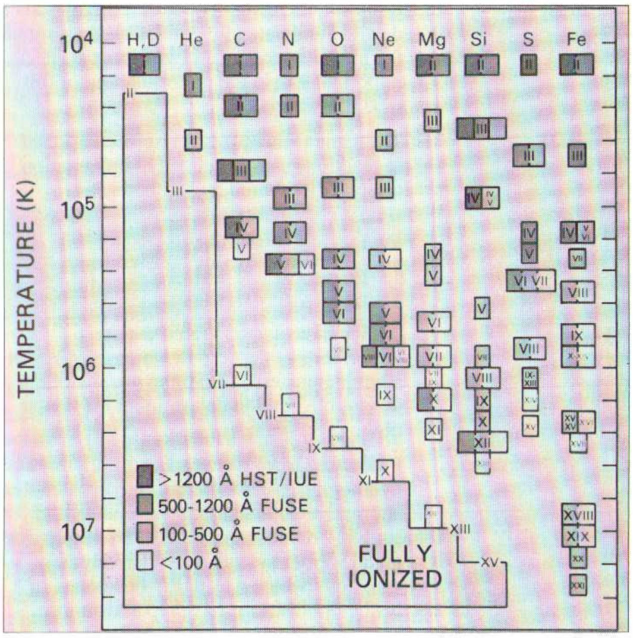
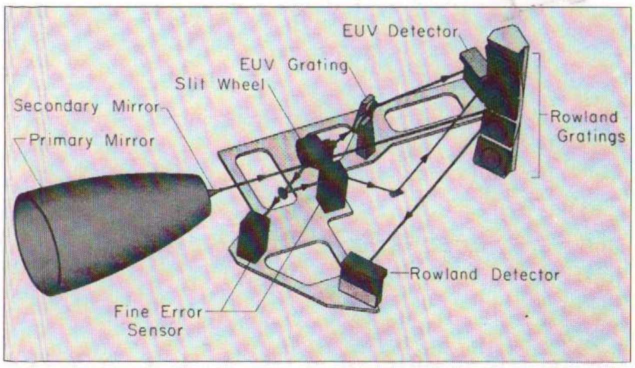


Figure 3 (left): An overview of the regions of the electromagnetic spectrum where the resonance and other strong lines of common ion occur, together with the characteristic temperature associated with each ion. (Picture: NASA)

Figure 4 (below): Schematic layout of the telescope and spectrometer optics. The UK will provide the Fine Error Sensor, Slit Wheel and instrument electronics (not shown) (Picture: NASA)



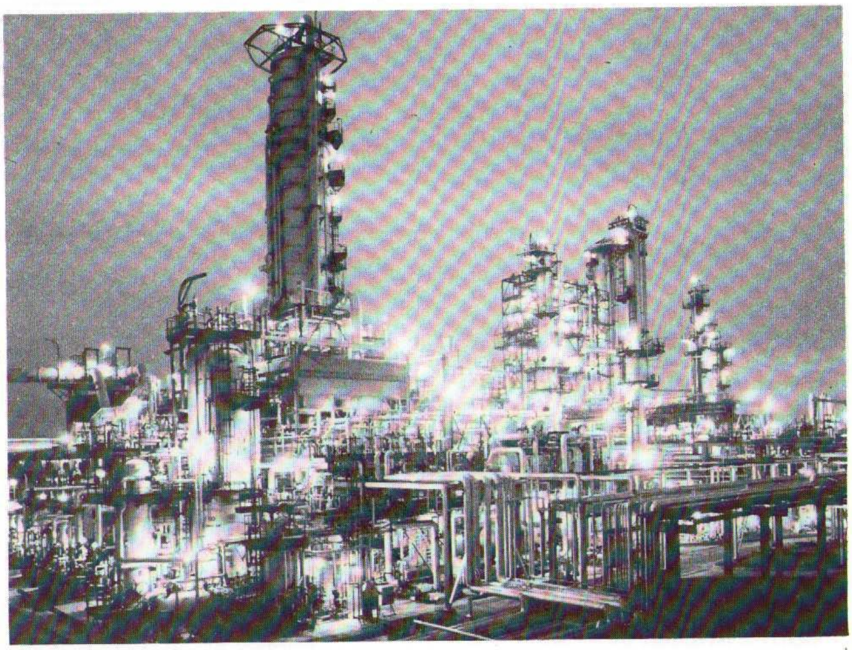
Understanding how catalysts work

The search for more active and safer drugs has led the pharmaceutical and fine chemicals industries to make increasing use of carefully tailored metal-containing compounds as catalysts since they increase the specificity of reactions, giving excellent yields of pure products. An understanding of the role of these catalysts is being gained by a combination of direct studies and an examination of the behaviour of model compounds. This is providing a rational basis on which to improve existing processes and devise new ones, writes Professor Reg Davis of Kingston Polytechnic.

Catalysis of chemical reactions has an impact on many facets of our lives, from enzymic reactions that control physiological functions, to large tonnage industrial processes that produce chemicals such as ammonia, a vital constituent of fertilisers. Recently manufacturers of pharmaceuticals and other speciality chemicals have been making increasing use of carefully tailored metal-containing compounds as catalysts since these show great specificity in their mode of action. Most of these catalysts consist of complexes formed between precious metals such as rhodium, palladium or platinum, and organic molecules (known as ligands) such as organo-phosphorous compounds. Such complexes dissolve in the reaction medium to form a single phase system and are known as homogeneous catalysts. Their role is to assemble the chemical reactants around the metal atom and to promote the formation of new chemical bonds.

Achieving a detailed understanding of how catalysts work is not easy. One of the main reasons is that the catalyst is used in much lower concentration than the reactants. Also, the complex added to the reaction may itself undergo some chemical changes before it is in the form required to promote the reaction. This active form may be present in even smaller concentrations and will be continually changing its structure as it becomes engaged in the different stages of the catalytic cycle that leads from reactants to products.

Despite these problems, a detailed knowledge of the way in which many catalysts work has been gained by direct studies of the reactions, often involving the use of spectroscopic forms of analysis, and by indirect studies of reactions of model compounds. To achieve this understanding, access to sophisticated instrumentation such as spectrometers has to be matched by the intuition of chemists concerning which are the appropriate model compounds to study. It also requires synthetic skills to make and purify the chosen models.



A petrochemical plant using catalytic reactors.

This combination is well illustrated by the work of Dr John Brown and Professor Malcolm Green, both of Oxford University. They are studying reactions catalysed by transition metal complexes, such as the addition of a molecule of hydrogen to carbon-carbon double bonds of organic molecules, for example alkenes and their derivatives. This type of reaction forms the basis of the industrial method for producing L-DOPA, a drug used in the treatment of Parkinson's Disease.

DOPA can be produced in two forms (termed D and L), the structures of which are mirror images of each other. Only the L-form is physiologically active and Brown's aim has been to study the mechanism of the hydrogen addition reaction in the presence of a catalyst which predominantly produces this form. He has made a number of studies in recent years, which have complemented those of chemists in other parts of the world. As a result of this intense effort, it is probably true to say that more is known about the details of this type of reaction than any other process involving homogeneous catalysis.

Before Brown's work, it was already known that the catalyst reacts with the alkene derivative to form an intermediate capable of existing in two forms which can rapidly interconvert. However, only one of these is involved in producing the desired L-form and this is the minor component. In order to maximise the yield of the L-form, it is important to understand the factors that affect the stability of the two forms and the process of their interconversion. Brown has tackled this problem using a sophisticated nuclear magnetic resonance (nmr) spectroscopic technique known as the DANTE method, which was originally devised by Professor Ray Freeman of Cambridge University. This has led to a detailed understanding of the mechanism of the interconversion, and so filling in an important gap in the understanding of this type of reaction.

The same technique has also been applied to reactions using a related hydrogenation catalyst discovered by Professor Sir Geoffrey Wilkinson at Imperial College, London. Again, some long-standing puzzles concerning the mechanism of its action have been resolved and additional computer-aided molecular modelling studies have demonstrated the great importance of the step in which a hydrogen atom is transferred from the metal atom to the double bond in determining the course of the reaction.

Professor Green has also been studying this hydrogen transfer step, but he has taken the alternative approach of synthesising and studying model compounds. By employing metal vapour synthesis, a relatively new technique which was partly developed in his laboratories, he has prepared an iron complex containing both a hydrogen atom and ethene (the simplest molecule containing a carbon-carbon double bond) bound to the metal atom. By using nmr techniques, it has been possible to show that the hydrogen can move to the ethene, paralleling part of the catalytic process. Also, it has been found that the hydrogen adds specifically to the nearest carbon atom of the ethene, forming a metal-bound ethyl group, and that this process is reversible, in agreement with Brown's mechanistic work.

Green and his colleagues have also been among the first to synthesise model compounds that freeze out stages of this transfer step. The compounds that do this contain a hydrogen atom that is bonded to both the carbon of the ethyl group and the metal. In making such compounds they have approached the problem from the other direction, by designing molecules that contain an ethyl group which might be expected to be distorted in this way. This represents the intermediate stage in the movement of hydrogen from metal to carbon and vice versa. Molecules that show this type of three-centre bonding are entirely novel and Green has coined the term 'agostic' to describe them (the Greek word *agostos* means to draw something towards oneself, as the metal draws in the hydrogen from the ethyl group).

The work of these two groups of Oxford chemists is providing an understanding of a number of important fundamental processes in catalysis and organometallic chemistry and represents some of the most exciting recent advances in this area. Additionally, the value of this detailed understanding of processes of this type is that it allows chemists to adopt a rational approach in designing new catalysts. This avoids having to rely on hit-and-miss screening programmes in which large numbers of compounds are tested for activity, a process which is both tedious and time consuming.

Professor R Davis
Kingston Polytechnic

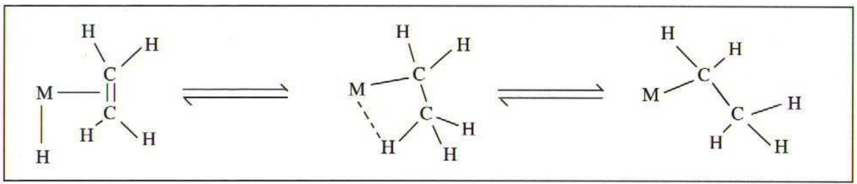


Figure 1: How a hydrogen atom is transferred between a two-carbon unit and a metal atom. Each stage in these processes has now been demonstrated.

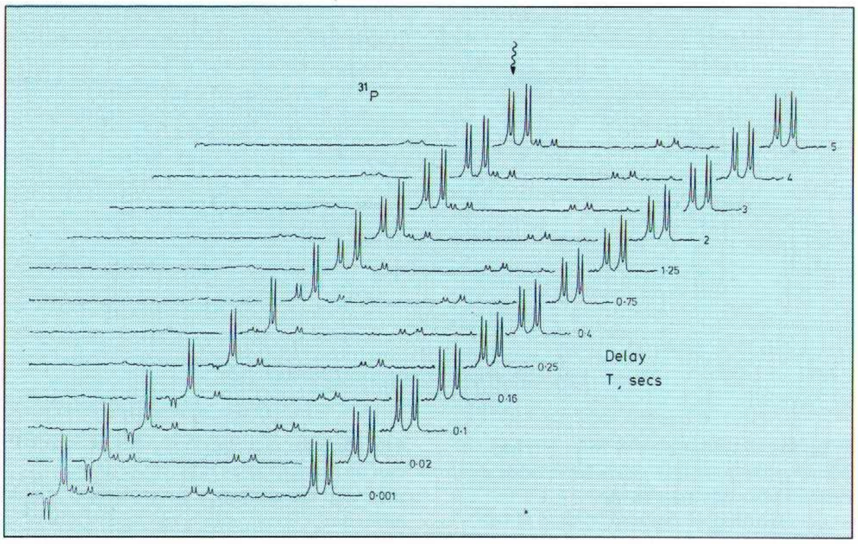


Figure 2: Nmr spectroscopy trace obtained from applying the DANTE method of Morris and Freeman to a rhodium catalyst.

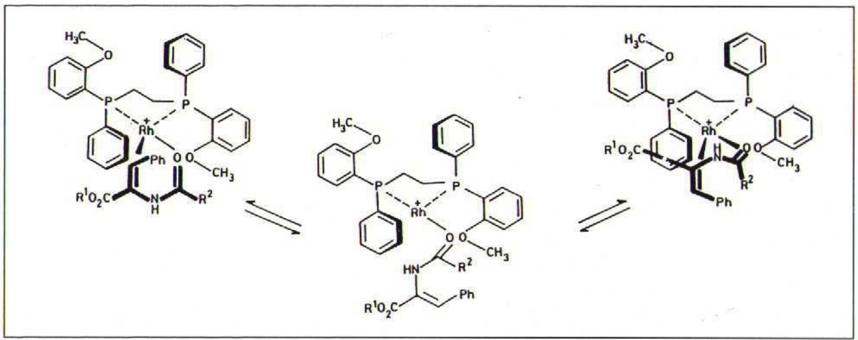


Figure 3 (shown right): Structure of intermediates in rhodium asymmetric hydrogenation and their dynamic interconversion pathway.

Atmospheric chemistry

A major new programme to study in the laboratory the chemical processes that occur in the atmosphere was launched by SERC in May. The seven-year research programme has a proposed budget of £4.4 million and will have £0.4 million to allocate in 1990-91.

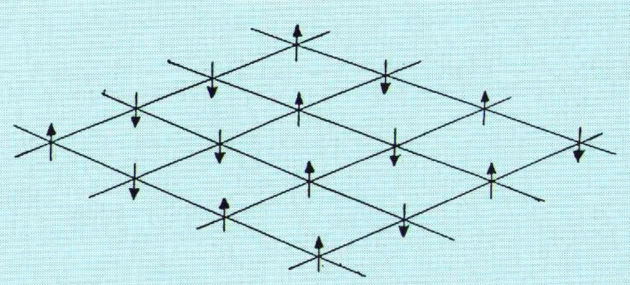
The programme is designed to stimulate laboratory-based studies of the detailed chemical processes that take place when pollutants are released into the atmosphere. A thorough understanding of these processes is essential if the effects of atmospheric pollutants are to be predicted accurately and if effective control measures are to be devised.

It is expected that researchers in the fields of gas-phase kinetics, an area of traditional strength in the UK, will play an important role in the programme. The initiative will also put a considerable emphasis on heterogeneous chemistry, an area that has received less attention in the past.

Among the major environmental problems to be considered under this programme will be the destruction of the atmospheric ozone layer by chlorofluorohydrocarbons (CFCs), acid rain, photochemical air pollution and aspects of the greenhouse effect. Studies of the chemical processes taking place in the unpolluted atmosphere will also form an integral part of the programme.

Professor Ian Smith of Birmingham University is the Chairman of the programme's management panel and **Dr Chris Anastasi** of York University has been appointed Coordinator. The SERC contact is **Dr Helen Brownlee**, telephone (0793) 411263.

Two-dimensional statistical systems


THE TWO-DIMENSIONAL ISING MODEL

With the development of Superstring Theory, the past few years have seen a remarkable advance in our understanding of the unification of the nuclear forces with gravity. One of the most surprising outcomes of this has been the realisation that the mathematics describing the Superstring also describes the critical behaviour of two-dimensional statistical systems. Dr Paul Mansfield of Oxford University takes a look at the critical behaviour of two-dimensional statistical systems, the Ising model and Conformal Field Theory.

The reason for surprise is that the models of statistical mechanics describe experimentally realisable systems that are characterised by energies of a few electron volts. For example the Ising model simulates a variety of physical phenomena such as the transition between two types of magnetic behaviour (ferro- and para-magnetism), or the transition between liquid and gas.

However the Superstring energy scale is the so-called Planck mass that arises in quantum gravity and is of the order of 10^{28} electron volts. This means that even the particles studied by high energy physicists are described by the low energy behaviour of Superstring Theory, where the strings shrink down to effectively point-like objects. The essential 'stringiness' of the Superstring is only revealed at extremely high energies such as were present at the birth of the Universe. That the mathematics describing this 'stringiness' should apply equally well to two-dimensional magnets and other condensed matter systems shows both the power of the modern mathematical description of nature and the well known effect that pure research in one field often throws light on apparently unconnected subjects.

The simplest two-dimensional Ising model can be thought of as describing atoms placed at the corners of a square grid. Each atom has a 'spin' which can be thought of as an arrow that points up or down. The atoms interact with an external magnetic field that tends to align the spins in one direction. Neighbouring atoms interact so that their spins point in the same direction as each other. At very low temperatures, therefore, where thermal fluctuations can be neglected, all the spins point in the direction determined by the magnetic field, and will do so even if the strength of the field is steadily reduced to zero. The magnetisation is proportional to the average value of the spins, so at low temperatures the Ising model shows spontaneous magnetisation. As the temperature is increased, thermal fluctuations become important, and these tend to destroy the alignment of the spins so that there is a critical temperature, T_c, above which there is no spontaneous magnetisation, and at T_c the model has a phase transition between a low-temperature ordered phase and a high-temperature disordered phase.

In 1944, Onsager solved this system in the absence of a magnetic field. His solution reveals two aspects of the phase transition that are generic to critical phenomena. First, because the critical point marks the onset of order, the individual spins are correlated over very large distances in comparison to their spacing, so near T_c they can be approximated by a quantity that depends smoothly on position. Such quantities are the 'fields' used by high energy physicists to study massive particles. Secondly, precisely at the critical temperature, the mass of the field vanishes. Because the value of the mass provides a scale against which other masses may be measured, the Ising model loses its scale at the critical temperature. This means that the system would look the same if we were to observe it through a microscope at different magnifications. It is called scale invariant. This is a property of the field theory that provides an effective description of the Ising model at its critical point; it is clearly not a property of the original square grid.

Until recently the most powerful tool in the study of critical phenomena has been the Renormalisation Group, which exploits the use of scale invariant field theory to derive a large number of approximate results. In the last few years, however, many of the two-dimensional critical systems have been solved exactly by exploiting an observation due to Polyakov that field theories which are unchanged by rotations and by displacements and which are also scale invariant are automatically unchanged by a wider class of operations called conformal transformations. These are transformations that preserve angles, and in two dimensions there is an infinite number of them. Displacements and rotations are special cases of conformal transformations. Operations that leave a system invariant are symmetries, and their existence provides a huge amount of information about such theories.

Physicists first developed Conformal Field Theory in the context of String Theory. A string, as distinct from a point particle, is an extended object. At any moment it occupies a curve in space. As time goes by it sweeps out a two-dimensional surface in space-time. Different kinds of string theories can be constructed by placing different field theories on that surface. A condition necessary for the consistency of the string is that those theories must be conformally invariant. So string theorists are interested in discovering all the two-dimensional conformal field theories, which, as we have seen, also describe statistical systems at their critical point. Furthermore the simplest Superstring is built out of precisely the field theory that describes the Ising model at criticality, the spins playing a crucial role in the construction of Superstring interactions.

One of the most exciting recent developments has been in the study of statistical systems slightly away from their critical points. Zamolodchikov, one of the founding fathers of Conformal Field Theory, has shown that the conformal symmetry is not destroyed, but only modified, so that the system remains highly symmetric. By using an old technique originally developed to study the strong nuclear forces, he was able to solve these systems exactly, providing yet another astonishing example of the application of ideas from one 'pure' branch of physics to another that is apparently unrelated but highly applicable.

Dr P R W Mansfield
Department of Theoretical Physics
Oxford University

Science and technology in Brazil

In Brazil, far-reaching economic plans for scientific and technical improvements are currently being implemented by the Ministry of Science and Technology. The 'RHAE' programme (Human Resources for Strategic Areas) has been set up to coordinate and resource the commissioning of international educational assistance and collaboration. One of the countries approached was the UK and it was arranged that the British Council would oversee the programme and SERC advise on the sources of expertise. Accordingly, in June 1989 a delegation travelled to Brazil. Their visit is described by Dr Paul Engel of Sheffield University and Dr Tony Gee of Cranfield Institute.

With the help of overseas advisers, Brazil has identified five priority areas as requiring long-term manpower resourcing, particularly in higher education. These areas are:

- New materials
- Biotechnology
- Fine chemistry
- Information technology
- Precision engineering.

The 'RHAE' programme aims to establish two-way interaction in these fields with developed countries through placing selected Brazilian nationals in higher education centres of excellence. In addition, overseas education/research specialists are required to help set up research activities and courses in Brazilian higher educational and research establishments. The programme, which is well funded, is intended to support about 2,000 trainees abroad.

The aim of the British delegation was simply stated: to sample and assess, in 10 to 14 days, the educational capabilities and needs of Brazil in the five chosen subject areas and the scope for UK assistance. This was no small task; a look at the map shows that the country extends over 35 degrees of latitude. It was clear this would require considerable organisation by the various authorities plus not a little stamina from those undertaking the task; both were forthcoming.

After briefings in Rio de Janeiro from the British Council local staff and in Brazilia, the capital, some 1000 km north, by the British Council's Science and Technology Officer for Brazil, Dr David Harrison, the delegation met officers of the Brazilian Ministry of Science and Technology, including the Deputy Minister. The delegation then split up and began a carefully arranged schedule of visits to about 70 centres chosen to match the five areas of expertise. Five visits in a day starting at 07.30 was not untypical. The Brazilians were most enthusiastic to interact and, to add spice to proceedings, several impromptu seminars were set up for delegation members with host academics or R & D staff, often continuing back at hotels.

The delegation's main impressions all round were of energy, determination and optimism. On the other hand, our hosts were acutely aware of the problems they face. Some of these are administrative, others are rooted in the country's economic difficulties. Brazilian scientists face great difficulties in purchasing imported consumables, spare parts and so on and are driven to ingenious stratagems to get round their own government's import controls. Similarly the policy of import substitution tends to encourage imitative R&D. This was particularly noted by the fine chemicals and computing science experts in the delegation and inevitably slows the growth of innovative research.

There were marked differences in the level and quality of research between some of the better equipped laboratories and others. It was also apparent that certain areas have been selected for special concentration of resources. In the biotechnology area, for example, high quality work was being done in plant cell culture and also in molecular parasitology, both areas relevant to Brazil's particular needs.

There is clearly scope for the UK to help in Brazil's RHAE training programme. The trainees are highly selected and would be welcome and able workers in most UK laboratories. There is a potential problem inherent in the programme, however, in that a returning trainee armed with a British PhD may not find it easy to function effectively under the much more difficult research conditions in Brazil. In some respects postdoctoral training might be more helpful for this reason.

There is certainly a need in Brazil for more information about UK laboratories. Traditionally Brazil has turned to the United States and some of the countries of continental Europe rather than the UK. Some British laboratories, however, seem to have established strong links and have already had a steady stream of young Brazilian scientists and engineers passing through in recent years.

Discussions are in progress over establishing a bilateral committee to supervise an Anglo-Brazilian training programme. In practice such a committee may find it difficult to keep the full picture in focus: the RHAE programme tends to award a block of training grants to an individual institution and the research director may choose to deal direct with UK labs without using the intermediary good offices of a central committee. It remains to be seen how well the machinery will work, but certainly, assuming that the RHAE programme remains intact, following the election of a new President and the introduction of radical new economic policies, the UK now has an opportunity to play a larger part than in the past in training Brazil's young scientists and engineers.

Dr P C Engel
Sheffield University

Dr A E Gee
Cranfield Institute of Technology

The British delegates to Brazil

Biotechnology — Professor Howard Dalton (Warwick University) and Dr Paul Engel (Sheffield University);

Materials science — Dr John Baldwin (Polymer Engineering Group) and Professor Fred Glasser (Aberdeen University);

Fine chemistry — Dr Simon Campbell (Pfizer) and Dr Keith Brent (Agricultural and Food Research Council Long Ashton Research Station);

Information technology — Dr Don Simpson (Brighton Polytechnic) and Professor Bob Bell (Loughborough University);

Precision engineering — Dr Tony Gee (Cranfield Institute);

Group Leader — Dr D Clark (Deputy Director of Programmes, SERC).

Third 'Framework Programme' (1990 - 1994)

In December 1989, the Council of Ministers reached a common position on a third Framework Programme (1990-1994) totalling ECU 5.7 billion (about £4.3 billion) which will overlap the current programme by two years. Under the new Framework Programme, European Community research activities will be grouped under the following six main areas:

Focal areas	Sums in million ECU	Proportion of total budget (%)
Enabling technologies		
1. Information and communications technologies	**2,221**	38.9
— Information technologies	1,352	
— Telecommunications	489	
— Development of technological systems of general interest	380	
2. Industrial and materials technologies	**888**	15.6
— Industrial and materials technologies	748	
— Measurement and testing	140	
Management of natural resources		
3. Environment	**518**	9.1
— Environment	414	
— Marine science and technology	104	
4. Life sciences and technologies	**741**	13.0
— Biotechnology	164	
— Agricultural and agro-industrial research (incl fisheries)	333	
— Life sciences and technologies for developing countries	111	
5. Energy	**814**	14.3
— Non-nuclear energies	157	
— Nuclear fission safety	199	
— Controlled thermonuclear fusion	458	
Management of intellectual resources		
6. Human capital and mobility	**518**	9.1
Total	**5,700**	**100.0**

At the time of writing the individual programmes were still under discussion in Brussels. SERC is keen to encourage British scientists to participate in community R&D programmes and, with the Research Councils' office in Brussels, is ready to offer help and advice.

Overall the new Framework Programme gives increased emphasis to research underpinning industry, and on the environment, with reduced emphasis on energy. Several of the new lines of action encompass continuations of existing programmes.

There will be substantial expansion of activities under the new sixth area, *Human capital and mobility*, which will include support for networks of centres of excellence and a European fellowships programme. Details of this and other programmes will be distributed by the Research Councils' Brussels Office as they become available.

Further information from:

Wendy Light
UK Research Councils' European Office
BP 10, Rue de la Loi 83
1040 Brussels
Telephone: 010 322 230 5275

Mrs Audrey Williams
International Section
SERC Swindon Office
Telephone: (0793) 411036

SERC/NWO umbrella meeting

The annual meeting of senior representatives of SERC and NWO (the Netherlands Organisation for Scientific Research) took place at SERC's Daresbury Laboratory on 1 June 1990. The meeting chaired by Professor Sir William Mitchell, Chairman of SERC, reviewed existing collaborations between the two organisations in astronomy and condensed matter research and considered areas in which new collaborative ventures might be undertaken.

Two major telescope facilities are currently operated in partnership by SERC and NWO; the Isaac Newton Group (ING) of telescopes on La Palma (in conjunction with Spain) and the James Clark Maxwell Telescope (JCMT) on Hawaii (in conjunction with the National Research Council of Canada and the University of Hawaii). The Netherlands astronomical community also has access to the UK Infrared Telescope (UKIRT) on Hawaii.

Scientists from the Netherlands pursue neutron scattering research on the ISIS neutron source at Rutherford Appleton Laboratory under the terms of an SERC/NWO agreement signed at the 1988 'umbrella meeting'. Collaborative projects using the Synchrotron Radiation Source (SRS) at Daresbury Laboratory are supported by an agreement between SERC and NWO which was renewed in 1989.

The meeting noted with satisfaction the excellent progress on the existing collaborations and while there were no formal collaborations in engineering, it was noted that links between UK researchers (SERC and university) and their Dutch counterparts existed, principally in the materials and information technology fields. During the course of discussions, several areas were identified where new collaborations on engineering topics might take place. These will be the subject of subsequent exploratory meetings between the two organisations.

For further information contact:

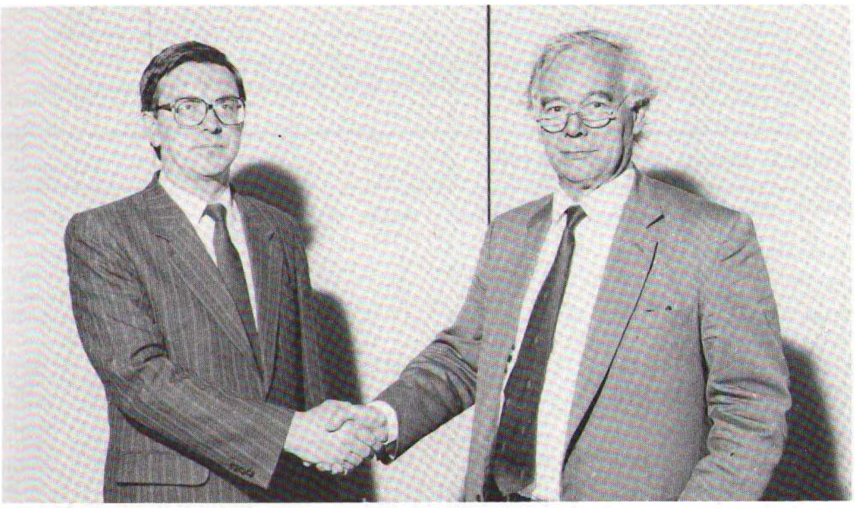
Roger Cann
International Section
SERC Swindon Office
Telephone: (0793) 411315

Collaboration . . .
. . . with the USSR

With the easing of international restrictions, SERC is anxious to develop its scientific relations with the USSR and hopes to build on the growing range of scientific collaboration already active with Soviet scientists. On 28 March the Director Programmes, Tony Egginton, met Academician Vainshtein and Professor Kiselev of the Institute of Crystallography of the Academy of Sciences to discuss collaboration.

Academician Vainshtein is Director of the Institute and Chairman of the Commission of the Soviet Academy of Sciences charged with developing UK/USSR relations. He responded positively to the idea of developing collaboration and was in favour of the suggestion of SERC having an *Aide Memoire* with the Academy of Sciences and this is now being pursued.

On 18 May a USSR State Committee of Science and Technology (GKNT) delegation visited the Council and during the visit a Joint Memorandum on collaboration in science and technology between GKNT and SERC was signed by Dr V Ezhkov, GKNT, and the Chairman of SERC. The Memorandum refers to the areas of science and technology regarded by GKNT as of priority national importance, including new materials, biotechnology and high temperature superconductivity. It is hoped that the Memorandum will further assist in collaboration between UK and Soviet scientists.



Dr V Ezhkov and Sir William Mitchell at the signing of the Joint Memorandum on collaboration.

. . . with Australia and New Zealand

Following a visit by the then Secretary of State for Education and Science Kenneth Baker, formal letters were exchanged between Ministers of the UK, Australia and New Zealand in the summer of 1989 under which a scheme was set up to encourage scientific collaboration between the three countries. The essence of the scheme is to enable research groups from the UK, Australia and New Zealand to work more closely together through the provision of small amounts of money for travel and other costs. It is hoped that these visits may act as a catalyst to secure more funding.

The scheme is concentrated on three science areas in which the major relevant Research Council is taking the lead. The areas, with the lead Council in brackets, are:

- global climate change (Natural Environment Research Council)
- biological and biomedical sciences (Agricultural and Food Research Council)
- advanced technologies (SERC)

The initial action in each area is a tripartite meeting. The first (global climate change) took place in New Zealand in November 1989 with a UK delegation lead by the SERC Director Laboratories, Dr Tony Hughes; the second (biological and biomedical sciences) was held in Australia in March 1990 and the third (advanced technologies) in June at Abingdon, Oxfordshire.

. . . with Spain

An agreement for the UK and Spain to collaborate in synchrotron radiation research was signed in Madrid on 9 July by Professor Sir William Mitchell and Professor Juan Rojo, Secretary of State for Universities and Research in Spain.

The three-year agreement follows from a Memorandum of Understanding that they signed in 1988. The new agreement provides for involvement of Spanish scientists and technologists with Daresbury Laboratory on a number of different levels, and aims to broaden the experience of and access to a synchrotron radiation source for Spain and to complement existing expertise at Daresbury by placement of Spanish technologists in selected areas.

The agreement also provides a framework for discussions between the UK and Spain on closer long-term collaboration in developing the Synchrotron Radiation Source.

Sir William commented that the Agreement was particularly significant as both countries are partners in the European Synchrotron Radiation Facility under construction in Grenoble.

NATO Advanced Study Institutes

Each year the NATO Scientific Affairs Division supports 60 to 70 Advanced Study Institutes in member countries. These are usually two-week tutorial courses at post-doctoral level conducted by leading scientists who present in-depth reviews of active research areas. They are intended to stimulate attendees, give direction to emerging research careers, and offer opportunities to establish working relationships with overseas scientists having similar research interests.

Funding is provided by NATO to individuals willing to direct Advanced Study Institutes. The grants cover direct organisational expenses, the travel and living expenses of lecturers, and a contribution to expenses of students from Alliance countries who cannot find sufficient support from other sources.

Deadlines for submitting NATO applications are January 15, April 15 and July 15. Application material can be requested from:

NATO Scientific Affairs Division
B-1110 Brussels, Belgium
Telephone: (32-2) 728 5096
Telex: 23-867 (NATOHQ)

Studentship numbers 1989-90

1989-90 report

The Council's Boards and Directorates allocated 5304 studentships for 1989 compared with 5112 in 1988. This included 915 awards for the information technology conversion course scheme which provides for honours graduates from other disciplines to receive training to masters level to help meet the increasing demand for information technology (IT) specialists. Also included were 140 advanced course awards made under the specially promoted Department of Education and Science's Engineering and Technology Programme ('Switch' awards) which are separately funded and provide an additional impetus to training in the engineering and technology areas.

From Table 1 it can be seen that by the 1 November 1989 a total of 4836 awards had been taken up — a slight increase on the 1988 total. Cooperative Awards in Science and Engineering (CASE) taken up by 1 November 1989 were however about the same (647 against 644 last year) but this was a lower proportion of the CASE target — 67% as against 77% last year.

In engineering the decline in CASE take-up was particularly marked, 196 compared to 277 last year. Similarly in biotechnology there was a marked drop in the number of CASE awards taken up from 37 last year to 26 this year and also in the proportion this figure represented of the CASE target: 82% down to 52%.

As in previous years, the absence of a closing date for CASE nominations narrowed the gap between take-up and provision as the awarding year has progressed but it is unlikely to close it and overall CASE take-up has been disappointing. By the 31 March 1990 CASE take-up had reached 746. A total of 423 (271 research studentship and 152 advanced course) 'appeal' awards were made in response to 380 research and 225 advanced course nominations from eligible candidates.

Demand for awards overall did not drop as much as had been expected . This in part was attributed to the increase in maintenance allowance approved in July 1989 and subsequent extension to the closing date for nominations.

No significant change in the quality of candidates in 1989 compared to the previous year has been identified with the exception of the increased number of candidates with first class honours degrees undertaking IT taught courses. However there was a small decrease (70) in the total number of eligible candidates who applied for awards compared with last year.

Table 1: Distribution of 1989 awards taken up as at 1 November 1989

(1989 targets agreed by Boards in brackets)

	APS	Engineering †	NP	Science	Biotech-nology	MSEC	Council CASE	DES Switch	Total
Research studentships									
Standard	75 (75)	588 (561)	59 (58)	937 (896)	34 (52)	145 (133)	– (–)	– (–)	1838 (1775)
CASE	6 (7)	196 (292)	3 (10)	310 (351)	26 (50)	75 (154)	31 (92)	– (–)	647 (956)
Instant	2 (2)	16 (24)	1 (2)	62 (70)	– (–)	2 (5)	– (–)	– (–)	83 (103)
Total RS	**83 (84)**	**800 (877)**	**63 (70)**	**1309(1317)**	**60(102)**	**222 (292)**	**31 (92)**	**– (–)**	**2568 (2834)**
Advanced course studentships									
Standard	15 (15)	1618‡(1718)	– (–)	329 (338)	23 (22)	52 (51)	– (–)	104‡ (183)	2141 (2327)
Instant	1 (1)	90 (96)	– (–)	20 (21)	– (–)	3 (8)	– (–)	– (–)	114 (126)
Total ACS	**16 (16)**	**1708(1814)**	**– (–)**	**349 (359)**	**23 (22)**	**55 (59)**	**– (–)**	**104 (183)**	**2255 (2453)**
Awards tenable overseas	**1 (3)**	**1 (5)**	**– (–)**	**8 (6)**	**– (–)**	**– (–)**	**– (–)**	**– (–)**	**13* (17*)**
Total	**100(103)**	**2509(2696)**	**63 (70)**	**1666(1682)**	**83(124)**	**277 (351)**	**31 (92)**	**104 (183)**	**4836 (5304)**

† Includes IT provision of 425 research, 300 advanced and 915 conversion course awards of which 434, 290 and 896 awards respectively were taken up.
‡ 36 of the 59 IT appeals subsequently transferred for funding under Switch, leaving 1207 IT and 140 Switch.
* Includes 3 overseas awards outside the Council's field, resulting from SERC's obligations under NATO Fellowships Scheme.

Table 2: Boards provision for 1990

	APS	Engineering †	NP	Science	Biotech-nology	MSEC	Council CASE	DES Switch	Tri-council	Total
Research studentships										
Standard	76	551	58	881	50	145	–	–	22	1783
CASE	7	291	10	336	50	160	92	–	3	949
Instant	2	24	2	70	–	5	–	–	–	103
Advanced course studentships										
Standard	15	1887	–	329	30	64	–	175	15	2515
Instant	1	110	–	21	–	8	–	–	–	140
Awards tenable overseas	1	5	–	6	–	–	–	–	–	13*
Total	**102**	**2868**	**70**	**1643**	**130**	**382**	**92‡**	**175**	**40**	**5503‡**

† Includes provision for IT and in particular 915 conversion course awards.
* Includes 1 overseas award for provision outside the Council's field, resulting from SERC's obligations under the NATO Fellowships Scheme.
‡ Includes 92 CASE Top Up awards subsequently provided.

All eligible first class honours candidates who applied for research studentships received an offer of an award. Fees-only awards taken up in the UK by candidates from other European Community countries increased from 121 in 1988 to 153 in 1989.

Plans for 1990-91

In keeping with Council policy, the number of students receiving postgraduate training will be maintained in 1990 with greater emphasis being placed on securing an increase in CASE take-up. Consideration is currently being given to ways in which interest in CASE can be stimulated.

A rise to the maintenance allowance for CASE studentships of £1000 a year was approved for new CASE awards starting in the 1990 academic session — comprising £250 a year from SERC and £750 a year mandatory contribution from the cooperating body.

Additionally a modification to the Appeals exercise was made so that Departments either without or with a CASE quota which had been fully allocated could nominate suitably qualified candidates against awards which had not been taken up. Historically CASE places not taken up at the Appeals stage have been 'pooled' with unused quotas of standard research awards to the detriment of the CASE scheme as subsequent awards made have been predominantly standard research awards. The creation of a separate CASE Appeals provision should help redress this imbalance.

Council has approved the allocation of 5411 studentships, including the DES provision of 173 Switch awards, for 1990-91 (compared with 5161 and 183 respectively for 1989-90).

Full details of the distribution of studentships to be made in 1990 are given in Table 2.

Thesis submission rates for research students

Under the alternating biennial review system, provision of research studentship quotas will not be considered again until November 1990. As part of the pressure to improve submission rates, Departments with a poor thesis submission rate have been subjected to a cut in the provision of quotas of standard research studentships allocated to them unless special circumstances prevailed. Currently the minimum level to escape a mandatory sanction is set at 35% of SERC's research students submitting of those who started their training four years previously excluding terminations in the first year. This represented an increase of 10% on the level enforced in 1987.

The overall position on submission rate performance within four years is a follows:

1985	1986	1987	1988	1989
53%	59%	61%	62%	64%

The five and six year submission rates are:

1987	1988	1989
72	73	78

The objective is for all Research Councils to achieve a 70% submission rate after four years and 85% after five years.

An analysis of the latest exercise covering SERC research students starting in 1985 by institution is set out below.

Table 1: Submission rates for a research degree

	Nos starting in 1985	Nos submitting by 1.10.89	Percentage submitting
Universities of England:			
Aston	22	12	55
Bath	44	31	70
Birmingham	62	39	63
Bradford	24	11	46
Bristol	67	36	54
Brunel	14	10	71
Cambridge	161	122	76
City	12	5	42
Cranfield Institute of Technology	21	8	38
Cranfield RMCS	2	1	50
Durham	31	20	65
East Anglia	29	17	59
Essex	14	12	86
Exeter	18	13	72
Hull	14	9	64
Keele	10	8	80
Kent	20	16	80
Lancaster	24	18	75
Leeds	74	65	88
Leicester	34	26	76
Liverpool	62	45	73
London:			
Birkbeck College	13	8	62
Imperial College	144	91	63
King's College	42	21	50
Queen Mary and Westfield College	39	22	56
University College	57	30	53
Royal Holloway and Bedford New College	12	7	58
Other institutions	38	13	34
Loughborough	20	8	40
Manchester	94	57	61
UMIST	71	45	63
Newcastle	37	28	76
Nottingham	84	61	73
Nottingham University Medical School	2	0	0
Open	7	3	43
Oxford	156	120	77
Reading	27	19	70
Salford	20	13	65
Sheffield	50	33	66
Southampton	83	52	63
Surrey	28	16	57
Sussex	46	34	74
Warwick	45	25	56
York	23	15	65
University of Wales:			
Aberystwyth	24	15	63
Bangor	8	3	38
Cardiff	49	27	55
Swansea	25	11	44
Universities of Scotland:			
Aberdeen	21	15	71
Dundee	14	9	64
Edinburgh	78	52	67
Glasgow	56	30	54
Heriot-Watt	25	14	56
St Andrews	31	21	68
Stirling	7	3	43
Strathclyde	38	24	63
University of N Ireland:			
Queen's	4	3	75
Total universities	2277	1472	65
Total polytechnics *	93	40	43
Other institutions *	17	5	29
Grand total	**2387**	**1517**	**64**

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

Table 2: Submission rates by SERC Boards and Directorates

	Nos starting in 1985†	Nos submitting by 1.10.89	Percentage submitting
Science Board:	1338	917	69
Biological Sciences	491	330	67
Chemistry	521	369	71
Mathematics	139	100	72
Physics, and SBA	187	118	63
Engineering Board	855	464	54
Astronomy and Planetary Space Board	79	53	67
Nuclear Physics Board	61	47	77
Biotechnology Directorate	54	36	67
Grand total	**2387**	**1517**	**64**

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

Fellowships 1990

Allocation, applications and awards in 1990 for the various Fellowship Schemes

Type	Allocation	Applications	Awards
Senior	4	38	4
Advanced	28	116	28
SERC/NATO Postdoctoral	64	241	66 *
RS/SERC Industrial	10	15	10
IT Fellowships	—	43	23 †

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

† Three at senior level (including one 'Logic for IT'), five advanced and 15 postdoctoral (including one 'Logic for IT').

Industrial fellowships

For 1990, Royal Society/SERC Industrial Fellowships have been awarded to:

Professor C Atkinson (Imperial College, London) — to Schlumberger Cambridge Research Ltd

Dr T Farrell (The Electricity Council) — to Liverpool University

Dr E J Fordham (Schlumberger Cambridge Research Ltd) — to Cambridge University

Dr D J Henwood (Brighton Polytechnic) — to B & W Loudspeakers Ltd

Dr N Jenkins (Kent University) — to Celltech Ltd

Dr J P Turner (Manchester Polytechnic) — to Creation Ltd Wigan

Senior fellowships

Senior Fellowships have been awarded to **Dr P V E McClintock** of Lancaster University, **Dr R J Nicholas** of Oxford University, **Professor G A Parker** of Liverpool University and **Dr G Ross** of Oxford University.

Dr Peter McClintock graduated in physics in 1962 from Queen's University of Belfast. He then moved to the Clarendon Laboratory at Oxford University, and was awarded his DPhil in 1966. He spent the two years 1966-1968 at Duke University, North Carolina, and has since been in the Department of Physics at Lancaster University, being promoted to a personal readership in 1983.

Dr Peter McClintock

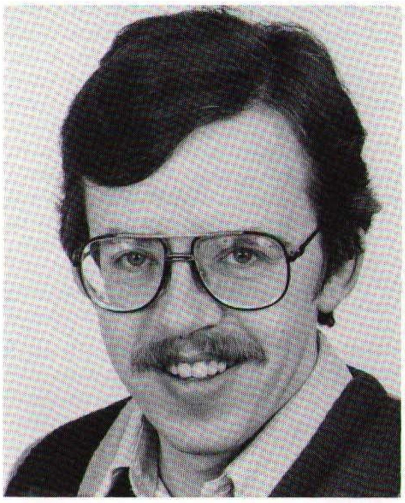
Dr McClintock's work at Lancaster falls into two distinct, but linked, sections: the breakdown of superfluidity in liquid helium-4; and the influence of random fluctuations (noise) on nonlinear dynamical systems.

The development of a technique for the preparation of isotopically pure ^{4}He and the measurement of the Landau critical velocity for roton creation through studies of the propagation of ions in the superfluid are among Dr McClintock's outstanding contributions to the field of liquid helium studies, for which he has an international reputation. During the term of his fellowship, Dr McClintock will be advancing recent work at Lancaster on the fundamental problem of vortex creation and extending the investigations to include the use of exotic ions. Complementary studies of modelling cosmic string production in the early Universe will also be pursued.

In nonlinear dynamics, Dr McClintock has pioneered the electronic modelling of stochastic systems and he intends to extend this work to cover periodically driven systems whose behaviour is already well understood in the purely deterministic limit. This will be a major contribution to both deterministic and stochastic nonlinear dynamics and has the potential to trigger new developments in both disciplines.

Dr Robin Nicholas graduated from Christ Church College, Oxford, with first class honours in Physics, and, following a three-year SRC research studentship, he was granted his DPhil in 1978. Since then he has been based at Oxford, and is presently a reader at the Clarendon Laboratory and a Fellow and Praelector in Physics at University College. He has been a Guest Scientist at the Max Planck Institutes on four occasions, and has also visited the University of Leoben.

During his career he has worked on the properties of a wide variety of both bulk and low dimensional semiconductors,



Dr Robin Nicholas

specialising in the use of high magnetic fields, infrared spectroscopy and electron transport. Dr Nicholas introduced the study of III-V heterostructures to Oxford, beginning in 1980, where it is now the largest part of the solid state research programme. Much of the work has been supported under SERC's Low Dimensional Structures and Devices (LDSD) programme, and has involved international collaboration with Bell Laboratories, Thomson-CSF Paris, Toulouse and Grenoble. Other fruitful collaboration has been undertaken with GEC Hirst and particularly with Philips Research at Redhill, the latter working on well defined GaAs-GaA1As quantum wells, superlattices and ultra-high mobility heterojunctions.

His research programme contains a number of strands, all concerned with the physics of low dimensional structures: the fascinating physics of the semi-metallic InAs/GaSb system; strained layer systems; and the properties of laterally patterned structures, in cooperation with the Rutherford Appleton Laboratory. The Clarendon is also currently installing a very high field (60T) pulsed magnet laboratory, which will provide an important tool to study the low dimensional structures.

Professor Geoffrey Parker FRS graduated from Bristol University with first class honours in Zoology in 1965 obtaining the Rose Bracker prize for the top honours

Professor Geoffrey Parker FRS

in biology. After his PhD at Bristol in 1968, he moved to Liverpool University where he was promoted through Assistant Lecturer, Lecturer, Senior Lecturer to Reader in Zoology. He was appointed to a personal chair in 1989, and elected a Fellow of the Royal Society in the same year.

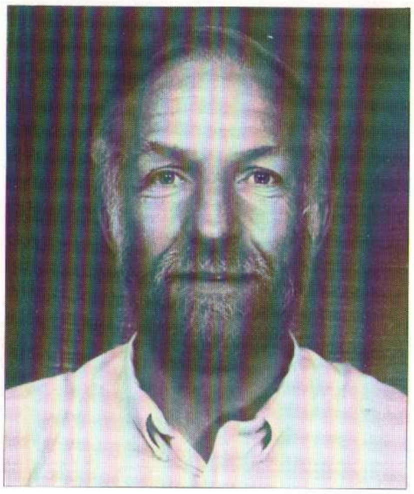
Professor Parker's research interests throughout his career have centred on the general area of evolutionary biology and especially on the development of concepts of adaptive strategies in reproduction, behaviour and life histories. He and other independent biologists made detailed quantitative analyses of the various behaviour patterns in terms of the selective benefits to individuals. In 1974-75 the various researches coalesced into the disciplines now known as sociobiology and behavioural ecology. Some of the main topics Professor Parker has worked on since 1965 are: the evolution of the two sexes, sexual selection, sperm competition and mating strategies, competitive mate searching, competitive resource use, evolution of animal fighting strategies, inter-familial conflict, evolutionarily stable strategies and life histories, and clutch and egg size in invertebrates.

During the course of his Fellowship, Professor Parker will undertake a major project on the evolution of complex life cycles, the evolution of optimal growth/reproductive strategies of parasites with a simple life cycle, harvesting efficiency and the evolution of virulence, coevolution with hosts, optimal egg, larval and adult size in parasites, insect life cycles, and a general model of reproductive expenditure. Subsidiary projects include work on the evolutionary biology of sperm competition and the evolution of phenotypic optima.

Dr Graham Ross graduated from Aberdeen University in 1966 with first class honours in Natural Philosophy. He then moved to Durham University where he was awarded a PhD in High Energy Physics in 1969. Between 1969 and 1984 he spent five years as a research associate at the Rutherford Appleton Laboratory, two years as a senior research fellow at CERN, two years as a Senior Research Associate at California Institute of Technology, three years as an SERC Advanced Fellow at Oxford and three years as an Atlas Fellow at Pembroke College Oxford. Since 1984 he has been a Lecturer — and is now Reader — in the Department of Theoretical Physics at the University of Oxford.

Dr Ross has an outstanding international reputation as a theoretical physicist. His research has ranged from formal theoretical development to purely phenomenological issues. For example, he was an author of one of the fundamental papers justifying the methodology of quantum chromodynamics and, he was one of the predictors of three-jet events in electron-positron anihilation, the discovery of which directly established the existence of the gluon. In addition to his significant achievements in QCD theory, he has had a major impact on the development of a unified electroweak theory and, more generally, on grand unified theories of all particle interactions. He is one of the few people who have grappled successfully with the problem of constructing a 'real world' model from superstring theories.

During the Senior Fellowship Dr Ross's research will centre on the theoretical description of the fundamental forces of nature: the strong, electromagnetic, weak and gravitational interactions. He hopes



Dr Graham Ross

this will develop further the theory, known as the Standard Model, which describes well the low-energy properties of the strong, electromagnetic and weak interactions.

Some new publications from SERC

Unless otherwise stated, all publications are available free of charge from SERC Swindon Office, telephone (0793) 41 + extension number.

Research grants
Copies of *SERC research grants September 1990* are available from Finance II Division, ext 1077.

Built environment
Copies of the *Review of the SERC Civil Engineering Research Programme 1983-88* (see page 15) are available from Mrs Sarah Toolen, ext 1493.

Nuclear physics
Copies of the *Particle Physics Committee Report 1988-89* are available from Mrs Pam Lennox, ext 1057; and the *Nuclear Structure Committee strategy review* from Mrs Sue Toolen, ext 1092.

Polymer research directory
The Polymer Engineering Group has published its second *Directory of publicly funded polymer research in the UK*, covering plastics, rubber, polymeric composites and structural adhesives. Copies are available from PEG, 5 Belgrave Square, London SW1 8PD, price £75 (£60 to BPF/BRMA members).

Royal opening of new RGO in Cambridge

On 14 June 1990 the new Royal Greenwich Observatory building at Cambridge was opened by HRH the Duke of Edinburgh before staff and invited guests from the UK and abroad. Prince Philip, after a tour of the building and presentations on some current RGO projects, unveiled a commemorative plaque. Both Professor Alec Boksenberg, the Director of RGO, and Sir William Mitchell, Chairman of SERC, expressed their appreciation to Cambridge University for its invaluable cooperation and support, and to all those in SERC and the astronomical community who contributed to the smooth transfer.

Prince Philip is welcomed to the new premises by Sir William Mitchell and Professor Alec Boksenberg (far right).

In his speech Sir William said: "Today's opening is the beginning of a new era for the RGO. We believe that in its new location, next to one of the finest university astronomy departments in the UK, if not in the world, the RGO will be able to provide an unequalled service to UK astronomers. It has some of the finest optical telescopes in the world and with its experience in designing and building first-class instrumentation will help the UK retain its place at the forefront of world astronomy.

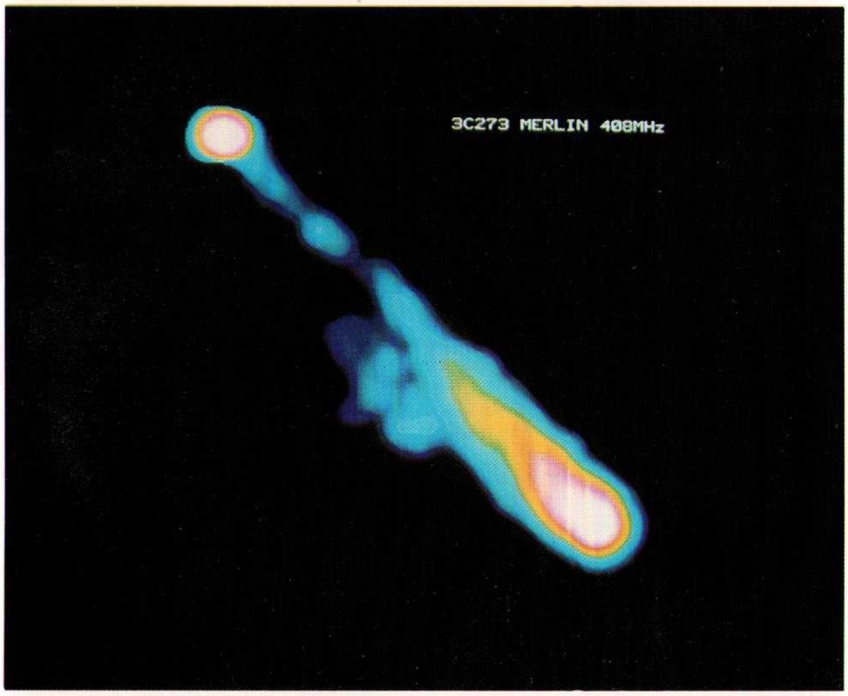
"I should like to congratulate all concerned both on the successful move from Herstmonceux and on the commissioning and operation of the William Herschel Telescope on La Palma. Both reflect great credit on the staff at RGO."

The new building has been much admired for its appearance and suitability, and reflects credit on the SERC Works Unit, which finalised the designs and supervised the construction and handover. It is fully equipped with laboratories, workshops, library, common room, offices etc as well as 'future-proofed' networking of power, data and telephones, and will provide a very appropriate base for RGO's operations into the next century. The removal itself was completed on schedule during the last week in March and the first in April.

Without wishing to minimise the personal upheavals inherent in a relocation, it has been a feature of the move that virtually all staff have achieved their first preferences. With very few exceptions, those who wished to move with the Observatory have transferred to Cambridge, those who preferred to take early retirement or redundancy have done so, and those seeking placement elsewhere have been given the transfers they wanted. The constructive support and active involvement of the Trade Unions, by no means uncritical, has been indispensible in arriving at this result. About 70 staff have moved from the previous site at Hertsmonceux in Sussex to Cambridge, and a further 25 have been specially recruited, mostly locally. Staff are settling well into the building and the area.

There is every indication that the aim of close association with Cambridge University will be achieved. Aside from the organisational links formed by, for example, the merger of the RGO and Cambridge Starlink nodes, there are already many instances of contact and collaboration. For example, Astronomy Open Days were held jointly by the RGO, the Institute of Astronomy and Mullard Radio Astronomy Observatory on 16 and 17 June, following a Schools Day. These had a magnificent attendance of 3,000 visitors to the new RGO site.

Peter Bradbury



The quasar 3C273 at a redshift of 0.158 mapped by MERLIN at 408 MHz. It has a one-sided jet emerging from a bright compact central core (upper left). The core is resolved on milliarcsecond scales by Very Long Baseline Interferometry. SEE PAGE 18.