SERC BULLETIN

SCIENCE & ENGINEERING RESEARCH COUNCIL

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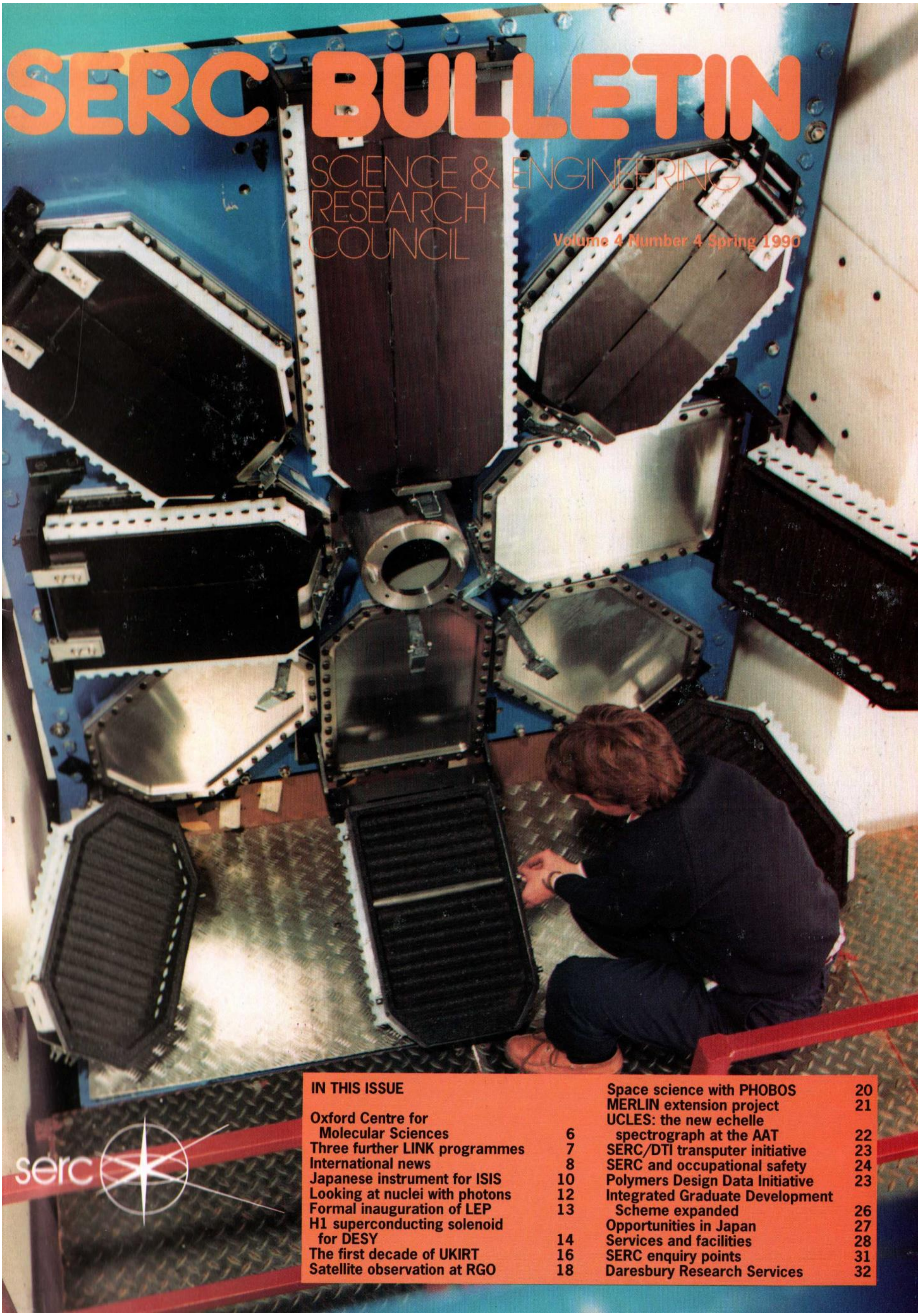

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The Science and Engineering Research Council is one of five research councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through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

Establishments of the Science and Engineering Research Council

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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

Zoë Bowden of the MARI team at Rutherford Appleton Laboratory begins to assemble the helium detectors for the low angle bank on the new Japanese neutron spectrometer for ISIS. Story on page 10.

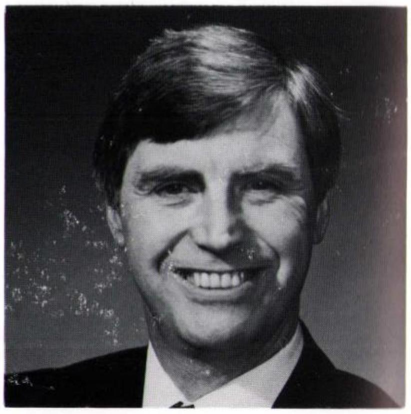
Professor Stephen Humble (1943-1989)

Stephen Humble, Director of the SERC-Department of Trade and Industry Teaching Company Scheme and Professor of Statistics and Operational Research at the Royal Military College of Science (RMCS), Shrivenham, died on 24 August 1989 after a sudden illness.

A particle physicist by background, between 1969 and 1975 Stephen Humble held posts with the (then) Science Research Council in Rutherford and Daresbury Laboratories and, as a Senior Visiting Scientist and Adviser to the European Universities Bubble Chamber Collaboration, at CERN in Geneva.

Despite considerable success in this field, his research interests then changed to studies of probability, risk analysis and reliability. He quickly gained recognition in his new academic career. From Sheffield City Polytechnic he moved to the RMCS in 1980, first as Associate Professor and then Professor of Operational Research and Statistics. In 1985 he became a Vice Principal of RMCS and Chairman of the newly formed School of Defence Management.

Professor Humble became Director of the greatly expanded Teaching Company and Integrated Graduate Development Schemes on 1 April 1988. He supervised the move out of SERC to the Cranfield Institute of Technology (parent body of RCMS).



Professor Stephen Humble

His major achievements were:

- to carry out a full analysis of the Scheme's objectives and management;
- to produce and gain approval of a corporate plan for the Scheme's future development and operation;
- to make rapid progress in the implementation of the plan.

Stephen Humble carried out these tasks with enormous energy and clarity of thought. The foundation he laid for the Scheme's future success is a fitting memorial.

Mitchell elected Vice President of ESF and CERN

Professor William Mitchell CBE, FRS, Chairman of SERC, has been elected a Vice-President of both the European Science Foundation (ESF) and CERN, the European Laboratory for Particle Physics. Professor Mitchell is a solid-state physicist by training and holds a personal chair of physics at Oxford University.

ESF is currently seeking to expand its activities in response to the increasing Europeanisation of scientific activities as a whole and, as Vice-President, Professor Mitchell will be closely involved in this process. ESF is an association of 53 member research councils and academies in 19 countries. It brings European scientists together to work on topics of common concern to coordinate the use of expensive facilities, and to discover and define new endeavours that will benefit from a cooperative approach.

CERN, which has 14 member states, provides world-class facilities for particle physics in Europe (see page 13). Science Minister Robert Jackson, commenting on Professor Mitchell's appointment, said: "Bill Mitchell, a Fellow of the Royal Society, has long experience of CERN and of European science generally which will be of great value in planning CERN's scientific development."

Council commentary

Among the topics discussed at the October and November 1989 Council meetings were the following:

More money for mission to the Sun

An increase in funds to £15.3 million was approved by the Council for UK participation in the pre-launch phase of the SOHO/Cluster project. This mission will deploy five spacecraft to probe the mysteries of the Sun's interior, the origins of solar wind and other related phenomena (see *SERC Bulletin* Volume 3 No 12, Autumn 1988). The project is the first Cornerstone mission of the European Space Agency's Horizon 2000 programme. Engineering models of the six instruments involving the UK are due for delivery to the spacecraft contractor early in 1992 with flight models due later that year. The launch is on course for 1995.

Equipment for research

The failure of the provision of research equipment in laboratories in academic institutions and SERC to keep pace with rapidly advancing experimental disciplines was reviewed by the Council. Based on experience with Interdisciplinary Research Centres, SERC has estimated that an injection of about £240 million is needed to provide modern equipment selectively in the subject areas that the Council covers. This compares with a recent survey commissioned by the Advisory Board for the Research Councils from Manchester University which found that additional equipment to the value of £260 million was needed and a further £200 million for research in new areas. This excluded medicine and free-standing computers. The Council has asked its Boards to locate particular problem areas within the general picture of under-provision.

Global environmental research

The conclusions of a report of an expert group on global environmental research set up jointly by SERC and the Natural Environmental Research Council (NERC) were discussed by the Council in October.* Called the NERC/SERC Expert Group on Global Environmental Research (NSEGGER) it was set up in late 1988 to advise the Chairmen of both Councils on important research that NERC and SERC should support. Following the report of the expert group, NERC and SERC have looked together at how the coordination of global environmental research could be improved. Proposals agreed by the Council include the establishment of a Global Environmental Research Coordination Office, an inter-agency committee with the Research Councils and government agencies and joint action on atmospheric sciences and instrumentation.

* *This report is not available on general distribution.*

Clean technology initiatives

A new environmental initiative — 'clean products and processes' — aimed at improving manufacturing techniques to make them environmentally cleaner is to be developed by SERC in consultation with the Agricultural and Food Research Council, the Department of Trade and Industry (DTI) and the Department of the Environment. It will focus on three themes: new clean processes, improving existing processes, and cleaning up industrial waste and pollution from the past.

New computing committees

Two new committees on computing were established. The Scientific Computing Advisory Panel, to be chaired by Professor P G Burke, is to provide an overview of computing matters directly for the Council across the scientific disciplines and a forum for considering the Council's computing strategy and future requirements. The second body, the Novel Architecture Computing Committee, chaired by Professor J T Stuart, will coordinate Council-wide activity in this rapidly developing field.

Plan for SERC Laboratories

An interim report by SERC's Director Laboratories, Dr Tony Hughes, on the role of SERC's four establishments in the 1990s was presented to the Council. The establishments are the two Royal Observatories and the Rutherford Appleton and Daresbury Laboratories. Scientific arguments have shown prima facie cases for a number of new capital facilities over the next ten years, including a vacuum ultraviolet / soft X-ray synchrotron ring and the use of ISIS for exotic radioactive beams for nuclear physics. In addition work will be required in the Laboratories for a gravitational wave detector and an extension of the ionospheric radar. Some of the new facilities should preferably involve small groups of countries in international collaborations. The plan will consider the balance of effort between the establishments and the universities and polytechnics in each case. The Council decided as the next stage to seek the views of the Boards on the interim report.

Studentships

In the 1989-90 awarding round, the closing date for nominations had been extended by two weeks to take account of the announcement of a £600 increase in stipends. At the normal closing date (31 July) the nominations were 20% down on the previous year but by the revised closing date nominations were essentially the same as last year. It appears that the increase (together with the abolition of means testing) had a significant effect on the level of nominations.

Information technology strategy

Mr Nigel Horne, Chairman of the Joint SERC/DTI Information Technology Advisory Board (ITAB), gave a presentation to the Council in November of the work of the Board set up under the Joint Framework for Information Technology, outlining its objectives, strategy and structure. DTI and SERC were, he said, together currently spending some £100 million a year on the support of IT and there were further substantial sums to come over the next five years from European programmes. Mr Horne said the ITAB's priorities were:

- to increase the productivity of IT research;
- to maintain the science base; and
- to provide the UK IT industry with a competitive edge.

More specific strategies had been established with clear technical and financial targets for each of the four areas within ITAB's remit. These priorities had been widely discussed and would be used to guide the recent call for new research projects in IT.

The application of IT to engineering research

The Engineering Board set up a working party in November 1988 under the chairmanship of Dr Nigel Kingsley of Eurotherm to consider, among other things, the scope for joint research programmes between the IT and other engineering committees and how to transfer the results of such IT research into other research fields in engineering. Dr Kingsley, in a presentation to the Council in November, gave 12 areas which the working party had identified where joint programmes would be useful. These programmes had been agreed by the Engineering Board and the academic community will shortly be invited to submit grant applications. The applications will be considered by the appropriate subcommittees of both the Engineering Board and ITAB and those approved will be funded from a central fund established by both.

STOP PRESS

Education and Science Secretary John MacGregor announced on 2 January the appointment of **Sir Mark Richmond** as the next Chairman of SERC, to succeed Professor William Mitchell on 1 October 1990. Sir Mark is currently Vice Chancellor of Manchester University.

Appointments on Council

The Secretary of State for Education and Science announced seven new appointments and two reappointments to the Science and Engineering Research Council in September 1989:

- **Professor Brian Fender and Dr Carol Jordan have been reappointed for one year;**

- **The new members are: Professor Thomas Blundell, Professor Philip Burke, Mr Derek Davis, Professor Alexander Donnachie, Mr Gerard Fairtlough, Dr Gordon Higginson and Professor J Trevor Stuart.**

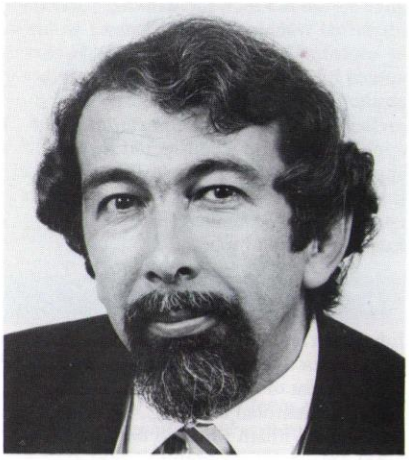
All the new appointments are for four years from 1 August 1989. They replace Professor Malcolm Jeeves, Professor Sir Robert Wilson, Professor David Davies, Professor Donald Perkins, Dr Alan Williamson, Mr David Shore, Sir Charles Reece and Sir Michael Atiyah. One further appointment remains to be made.

As a result of these changes SERC has made the following appointments within the Council:

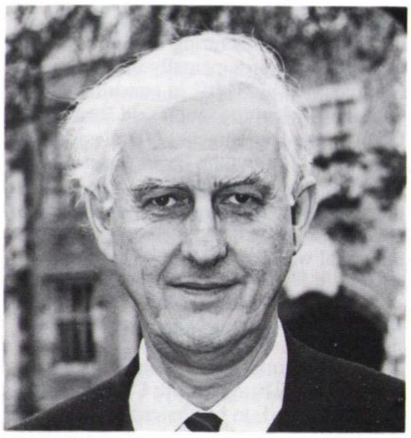
- Dr Gordon Higginson to be Chairman of the Engineering Board in succession to Mr David Shore.

- Professor Alexander Donnachie to be Chairman of the Nuclear Physics Board in succession to Professor Donald Perkins.

Professor Tom Blundell FRS is Professor of Crystallography at Birkbeck College, London, and Honorary Director of the Imperial Cancer Research Fund Unit for Structural Molecular Biology. For SERC, he has been a member of the Science Board and Chairman of the Biological Sciences Committee (1983-87) and has chaired panels that reviewed synchrotron radiation and the Biotechnology Directorate. He is also a member of the Agricultural and Food Research Council and the Advisory Council on Science and Technology. His research interests are in the biochemistry and structure of proteins, through the use of X-ray crystallography and computerised approaches.



Professor Tom Blundell

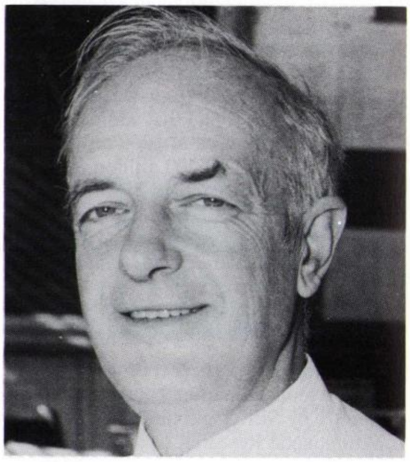


Professor Philip Burke

Professor Philip Burke FRS is Professor of Mathematical Physics at Queen's University of Belfast. In the 22 years that he has held that post, he has served on many SERC committees and panels, twice as Chairman of the Science Board's Computer Committee and most recently as Chairman of the Atlas Centre Supercomputer Committee, and as a member of the Plasma Physics and Fusion Panel. At the same time he was, from 1977 to 1982, Head of Daresbury Laboratory's Theory and Computational Science Division and, from 1986 to 1987 was on part-time secondment to the Rutherford Appleton Laboratory as Head of the Advanced Computational Science Group in the Atlas Supercomputer Centre. His research interests range from atomic and molecular physics, especially in astrophysics, laser physics and controlled thermonuclear fusion, to scattering theory and the application of computing in physics and chemistry.

Derek Davis is an Executive Board Member of the Central Electricity Generating Board (National Power Company), with special responsibility for technical planning, computing and environmental matters. Mr Davis spent his early career in the aircraft industry. He joined the CEGB in 1956 working on vibration and stress analysis problems. He then held a series of posts in planning, became Director of Production in 1976 and of Corporate Strategy in 1981, joining the Board in 1984. In preparation for privatisation, Mr Davis has been concerned with the allocation of CEGB technical resources to the successor companies. In recent years he has been closely involved in international collaboration in the energy field, particularly through the European Coal and Steel Community, UNIPEDE and the World Energy Conference, and chairs the committee dealing with thermal generating plant availability.

Derek Davis



Professor Alexander Donnachie

Professor Alexander Donnachie, the Nuclear Physics Board's new Chairman, is Professor of Physics and Director of the Physical Laboratories at Manchester University. For SERC, he has been a member of the Nuclear Physics Board (1978-81) and the Postgraduate Training Committee. He is currently Chairman of CERN's Super Proton Synchrotron Committee and a member of its Research Board and Scientific Policy Committee. As well as publishing well over 100 scientific papers, he has been guest speaker at international conferences throughout Europe, the United States and Japan.

Dr Gordon Higginson, the new Chairman of the Engineering Board, is Vice Chancellor of Southampton University. He is a member of the Engineering

Dr Gordon Higginson

Council, is on the Board of Management of the SERC-supported Marine Technology Directorate Ltd and has served on SERC's Medical Engineering Subcommittee. Dr Higginson was, in 1965, a founder member of Durham University's Department of Engineering, where he was Professor of Engineering until his appointment to Southampton in 1985. His research interests are in applied mechanics, especially in the fields of plasticity, stress analysis, lubrication and biomechanics.

Gerard Fairtlough has been the Chief Executive of Celltech Ltd, the biotechnology company, since its formation in 1980. He worked for the Royal Dutch Shell Group of Companies for 25 years, in London, New York and Manchester, his final position with the group being Managing Director of Shell Chemicals UK. In 1978 he joined the National Enterprise Board where he, and others, developed the ideas that led to the formation of Celltech, of which he was then invited to take charge. Mr Fairtlough is also chairman of a management consultancy, the Coverdale Organisation, specialising in behavioural science, and is on the Council of the Sainsbury Laboratory of Molecular Plant Pathology.

Gerard Fairtlough

Professor Trevor Stuart FRS is Professor of Theoretical Fluid Mechanics at Imperial College, London. He was Chairman of SERC's Mathematics Committee and a member of the Science Board from 1985 to 1988, and was a member of the Council of the Royal Society (1982-84). Having worked for some years in aerodynamics at the National Physical Laboratory, he was appointed to his present post in 1966. He has been a Visiting Professor of Applied Mathematics at both the Massachusetts Institute of Technology and Brown University and is an Honorary Professor at Tianjin University, China.

Professor Trevor Stuart

Congratulations to ...

Dr Bill David of the Rutherford Appleton Laboratory's ISIS Neutron Science Division, winner of the 1990 Charles Vernon Boys Prize of the Institute of Physics, for distinguished research in experimental physics.

Malcom Fox (Leicester Polytechnic), co-recipient of the 1988 Award for Research in Automotive Lubricants from the Society of Automotive Engineers (USA).

Dr Roger Phillips, Head of Theory Group in the RAL's Particle Physics Department, winner of the 1990 Rutherford Medal and Prize of the Institute of Physics for contributions to particle physics.

Professor F G A Stone FRS (Bristol University), former member of SERC's Chemistry Committee, winner of the Royal Society's Davy Medal for 1989 for many contributions to organometallic chemistry.

Relocation to Cambridge

Arrangements are now well advanced for the move of the Royal Greenwich Observatory to Cambridge, scheduled to take place during the two weeks 26 March-6 April 1990 Since the shell of the new building was completed last July, internal work has progressed quickly. There remains some fitting out to do, and the landscaping to be completed.

Overall, staff transfers to Cambridge from Herstmonceux are likely to total about 60, of whom more than half are now resident there and the others are actively house-hunting. Virtually all staff wishing to transfer have been able to do so, although some mobile staff have opted to remain at Herstmonceux with the Satellite Laser Ranger, or to retire early or be placed outside RGO; in most cases these preferences are being met.

A state of non-mobile redundancy has been declared on the Herstmonceux site. About 30 staff have already volunteered for early redundancy, some of them to join James Developments, the purchasers of the estate. Of the remainder, those who do not transfer to Cambridge or elsewhere within SERC will be made redundant.

A removal contractor has been appointed, and detailed planning of the logistics of the move is complete, a process which has involved many of the staff of the Observatory. The aim is to cause minimum disruption to work programmes over the move.

After the joint RGO/Institute of Astronomy Starlink node has been established, both organisations' measuring machines will become a unified facility under RGO management. The two libraries will remain separate but purchases, particularly of periodicals, will be coordinated to minimise duplication. A clubhouse has been incorporated into the new building, and the RGO Club plans to welcome IoA staff as members. A large portion of the RGO archives has been transferred to the Cambridge University Library and other material will be moved there as it becomes available.

The new address will be:
Royal Greenwich Observatory
Madingley Road
Cambridge CB3 0EZ
Telephone (0223) 374000
Fax (0223) 374700.

Oxford Centre for Molecular Sciences

The Oxford Centre for Molecular Sciences (OCMS), one of the first of the SERC-supported Interdisciplinary Research Centres (IRCs), was opened by the Prime Minister, Mrs Margaret Thatcher, on 4 August 1989. The Centre is funded by an 85% contribution from SERC, totalling £6.3 million over six years, with the remaining 15% coming from the Medical Research Council, a joint funding venture that reflects the interdisciplinary nature of the Centre's work, which focuses on proteins, writes Sarah Hargreaves of the OCMS.

Present at the opening were academic members of OCMS, officials from both research councils, industrialists from the Oxford Molecular Science Affiliates, the Centre's Steering Committee (chaired by Professor Cedric Hassall), distinguished advisers including Professor E Abraham and Professor Ewart Jones, and other researchers and collaborators. The Vice Chancellor welcomed all the guests on behalf of Oxford University and spoke of the University's commitment to and hopes for the Research Centre.

The Prime Minister said that her main reason for coming was to pay "immense tribute to the work of universities in the life of the nation". She spoke of her initial scepticism to the concept of IRCs but explained that she had been attracted by the idea of targeting a multiplicity of approaches and experiences to specific research problems. It was essential to the health of the national economy, she said, that British universities were at the forefront of research, knowledgeable about science discoveries worldwide and that strong links with industry were established. Mrs Thatcher was particularly pleased that industry would be making a significant contribution to the OCMS through the Molecular Science Affiliates, the fee for joining which she declared to be "very good value indeed". She finished by saying that she was honoured to be associated with the OCMS and would be watching the results with the greatest possible eagerness.

The Chairman of SERC, Professor William Mitchell, responded to the Prime Minister's enthusiasm by citing IRCs as a new venture in science funding policy. Speaking on behalf of both the research councils involved, he stressed that it was not possible to fund all proposed research projects and that it was necessary for the research councils to make choices; in the case of IRCs the choice was made on a competitive basis. The councils, he said, "aim to provide an environment in which there is a catalysing of the interaction between specialists; the best equipment is provided; there develops a flow to and from industry... and there is a devolving of scientific decisions". Professor Mitchell noted that the councils were aware that the role of the Director was a super-human task, but that Professor Jack Baldwin came as close as was possible to that ideal.

The Prime Minister, The Rt Hon Mrs Margaret Thatcher, with research students at the opening of the Oxford Centre for Molecular Sciences.

Professor Baldwin, Director of the OCMS, disclaimed any super-human tendencies but did not deny the difficulty of the task ahead. He noted the earlier collaborative studies of proteins in Oxford under the auspices of the Oxford Enzyme Group, established in the early 1970s. The research programme of the OCMS is directed towards the deeper understanding of the fundamental nature of proteins through their effects on catalysis, structural organisations, signalling and specificity, and recognition in life processes. These questions are being approached in the OCMS from three directions: how do proteins fold to achieve their three-dimensional structures; how do they interact with small molecules; and how do they interact with other proteins? Professor Baldwin pointed out that these studies require a high level of instrumental and technical support, the best use of which requires a well organised and consolidated research programme, which is the basic management responsibility for the OCMS.

After the formalities, guests toured a poster display based on the six core research areas of the Centre:

- protein folding and specificity
- blood clotting and fibrinolysis
- immunology
- viruses
- secondary metabolism and
- signal transduction.

Professor Baldwin and Dr Chris Dobson (OCMS Deputy Director) guided Mrs Thatcher, the Vice Chancellor, Professor Mitchell, Mr John Fairclough (Chief Scientific Adviser to the Cabinet) and others on a visit to the Rex Richards Building where they were able to inspect the use of some of the research centre's excellent facilities, including the 600MHz NMR spectrometer, the largest high field NMR magnet in the world. Professor Sir David Phillips reminded the Prime Minister of her research time in Oxford with the aid of some archive photographs before bringing her right up to date with current work with the area detector and molecular modelling techniques used in the crystallography facility.

S Hargreaves
Oxford Centre for Molecular Sciences

Three further LINK programmes announced

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. Three new LINK programmes have recently been announced, bringing the total number in the LINK initiative to 22. Brief details of the new programmes are given below.

Transport Infrastructure and Operation

There is a clearly perceived need to improve the UK transport infrastructure to meet the increasing levels of demand being placed upon it. This £9 million programme, supported by SERC, the Department of Transport and industry, aims to develop such improvement. Primary topics include safety, construction and maintenance, traffic congestion and the environmental impact of transport systems. A central element, common to most of these, would be the use of information technology in transport applications.

For further information contact Jane Sykes, SERC Swindon Office; telephone (0793) 411353, or the LINK Transport Infrastructure and Operation Programme Secretariat, Department of Transport, 2 Marsham Street, London SW1P 3EB; telephone 01-212 3434.

Technology for Analytical and Physical Measurement

Analytical and physical measurement is a fundamental feature of science. The Department of Trade and Industry, SERC and industry are providing support of up to £8 million for a programme which aims to bring together scientists, designers and engineers with ideas for new measurement techniques. The main research areas will be chemical and physical analysis and measurement of physical quantities. Primary themes will include measurement of environmental pollutants, biotechnology and life sciences, pharmaceutical and agrochemistry, and materials science.

For further information contact Dr Chris Horn, SERC Swindon Office; telephone (0793) 411305, or the LINK TAPM Secretariat, Department of Trade and Industry, Kingsgate House, 68-74 Victoria Street, London SW1E 6SW; telephone 01-215 7877.

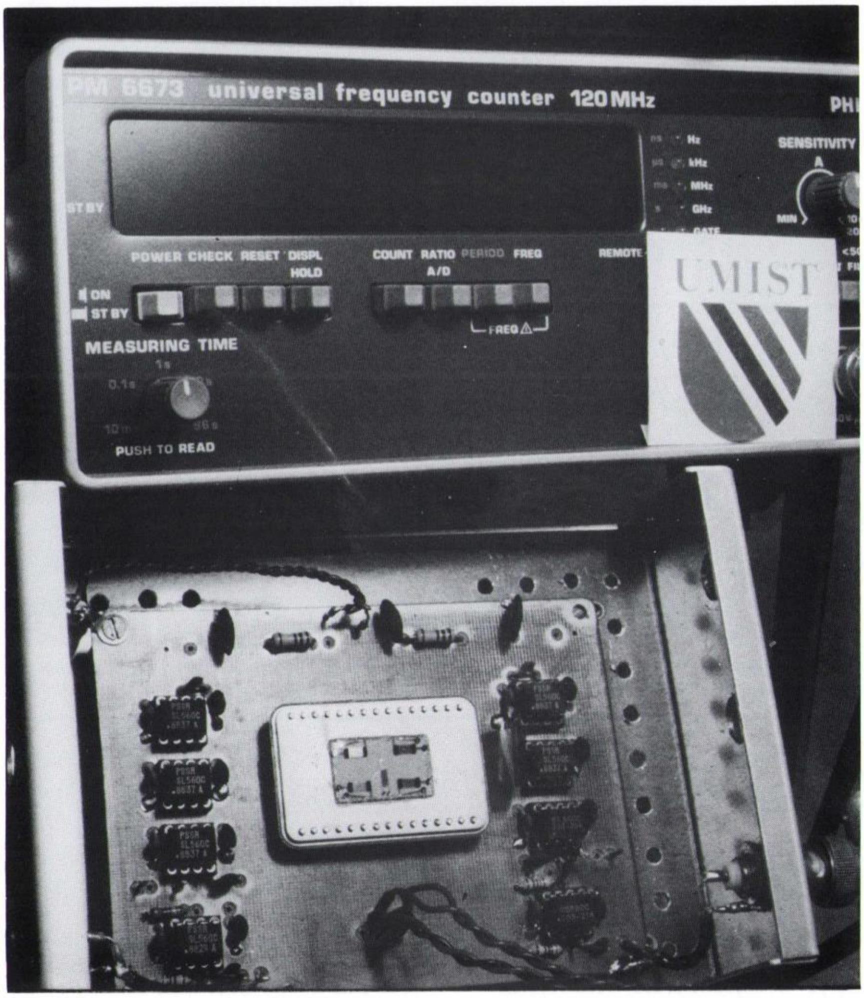
Molecular Sensors

This £10 million programme is supported by SERC, the Department of Trade and Industry, the Agricultural and Food Research Council, Department of Health, and industry. The Ministry of Defence and Medical Research Council may provide additional funding in support of particular projects. The programme aims to develop molecular sensors as an enabling technology over a range of industrial applications. Primary topics will include reversible continuous sensors, biosensors for diagnostics, environmental pollutant sensors, sensors for non-destructive testing, and semiconductor, optoelectronic and ceramic sensors.

For further information please contact Dr Alan Thomas, SERC Swindon Office; telephone (0793) 411108, or the LINK Molecular Sensors Programme Secretariat, Laboratory of the Government Chemist, Queens Road, Teddington, Middlesex TW11 0LY; telephone 01-943 7388.

For more general information regarding the LINK Initiative contact:

Paul Tomsen
LINK Unit
SERC Swindon Office
Telephone (0793) 411162.



Surface acoustic wave sensors for gas analysis. (photo: UMIST).

International news

Chairman's visit to Canada

During a two-week programme of official visits in Canada in August 1989, Professor William Mitchell, Chairman of SERC, had meetings at the Natural Sciences and Engineering Research Council (NSERC), the National Research Council (NRC) and several of its institutes, the recently created Canadian Space Agency, industrial and other organisations undertaking related research and the Ecole Polytechnique.

The discussions at NRC were preceded by a formal ceremony at which the SERC/NRC/NWO (Nederlandse Organisatie Voor Zuiver-Wetenschappellijk Onderzoek) James Clerk Maxwell Telescope Tripartite Agreement was signed by Professor Mitchell on behalf of SERC, and Dr Perron, President of NRC.

NSERC is a grant awarding body covering roughly the same fields as SERC; the NRC runs a series of research institutes, including the responsibility for facilities. The institutes visited included the superbly equipped and effective Biotechnology and Materials Institutes in Montreal. The collaborative work in millimetre-wave and optical astronomy was covered in visits to the Herzberg Institute in Ottawa and the Dominion Astronomical Observatory in Victoria, British Columbia. The Chairman visited the TRIUMF organisation and received detailed presentations of the proposed KAON factory.

A return visit by Dr Arthur May, President of NSERC, was made in September 1989, when he attended the Management Board and discussed the Teaching Company Scheme and PhD submission sanctions.

Further information: Roger Cann, SERC Swindon Office; telephone (0793) 411315.

Dr Pierre Perron, President of Canada's National Research Council (left), watching Professor William Mitchell, Chairman of SERC, signing the James Clerk Maxwell Telescope Tripartite Agreement in Ottawa.

UK Research Councils' European Office

Membership of the Brussels Club by UK universities and polytechnics rose substantially during the first year of support by the five Research Councils. A successful Brussels Club seminar was held in June 1989 at the British Geological Survey headquarters, Keyworth, Notts, with speakers from the European Commission, government departments and for the first time CNRS (the main French research council). A second Assistant Liaison Officer is being recruited for the Brussels office to handle the extra work generated.

Further information: Miss Wendy Light or Miss Gaynor Whyles, UK Research Councils' European Office, 83 Rue de la Loi, B-1040 Brussels, Belgium; telephone 010-322-230-5275; or Miss Alison Bowen, SERC Swindon Office; telephone (0793) 411036.

SERC/British Council delegation to Brazil

In June 1989 a delegation of ten UK scientists led by Dr David Clark, SERC's Deputy Director Programmes, visited Brazil to investigate (on behalf of the British Council) the opportunities for placing Brazilian scientists in the UK for training under the Brazilian Human Resources in Strategic Areas (RHAE) scheme, and to investigate the possibilities for collaboration between British and Brazilian scientists and engineers in the areas of information technology, biotechnology, new materials, fine chemistry and precision engineering.

The delegation met members of the Federal Secretariat for Science and Technology (SCT) and the National Council for Scientific and Technological Development (CNPq), a grant-awarding agency similar to SERC which administers the scheme for the SCT. Meetings also took place with the Sao Paolo and Rio de Janeiro State Secretaries for Science and Technology and the Agency for the Financing of Studies and Projects (FINEP). In addition, the delegates dispersed to visit some 70 industrial and university laboratories.

The major problem for Brazilian scientists is funding for advanced instrumentation. There are many enthusiastic, hard-working young people and areas of strength where there is a basis for collaboration to mutual benefit, one example being biotechnology. Some encouraging results have already emerged with several student placements secured.

Copies of the visit report may be obtained from Mrs Ginny May, SERC Swindon Office; telephone (0793) 411342. Other enquiries to: Mrs Diana Herbert, SERC Swindon Office; telephone (0793) 411480.

N+N meetings

These are scientific meetings of an exploratory nature. They are usually, but not necessarily, bilateral on a specific subject area of interest to SERC, with a matching number of participants (up to ten) from each country, where the broad objective is to enhance collaboration between the countries concerned. In an effort to introduce a more standardised and widely understood (but not inflexible) procedure, most N+N proposals are now referred to SERC's International Section for assessment. The comments of the relevant subject committee chairman are sought before consideration for funding from a modest central fund held for the purpose.

UK scientists interested in organising or taking part in such meetings should contact Mrs Diana Herbert (as above), or their usual Committee Secretary.

European agreements on ISIS

Two major international agreements have been signed for collaboration in exploiting SERC's ISIS spallation neutron source at Rutherford Appleton Laboratory.

With Italy

In October 1989, an agreement between the governments of the UK and Italy was signed by the Hon Francis Maude MP, Minister of State for Foreign and Commonwealth Affairs for the UK, and the Ambassador of the Italian Republic, His Excellency Signor Boris Biancheri for Italy. SERC expects the agreement to lead to the signature of further protocols between SERC and the Italian National Research Council — CNR — covering increased use of ISIS.

ISIS is the world's leading high-intensity pulsed neutron facility primarily used for condensed matter research. Recently it has been used to investigate the structure of high-temperature superconductors. Italy's scientists now use some 10% of the facility's beam time making them a major participant in ISIS. Other important contributors to ISIS are France, the Netherlands, Sweden, Japan, India and the Federal Republic of Germany.

With West Germany

In November, an agreement was signed between SERC and the BMFT (Bundesministerium für Forschung und Technologie), the Federal Republic of Germany's research and technology ministry. The agreement will enable the performance of ISIS to be developed further. This will benefit mainly neutrino experiments using the predominantly West German neutrino facility KARMEN. Neutron beam experiments on condensed matter will also gain.

The agreement was signed by Professor William Mitchell, SERC Chairman, and Mr Reinhard Loosch, Under Secretary for International Cooperation at BMFT, in the presence of the West German Minister for Research and Technology Dr Heinz Riesenhuber, and Mr Robert Jackson, Minister at the Department of Education and Science responsible for science. West Germany will provide a total of 7 million DM (£2.5 million) over three years which will be used towards improving reliability and doubling the present ISIS beam intensity, reinforcing its position as the most powerful machine of its kind in the world.

The increase is important for neutrino experiments using KARMEN because it will ensure that the time taken to do these experiments is reasonable. The neutrino experiments are designed to study aspects of the fundamental forces of nature.

Speaking after the signing, Professor Mitchell said: "I welcome this agreement which consolidates existing UK-West German collaborations in neutrino muon and neutrino research and in particular I look forward to increased participation by West German scientists."

During his visit to RAL, the West German Minister toured the neutrino neutron and muon facilities at ISIS, which already have fruitful collaborations between scientists from the two countries.

The West German Minister's visit to RAL formed part of a three-day visit to the UK during which he met the Secretary of State for Education and Science, Mr John MacGregor, the Secretary of State for Trade and Industry, Mr Nicholas Ridley and the Secretary of State for Energy, Mr John Wakeham.

David Gray
Rutherford Appleton Laboratory

Dr Heinz Riesenhuber, the West German Minister for Research and Technology, listens while Professor John Finney describes the ISIS facility.

EC Large Science Facilities Programme

SERC was successful in its two bids to this new European Community programme, which provides funds to contribute to the running costs and some enhancements of major facilities in exchange for time made available to scientists from other EC member states who would not normally have access to them. Support has been offered to enhance and help run the muon beam facility on ISIS at Rutherford Appleton Laboratory and the synchrotron radiation source (SRS) at Daresbury Laboratory. Negotiations on details are still in progress.

Further information on the EC Large Science Facilities Programme: Miss Alison Bowen SERC Swindon Office; telephone (0793) 411036. Details on ISIS: David Gray, RAL; telephone (0235) 445428. Details on the SRS: Professor Joan Bordas, Daresbury; telephone (0925) 603000.

Japanese instrument for ISIS

One of the most complex neutron spectrometers to be designed so far for ISIS, the UK national pulsed neutron facility at the Rutherford Appleton Laboratory (RAL), is the Multi-Angled Rotor Instrument (MARI), which is currently being commissioned in the main neutron experimental hall. The spectrometer is funded by the Japanese Ministry of Education, Science and Culture (Monbusho) as part of a UK-Japan Collaboration in neutron scattering and was initiated in 1984 by the late Professor Y Ishikawa. In tribute to Professor Ishikawa's work in pulsed neutron source development, the instrument was renamed MARI in honour of his daughter, write Dr Ron Holt and Dr Andrew Taylor of RAL.

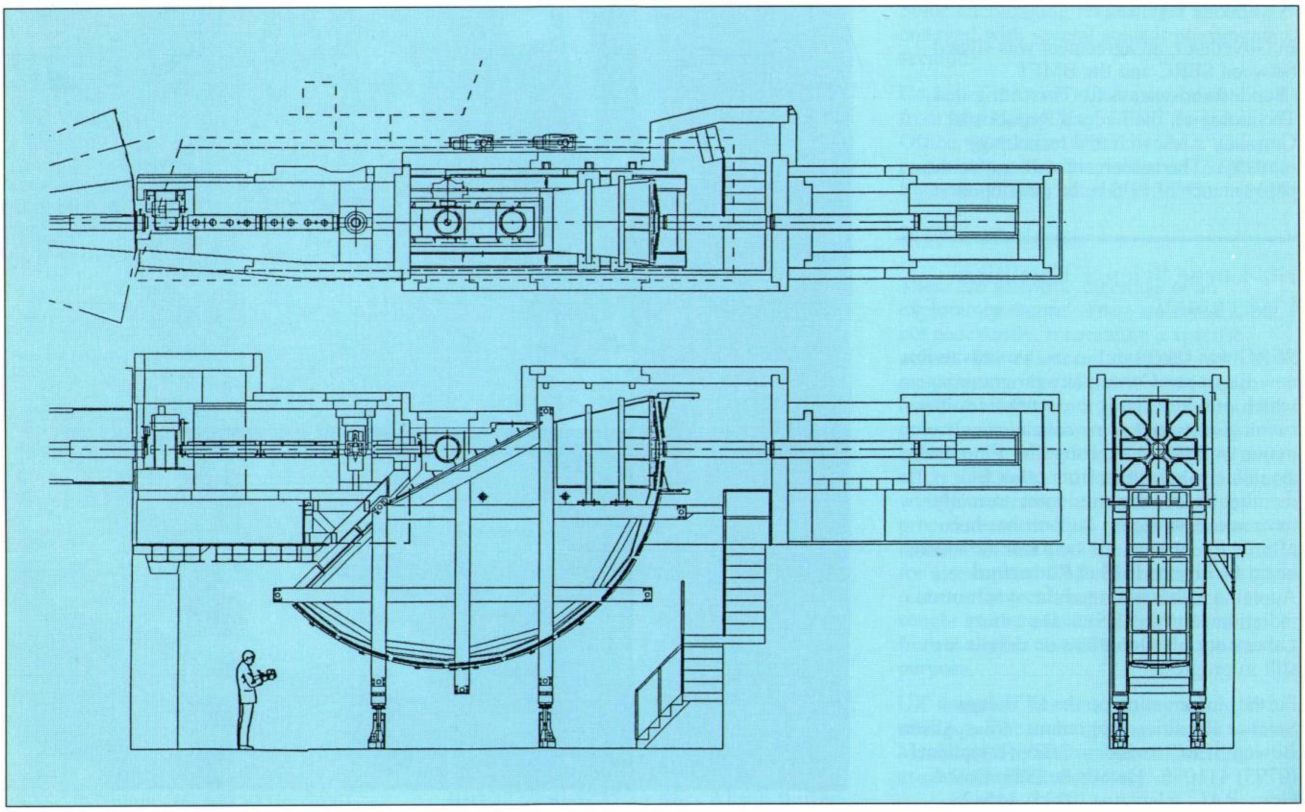
The MARI spectrometer is effectively a 'big sister' to the already well established and pioneering ISIS instrument — the High Energy Transfer spectrometer (HET), and is based on a similar fast Fermi rotating chopper-monochromating system. Manufactured by Uranit GmbH at Julich, the chopper device is run on a magnetic bearing system and is located some 10 metres from the neutron source. Spinning at frequencies up to 600 Hz, it produces a sharp burst of neutrons (about a microsecond) on to the sample with the 'chopper' opening time defining the velocity or energy of the incident neutrons.

Those neutrons which have been scattered from the sample are collected by an extensive detector bank located some 4 metres away from the sample and forming a continuous angular coverage between 3° and 135°. The detector array can however be divided into two distinct regions. An octagonal arrangement of 136 high pressure helium detectors forms the low angle bank and collects scattered neutrons in a forward cone defined by the angular range between 3° and 10°. The remaining much larger detector array, covering the scattering angles above 10°, joins smoothly on to one side of the low angle bank maintaining the continuity of the Debye-Scherrer cone at any angle. Because of the constraints imposed by neighbouring ISIS instruments, the scattering in this region takes place in the vertical plane. At any one angle in this large detector bank up to three high pressure helium tubes can be placed end-to-end, and this optimises the solid angle covered. The total number of helium detectors is therefore over 1000.

Located upstream of the monochromating chopper is a background suppression chopper which effectively screens out the main neutron beam during the initial power pulse. Composed of a 0.3-metre long bar of nimonic alloy, the chopper is spun at 100 Hz preventing fast neutrons from entering the spectrometer and hence helps to reduce the overall background levels within the scattering vessel. As in other ISIS instruments, a standard primary collimator system is used which limits the beam area to 0.06 x 0.06 m^2 at the sample position and prevents the lowest angle detector from directly viewing the chopper.

A large part of the design, manufacturing and installation work on the MARI spectrometer was completed last year with the main detector tank installed on to its mounting jacks during the previous ISIS shutdown period in January and February 1989. In addition to the external wax tanks which completely surround the spectrometer, a complex pattern of B_4C 'crispy' panels lines the complete inner walls of both the detector and sample vessels.

The spectrometer views the gadolinium poisoned 95K liquid methane moderator on



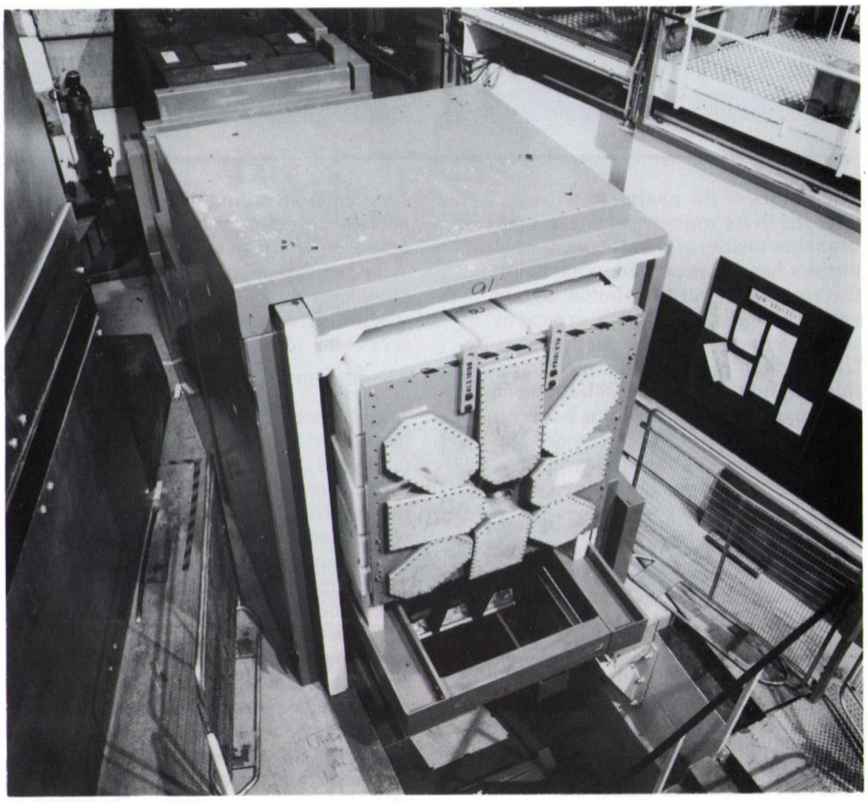
General layout of the MARI spectrometer.

the S6 beam hole. The fast Fermi chopper system can be coupled to a variety of interchangeable curved slit-slot packages which are optimised for several incident energies. These provide a range of monochromatic neutron energies from 20 meV to about 2 eV with excellent flux and energy resolution characteristics. The KEK-RAL spectrometer will be a particularly powerful instrument used for the study of a diverse range of scientific areas. For example the large number of closely packed detectors at both low and high scattering angles provides a dense net in momentum transfer space (Q-space). This is important in measurements of the excitation spectrum — the dynamic structure factor $S(Q,\omega)$, in polycrystalline and amorphous solids, liquids and gases. It is also important to facilitate the interpolation of constant ϕ scans to constant Q scans.

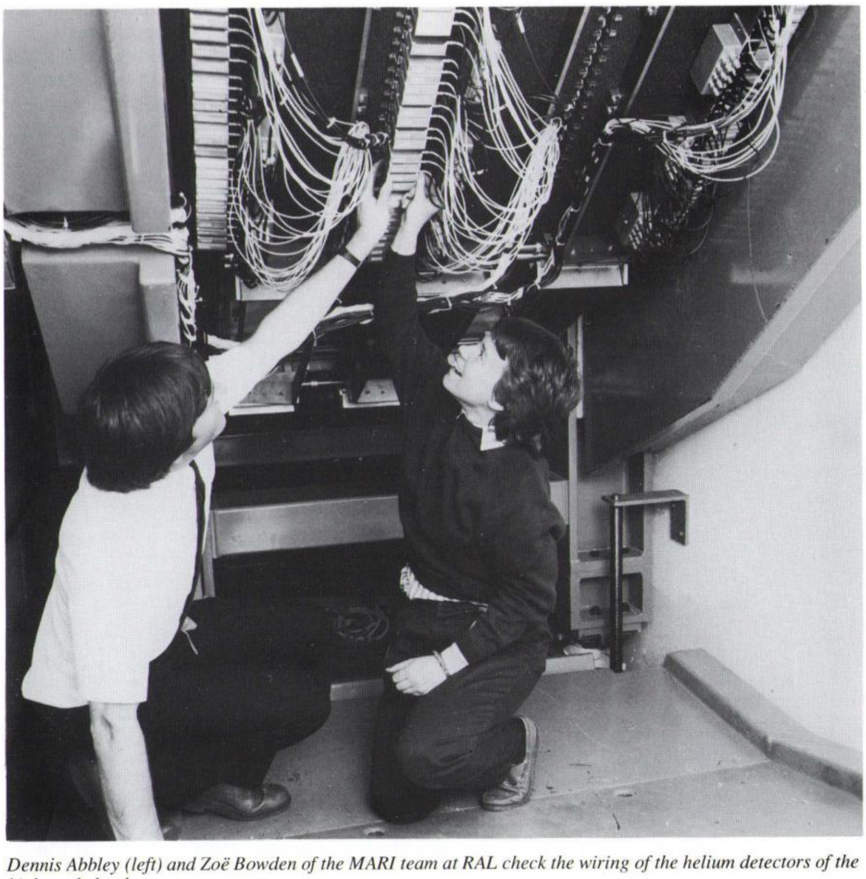
The low-Q capability of MARI is also ideally suited to the measurement of the magnetic response of 3d-systems over the whole excitation spectrum as well as the magnetic spectroscopy in f-electron metals and alloys, including magnetic metal glasses and spin glasses. Measurements at energy transfers in the range 10 meV to 250 meV, with good energy resolution, as a function of Q are equally important for molecular spectroscopy where it is necessary to identify peaks in both simple and complex molecular systems and to observe possible weak dispersions. In addition measurements at both high momentum and energy transfers allow the dynamic structure factor to be measured within the impulse approximation giving further important information on the motion of atoms, or momentum distributions in light elements and compounds. This will include the study of momentum densities in hydrogeneous materials and will be of particular interest for quantum systems and the helium liquids.

The MARI spectrometer began its commissioning programme in Autumn 1989 and the first user programme will start during the Spring of 1990. The spectrometer will provide Japanese, UK and international groups with a unique opportunity to carry out advanced neutron scattering experiments at the most powerful pulsed neutron source in the world.

Dr R S Holt and Dr A D Taylor
Rutherford Appleton Laboratory



The MARI spectrometer shown partially assembled on the ISIS beam line. The low angle detector area is clearly visible.



Dennis Abbley (left) and Zoë Bowden of the MARI team at RAL check the wiring of the helium detectors of the high angle bank.

Looking at nuclei with photons

The virtues of the photon as a probe have led to its widespread use in many branches of science. In the past, nuclear physics has not benefited much from this technique, but the photon tagging system installed by two UK groups at the university of Mainz and operated by UK-German collaboration has changed that position. Professor Bob Owens of Glasgow University explains how recent technical advances have provided the new opportunities and discusses the recent achievements and future plans.

The advantage of using photons to probe the structure of nuclei is clear: the initial electromagnetic interaction with the particles which make up the nucleus is completely understood. This is not the case for other probes. The disadvantage is equally clear: photons with energies in the range 1-1000MeV cannot be made to emerge from the end of an accelerator in a tuneable, monoenergetic beam like the other particles used for nuclear research. The available photon sources are secondary beams, such as bremsstrahlung, with a wide energy spread.

A way round this problem, the photon tagging technique, was suggested many years ago, but could not be properly exploited until recently because the only available electron accelerators produced pulsed beams. The University of Mainz has led the way in Europe in the development of an accelerator to produce a continuous electron beam using the racetrack microtron principle. In the early 1980s the groups in Glasgow and Edinburgh Universities took the opportunity to exploit the potential for photonuclear physics by collaborating with Mainz physicists to utilise their microtron. With SERC support, the UK groups provided a photon tagging system of high specification and also some help with the accelerator technology.

The photon tagging system

The bremsstrahlung tagging system installed at Mainz is shown schematically in figure 1. It uses a magnetic spectrometer to bend those electrons, which have generated a high energy photon and therefore lost energy, out of the main beam and into an array of detectors. The energy of the residual electron is determined with high precision by noting which detector has fired. Measuring each reaction product in coincidence with the correlated residual electron allows the energy of the photon which caused the reaction to be worked out from the energy loss of the electron — a major advantage compared to other techniques for photonuclear measurements. The other great advantage is the well defined photon flux: each photon is tagged. The tagging system was installed ready for the operation of the 180 MeV microtron in Mainz early in 1984. The result was a facility for photonuclear studies unmatched at any other laboratory worldwide. Over the following three-and-a-half years it was intensively used, carrying out a wide range of new experiments.

Nucleon interactions

The early experiments carried out with the tagging system illustrate the major improvement in capabilities which it provides. The first was an investigation of reactions in which a pair of nucleons emerge from a nucleus, usually in opposite directions, following the absorption of a photon. This suggests that the photon must catch the pair while they are already interacting strongly. The special interest in this process lies in the expectation that information can be obtained on the behaviour of nucleons while very close together. This is the area from which our understanding of the relation between the interaction of nucleons and their make-up in terms of quarks and gluons must begin. Such short-range correlations between nucleons have been much sought but the present evidence is inconclusive.

To obtain information from photoreactions the first requirement is to establish the reaction mechanism beyond doubt, a quantitative test which past experiments have all failed. The recent work at Mainz has cleared up this problem. Figure 2 shows the latest test of the reaction mechanism; the measured distribution of momenta of those residual spectator nuclei which are left with little excitation energy is now in good accord with the simplest reaction model. The new comparison relies on the energy resolution of the tagging system which, as shown in the inset, resolves features which could not previously be seen.

The other basic advance provided by the tagging system shows up dramatically in an experiment on the break-up of the deuterium nucleus into a proton and neutron. This, the simplest photonuclear reaction is an obvious place to test our understanding of nuclear processes. Its special interest is its sensitivity to the effects of the mesons and nuclear isobars, whose transient presence in nuclei and influence on nuclear properties, although very important, is difficult to isolate. Past hopes of insight from such studies have been thwarted by large disagreements between the results of different experiments due to the difficulty of measuring the photon flux. Figure 3 shows a small sample of the data, both the older experiments and two recent measurements, one of which is from the Mainz photon tagging system. The previous difficulties, if not completely absent, are very much removed and the latest results have already provided the impetus for an improved theoretical treatment.

European collaboration

Despite its productivity, the first photon tagging system at Mainz was closed down in 1987. The 180 MeV microtron was never intended as other than a temporary stage in the provision of a more powerful,

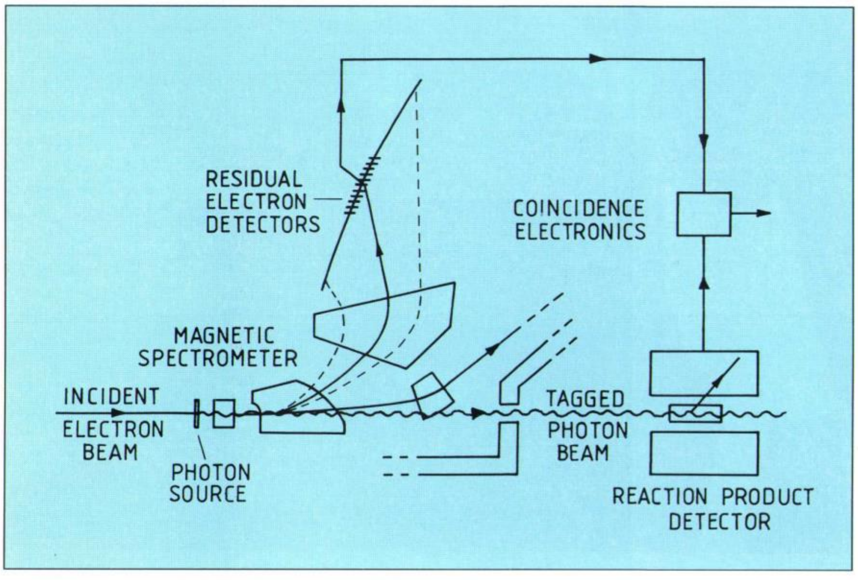


Figure 1: Photon tagging system.

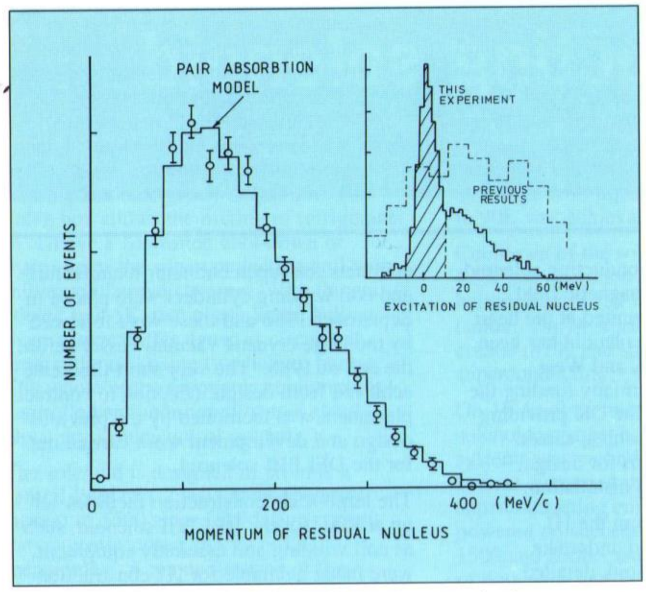


Figure 2: Momentum distribution in the $^{12}C(\gamma,np)$ reaction showing agreement with the pair absorption model for low lying final states (shaded region in inset).

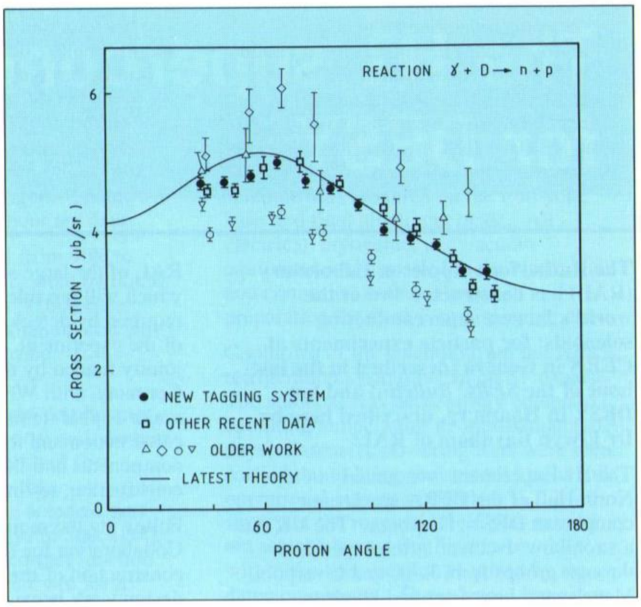


Figure 3: Cross-section for deuteron photodisintegration at 140 MeV.

850 MeV accelerator. This is now under construction at Mainz and will come into operation later this year. The excellent results obtained with the first tagging system have attracted wide attention and have been responsible for bringing together a large collaboration involving nine groups from five European countries. This collaboration, in which the UK partners are again playing a central role, will prepare and install a new tagging system and detection equipment on the upgraded accelerator. An interesting decade of experimentation in the field of intermediate energy nuclear physics lies ahead using first-class facilities which have several years' lead over any competition yet seen on the horizon.

Professor R O Owens
Glasgow University

Formal inauguration of LEP

The world's largest scientific instrument, the Large Electron-Positron Collider (LEP) was formally inaugurated on 13 November in the presence of representatives of the 14 member states of CERN and representatives of non-member states involved in CERN's scientific programme. The UK was represented by the Secretary of State for Education and Science John McGregor, Parliamentary Under Secretary of State for Education and Science Robert Jackson, and the Chairman of SERC William Mitchell.

Commented Professor Mitchell: "This is a proud moment for CERN and for Europe. LEP has already proved its worth with its initial physics results which has shown that there are only three families of neutrinos. LEP will keep Europe in the forefront of particle physics for the next decade."

Members of the UK delegation to the LEP inauguration, John McGregor (centre) and, on his right, Robert Jackson, being shown around the OPAL detector by CERN scientists. On Mr McGregor's left is Dr John Thresher, one of CERN's three Directors of Research (formerly Associate Director for Nuclear Physics at Rutherford Appleton Laboratory).

The H1 superconducting solenoid for DESY

The Rutherford Appleton Laboratory (RAL) has constructed two of the world's largest superconducting solenoids: for particle experiments at CERN in Geneva (described in the last issue of the *SERC Bulletin*) and for DESY in Hamburg, described here by Dr Elwyn Baynham of RAL.

The H1 Experiment is mounted in the North Hall of the HERA accelerator complex at DESY, Hamburg. The UK has a strong involvement in the experiment through groups from RAL and Liverpool, Manchester, Lancaster and Glasgow Universities.

A major UK commitment to the experiment has been the construction at RAL of the large superconducting solenoid which will provide the magnetic field required by detectors mounted at the heart of the experiment. The solenoid has been jointly funded by the UK and West Germany, with West Germany funding the major capital items and the UK providing construction and test facilities, capital components and the effort for design, construction, testing and installation.

Following the request from the H1 Collaboration for RAL to undertake construction of the solenoid, detailed design work began at RAL at the beginning of 1986. The next task was to place contracts for large, long delivery items essential to solenoid construction at the earliest possible date. The first major contracts for superconductor manufacture and coil winding cylinders were placed in September 1986 and these were followed by the large cryostat vacuum vessel before the end of 1986. The very short timescale achieved from design inception to contract placement was facilitated by the previous design and development work carried out for the DELPHI solenoid.

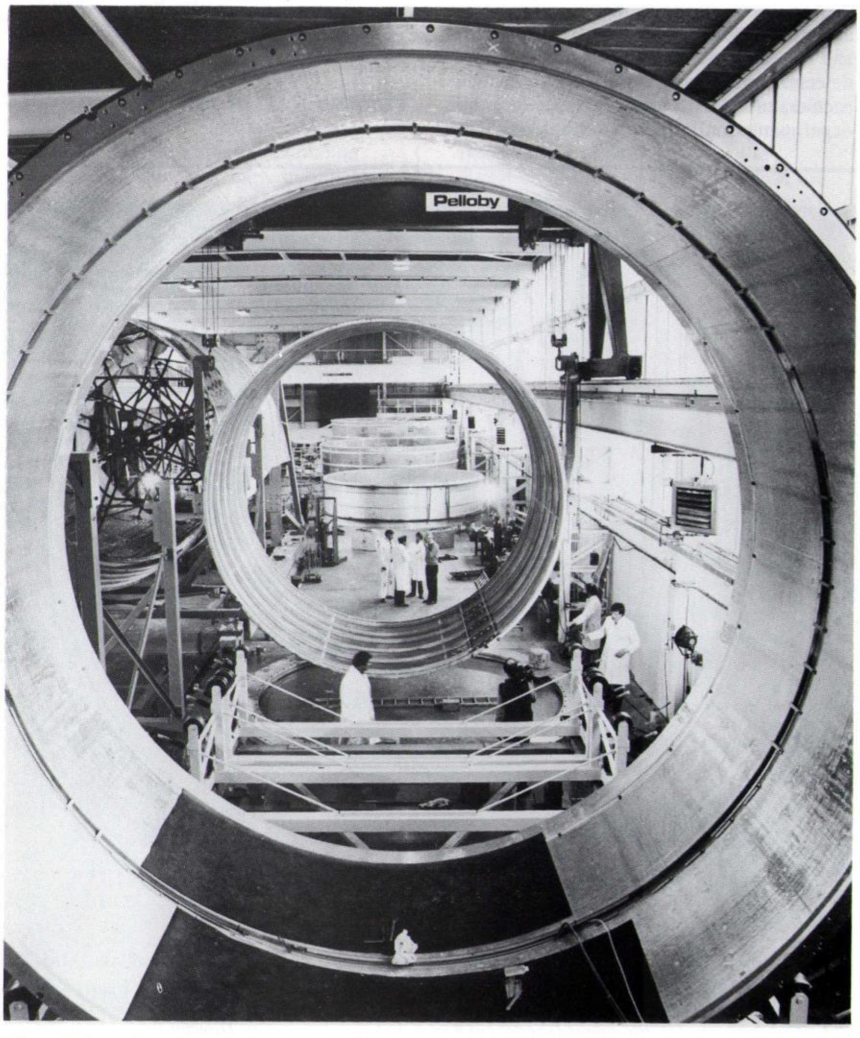


Figure 1: Assembly of the coil section.

The large-scale construction facilities set up at RAL for the DELPHI solenoid, such as coil winding and assembly equipment, were made available for H1 construction and required only minor modifications. In addition to the design and construction of the basic solenoid, RAL also undertook technical responsibility for the design, specification and procurement of all the ancillary equipment covering electrical, cryogenic and vacuum systems.

The agreement set up between the H1 Collaboration, DESY and RAL also required a full assembly of the solenoid with ancillary equipment at RAL, cooldown of the coil to 4.5K and powering of the solenoid to approximately 30% of design current.

The basic solenoid consists of a superconducting coil 5.5 metres in length and 5.5 metres in diameter mounted in a stainless steel cryostat vessel. The solenoid coil was wound in four main sections using some 22 km of aluminium-stabilised Nb Ti superconductor. The winding procedure used the 'internal winding' technique developed at RAL for the DELPHI solenoid. Figure 1 shows the main construction area at RAL during assembly of the solenoid coil sections.

The cryostat vessel was manufactured in Vevey, Switzerland and shipped to RAL as a complete unit. At RAL the vessel was equipped with superinsulation blankets and radiation shields before the completed 25-tonne solenoid coil was mounted inside. Final mounting of the solenoid and closure of the cryostat vessel was achieved in November 1988.

For operation the superconducting coil must be maintained at a temperature close to 4.5K. At DESY the superconducting coil and radiation shields are being cooled by refrigerants from the central HERA refrigeration facility, which were distributed around the full 7 km of the HERA tunnel using a ring main transfer line. The refrigeration facility is designed to serve magnets in experimental areas in addition to the superconducting magnets of the HERA proton ring.

RAL carried out the design, procurement and testing of the cryogenic equipment necessary to interface the solenoid with the HERA refrigeration plant. The main interface element is a cryogenic valve box which is used to route and control the flow of refrigerants during cooldown, normal running and emergency situations. This valve box allows the mixing of refrigerants to achieve a controlled cool-down or warm-up of the superconducting coil with minimum thermal stresses. With the coil cooled to 4.5K, two phase liquid helium from a large buffer dewar is circulated around the coil using two helium pumps. The whole of the cryogenic equipment is controlled and monitored from a stand-alone cryogenic control system.

The solenoid is designed to provide a central field of 1.2 tesla at an operating current of 5500 amps. At design current the magnetic stored energy is 120 megajoules. A major function of the electrical power system is the safe extraction of this stored energy under fault conditions.

The solenoid is powered from a 20 volt, 6000 amp power supply connected to the coil through high-voltage, high-power circuit breakers. During normal operation the power requirements are relatively small (about 15 kilowatts) since it is only necessary to make up the ohmic losses in the normal conductor cables between the power supply and the solenoid. During fault conditions the circuit breakers are opened and approximately 100 MJ of the stored energy is dumped into a large external resistor weighing some 1.5 tonnes. In this process, which takes approximately two minutes, the resistor will rise to a temperature of 200°C. For normal run-down of the magnetic field, the voltage and current decay are controlled by passive diode-resistor assemblies.

The specification and procurement of the large electrical components were undertaken by RAL. For installation at DESY, the electrical equipment is mounted in a three-storey structure with the lower level housing control and monitoring equipment and the two upper floors the heavy electrical equipment. Each floor was designed as a modular unit which could be shipped to DESY intact leaving cabling and connections within each unit undisturbed. All heavy electrical equipment and platforms were delivered to RAL during Summer 1988 and installation completed by December 1988.

The solenoid and ancillary equipment contain several hundred transducers for monitoring temperature, strain, vacuum pressures etc. The monitoring of transducers is carried out by a commercial data acquisition system which also controls the main power supply.

The final build-up of the total solenoid system for the RAL test took place between January and March 1989. During this period, it was necessary to bring together for the first time all the different sub-systems, to establish interfaces and finally commission the total system. Initial cooldown of the solenoid and radiation shields began at the end of March using a cooler unit supplied by DESY. In this phase the coil and radiation shields were cooled by circulating helium gas in heat exchange with liquid nitrogen. Cooldown to 90K was achieved in about ten days.

Cooldown of the solenoid from 90K to 4.5K and operation at 4.5K were by liquid helium transferred from a 30,000-litre tanker. On 14 April the solenoid coil was cooled to 5K and shown to be superconducting.

On 16 April the total system comprising solenoid, cryogenic, electrical and vacuum systems was commissioned and first current circulated through the superconducting coil. The solenoid was powered on successive days to 500, 1000, 1500 and 2000A and the correct function of both slow and fast current discharge established.

This concluded successfully all the test objectives set for the commissioning at RAL and the coil was warmed up to room temperature in preparation for shipping.

On 12 May the large solenoid coil was loaded on a special trailer for the journey by road to Southampton and onward by ship to Hamburg where it docked on 21 May. Figure 2 shows the solenoid being lowered into the North Hall at DESY on 30 May. During the period June to August the solenoid was mounted on the iron yoke base and final alignment made. All electrical, cryogenic, and vacuum equipment was installed in the North Hall and connected to the solenoid in preparation for final commissioning tests.

Cooldown of the solenoid from the HERA refrigeration system began on 31 August. The solenoid was successfully cooled to operating temperature in approximately ten days. Extensive powering tests were then carried out to bring the solenoid to its full operational current of 5500A. A full survey of the magnetic field was carried out which showed the field to be well within the specification required by the detector systems. The solenoid has since been warmed up to room temperature and installation of detector equipment is now progressing.

Dr D E Baynham
Rutherford Appleton Laboratory

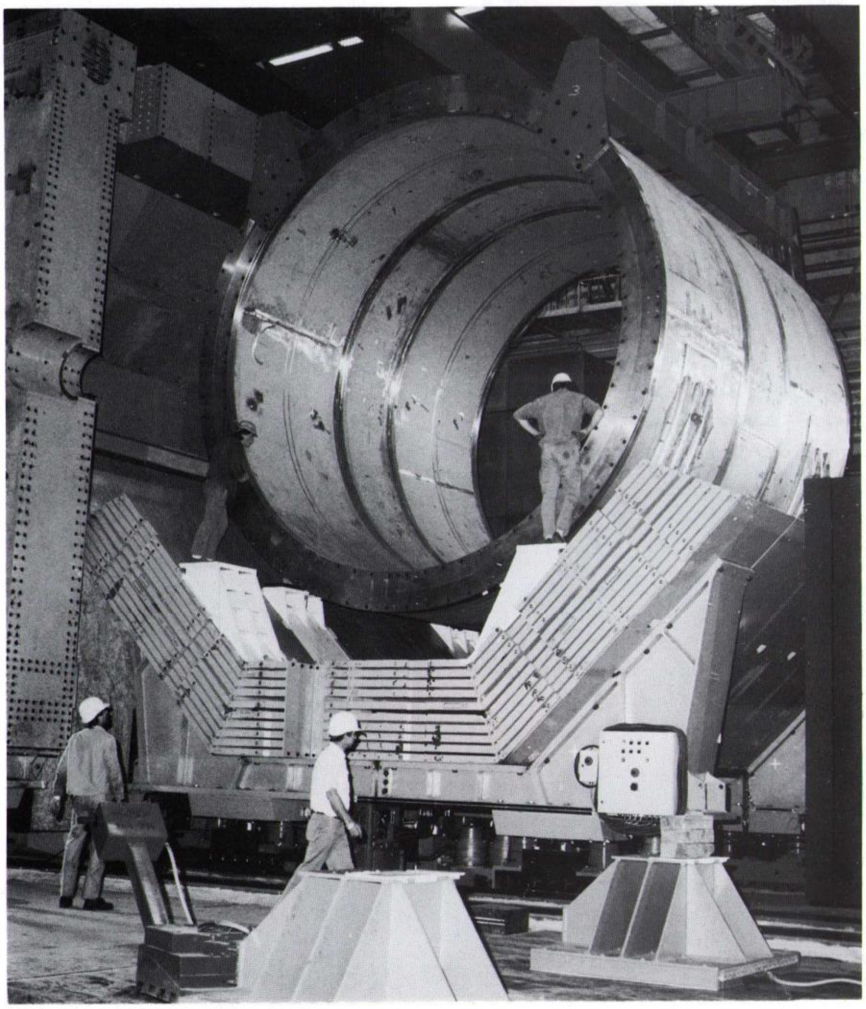
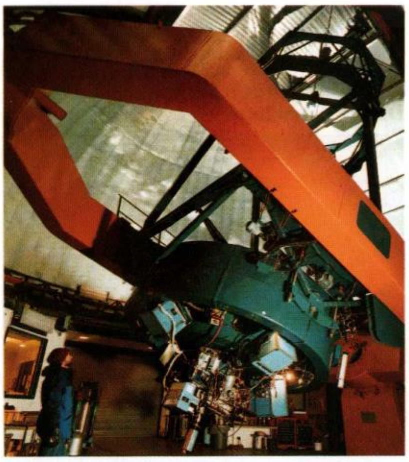


Figure 2: Lowering the solenoid into the North Hall at DESY.

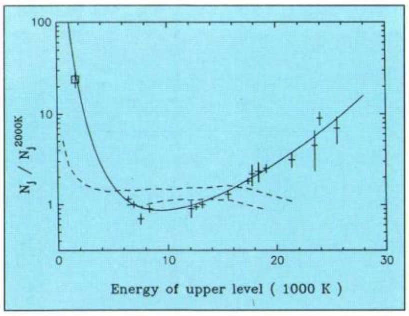
The first decade of UKIRT

In October 1989, the United Kingdom Infrared Telescope (UKIRT) completed a decade of scheduled astronomical observing. During this time, the telescope and ancillary instrumentation have been developed by the Royal Observatory, Edinburgh (ROE) to transform UKIRT from a low-cost flux collector to a powerful and versatile 4-metre class telescope. Present day instruments based on array detectors have increased the data rate by a factor of several thousand and the sensitivity by a factor exceeding a hundred. The versatility is a consequence of the excellence of the sky above Hawaii's Mauna Kea and the range of instrumentation built to exploit it; observations have been made at wavelengths from the visible to beyond a millimetre. Dr Peredur Williams of ROE gives some highlights from ten years of achievement.

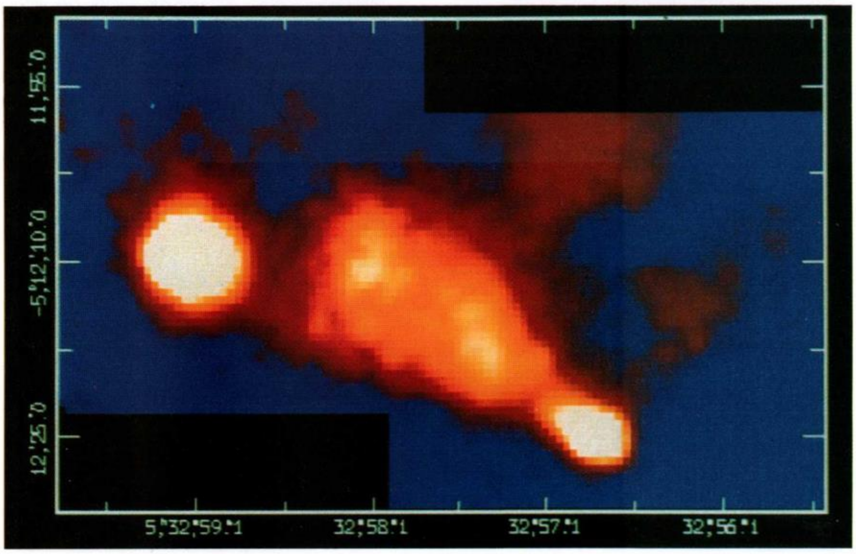


The instrument cluster at the Cassegrain focus of UKIRT. The Instrument Support Unit below the mirror cell carries up to four instruments simultaneously, allowing the observer to change to a different instrument in a matter of minutes.

Over the last decade, what have we learnt from infrared astronomy and UKIRT in particular? Any selection will be personal but must be based on the features of infrared astronomy. These include observability of forbidden fine-structure lines and molecular vibration-rotation and pure rotation spectra. Infrared radiation suffers less extinction than the visible, and is sensitive to matter too cool to emit in the visible or so distant that its visible radiation is red-shifted into the infrared. Above all, there is the sheer range of frequency space covered, allowing study of the variety of physical processes that can occur in the same object.



Molecular hydrogen lines in Orion: comparison of H_2 column densities in Orion, from 16 transitions in the 2-4 micron region with the predictions J-shock (solid line) and C-shock (broken line) models.



A jet associated with star formation in the molecular cloud OMC-2 imaged in the 2-2.4 micron waveband.

In 1988, for instance, 53 papers based on observations made with UKIRT were published in refereed scientific journals. The authors of these came from 16 institutions in the UK and 32 overseas: in Europe, North America, Japan and Australia. The targets covered a huge range of astronomical distance: from Saturn's rings observed at a wavelength of 380 microns to the discovery of a radio galaxy at a redshift of 3.395. Most studies, however, were of star formation in our own or other galaxies: dense interstellar and protostellar clouds, bipolar outflows from young stars and newly-formed stars.

Multi-frequency studies of active galactic nuclei

Quasars and the bright, compact nuclei of some radio and Seyfert galaxies have energies around 10^{50} erg/s and are considered active galactic nuclei (AGN). Their study requires consideration of the emission over the entire range of the electromagnetic spectrum from low radio frequencies right up to gamma-rays to separate and understand the physical processes at work, such as synchrotron emission, inverse Compton scattering, thermal emission by dust and a small amount of starlight. Observations with UKIRT and its common-user infrared and submillimetre photometers have provided data over a wider frequency range than any other telescope. This allowed, for example, a detailed study of a dramatic outburst observed from 3C273, the archtypal quasar, during 1983. Analysis of the observations of this flare led to the development of a new model for the evolution of compact sources where the flare emission arises in a small region behind a shock wave travelling down a relativistic jet.

UKIRT observations of the most extreme AGN, the BL Lac objects, have shown that their infrared radiation is strongly polarised and that this can change over very short timescales; again pointing to relativistic jet models.

Observations of the centre of our own Galaxy

The nucleus of our own Galaxy is heavily obscured by intervening matter in the line of sight because we live in the galactic plane. Much of our knowledge of it therefore comes from observations in the infrared and most of these have been made with UKIRT. Observations of infrared line emission from molecular hydrogen shows that there is a rotating ring of molecular material of radius around 2 parsec around the nucleus. Within this ring, ionised plasma and heated dust can be observed. Infrared spectroscopy of this plasma shows that there is a small but extended region in the very centre where material is flowing out at velocities up to 700 km/s, exciting the molecular hydrogen emission in the ring. This region is currently being observed at higher spectral and spatial resolutions to tie down the nature of the central engine of the Galaxy.

The highest resolution observations have been made when the galactic centre has been occulted by the moon, as in 1987 when infrared images were taken with the infrared array camera (IRCAM) four times a second as the limb of the moon moved across the galactic centre to obtain spatial information on scales up to 0.1 arc second.

Studies of molecular hydrogen emission

Besides the galactic centre, molecular hydrogen line emission has been observed from regions of current star formation, where the emission arises from the impact of material flowing from the newly formed stars on clumps in the interstellar medium. We now know that the formation of low mass stars includes a phase when they lose matter in two oppositely directed jets, making a bipolar structure. From the relative strengths of different hydrogen ion lines, it is deduced that the hydrogen emission is collisionally excited. Because the vibrational and rotational energy levels of the hydrogen molecule are widely spaced, collisional excitation of hydrogen requires higher temperatures than are expected to persist in molecular clouds. This, in turn, implies that the heating must be in shock waves in the interaction regions. A detailed analysis of the spectrum of hydrogen ions from the Orion Nebula allowed discrimination between the models where there is a sharp discontinuity (J-shocks) and those where the acceleration is more gradual due to the influence of magnetic fields (C-shocks). Mapping of the hydrogen emission at high spatial resolution with IRCAM reveals the morphology of the jets and shocks. Molecular hydrogen emission has also been mapped from evolved objects such as the planetary nebula NGC 7027, where the line profiles show that the hydrogen is formed in an expanding shell of neutral material overtaken and thus shocked by a faster-moving shell of ionised gas.

If the surface of a molecular cloud is close to a hot star with a strong ultraviolet flux, hydrogen line emission can also be excited by fluorescence. This has been discovered in reflection nebulae and a number of extragalactic objects, such as the giant HII region in M33 (a nearby spiral galaxy) which is known to border on a molecular cloud. Altogether, observations of hydrogen line emission have taught us a great deal about processes occurring during star formation in our own and other galaxies and UKIRT continues to be the world leader in this field.

Solid state spectroscopy

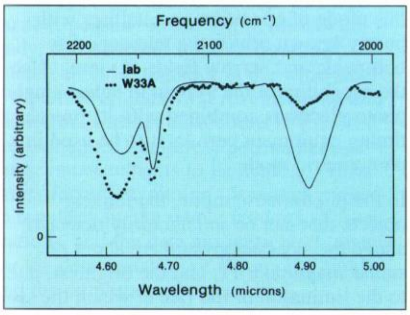
Although extinction by interstellar dust is generally considered a nuisance, the grains themselves play an important role in the chemistry of the galaxy. Infrared spectroscopy shows that most have cores of amorphous silicates related to enstatite and olivine. Grains in molecular clouds have icy mantles. Besides water ice, features due to ammonia, carbon monoxide, methanol, and other frozen molecules have been observed. It is believed that reactions, perhaps stimulated by cosmic rays, on the surfaces of such grains deep in molecular clouds are responsible for the complex molecules observed in the interstellar medium.

A great deal of interest has been generated by observations of emission features identified with polycyclic aromatic hydrocarbons (PAHs), such as coronene (8 rings). These are observed from reflection nebulae and HII regions, where there is ultraviolet radiation to excite the emission. They form particularly small grains and may be on the pathway to the formation of larger, carbon grains.

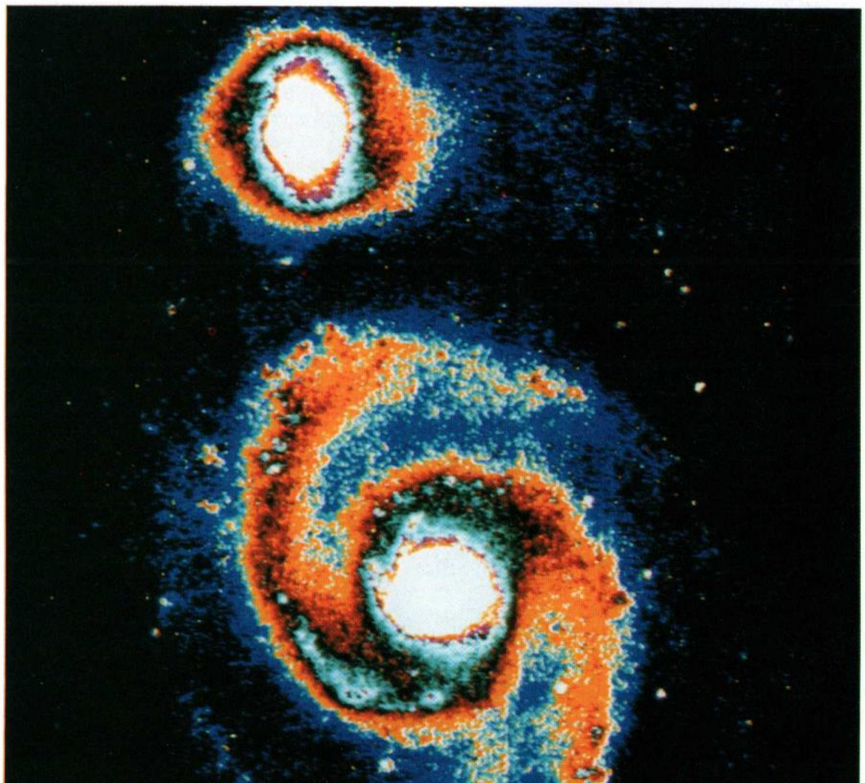
The next decade

Two new instruments are scheduled for delivery to UKIRT in 1990: a medium-resolution spectrometer for observations in the 10 and 20 micron regions and an array spectrometer for observations in the 1-5 micron region. They will be used for detailed studies of objects discovered with the present instrumentation but the infrared is so full of surprises (witness the discovery, at UKIRT, of shock-excited hydrogen in the harsh, high-energy environment of the Crab Nebula), that the best may still be to come.

Dr P M Williams
Royal Observatory Edinburgh.



Spectroscopy of exotic ices: the 4.5-5.0 micron spectrum of W33A (dots) showing absorption features due to ices frozen on to solid dust grains. The continuous line is the laboratory spectrum on which CO, NH_3 and H_2S were deposited and then subjected to ultraviolet radiation and temperature variations, resulting in the formation of more complex molecules on the substrate. The only absorption clearly identified is that at 4.657 microns, due to solid CO; it is known that the 4.62 micron band involves a molecule containing a CN band and that the 4.9 micron band involves a molecule containing sulphur.



Infrared image of the 'Whirlpool' galaxy, M51 (bottom), giving the first unobscured view of the distribution of stars in it. It is interacting with the galaxy to the North (NGC 5195).

Satellite observation at the Royal Greenwich Observatory

The satellite laser ranging (SLR) system became fully operational at the Royal Greenwich Observatory (RGO) at Herstmonceux at the end of 1983. The system was described in detail in *SERC Bulletin* Volume 3 No 1, January 1985; this article, by Andrew Sinclair of RGO, gives a brief progress report on the laser ranging activities, and also describes some of the other types of observations of satellites that can be made with the SLR system, and related activities by the Hewitt camera satellite tracking team and satellite prediction service, which are now part of RGO.

The SLR makes range measurements to special satellites carrying corner-cube retroreflectors by timing accurately the time-of-flight of very short laser pulses. Typically about 10^{17} photons are emitted in each pulse, and the normal return rate is about 1 photon in every 5 to 10 shots. At night, these returned photons are easily identified as the background noise is low. In daytime the noise is reduced by using a small field of view, a narrow spectral filter, and a short range gate, and then the returning photons are distinguished from the remaining noise by the smooth behaviour of their residuals from the predicted range.

Since becoming operational the SLR has run smoothly as one of the most productive and accurate systems in the world, and in the five years 1984-1988 it tracked 13% more passes of the prime target satellite Lageos than the next most productive system over that period, which is in California. The accuracy of a single shot range measurement has been improved over this period from about 5 cm to 3.5 cm, and plans are in hand for further improvement.

The SLR telescope system, showing the main 50 cm telescope, and the 10 cm telescope used for emitting the laser pulse.

The data have made and continue to make a valuable contribution to studies of Earth rotation, global plate tectonics, crustal kinematics in the Eastern Mediterranean area, and the determination of the Earth's gravity field. The site at Herstmonceux is now established as an accurately known point in a global geocentric reference frame. Due to the high observational performance of the SLR the site has become a principal reference point for the study of crustal kinematics in the Mediterranean region, and the site is frequently used as a colocation point for GPS receivers in regional geodetic campaigns. For these reasons, and also because of the better weather on the South coast, it has been decided that the SLR will remain at Herstmonceux as an outstation of the RGO when RGO moves to Cambridge in March.

High accuracy

The main function of the system is laser ranging to artificial satellites, but the high accuracy of the telescope's positional encoders permits it to make angular positional measurements of satellites to an accuracy of about 3" and, in order to use this mode of operation on satellites with poorly-known orbits, the telescope has both wide and narrow fields of view. Also the capability of the system to detect single photo-electrons combined with its precise timing equipment permits it to be used in a photometric mode.

In the photometric mode, the faintest objects that can be satisfactorily detected above the sky background are about of stellar magnitude 11, and the brightest, due to the limitation of the rate at which the counter can operate, of about magnitude 0.9. As an example, the photometric trace recorded from the discarded rocket body of Cosmos 1844 is shown in figure 1, and it shows a smooth variation of brightness due to the varying diffuse reflection from the rotating body, with spikes due to specular reflections from flat surfaces.

These raw photometric measurements need to be corrected for several effects: the sky background is determined and removed from the data by following the same track immediately after the satellite pass; the data are corrected for atmospheric extinction as the zenith angle varies and for the varying distance of the satellite. It is then possible to attempt to represent the data using a model of the light reflected from a rotating body of the approximate shape of the satellite, by determining the various parameters of the model. For Cosmos 1844 the shape was approximated by a cylinder with flat ends, and the parameters of the model determined from the data were the direction of the rotation axis, the rotation rate and the reflectivities of the sides and ends of the cylinder. A fairly good representation of the photometric data was achieved, and the rotation was deduced to be as shown in figure 2. The procession of the rotation axis is probably a forced motion due to magnetic effects.

A further application of the photometric mode arose in July 1989 when Titan, a satellite of Saturn, passed in front of a fifth-magnitude star. The photometric trace of the light from both objects is shown in figure 3, and shows the gradual fading of the light from the star through the atmosphere of Titan, with sharp dips probably due to clouds in Titan's atmosphere. The central spike is due to a lensing effect around Titan.

The wide and narrow fields of view of the SLR permit it to play an important part in obtaining early range measurements to newly launched satellites carrying retroreflectors, so that the orbit can be improved to the point where the majority of laser stations can begin to operate. This occurred for the Japanese satellite Ajisai (height 1500 km) launched in August 1986, and for the Soviet satellite Etalon (height 19,000 km) launched in January 1989. In each case the UK SLR was the first to obtain accurate range measurements. For the launch of Ajisai, the Hewitt Camera team set up a radio link via satellite to Japan which was used to obtain the exact time of launch, and this made it possible to see Ajisai, the rocket body, and a second satellite from the launch all close together in the wide-field TV picture on their first revolution around the Earth. Further corrections to the orbit were obtained, and these permitted laser range measurements to be made to Ajisai on its second revolution. It is now ranged-to regularly by the whole network of laser stations, and the data are particularly useful for the determination of the gravity field and the amplitude of ocean tidal constituents.

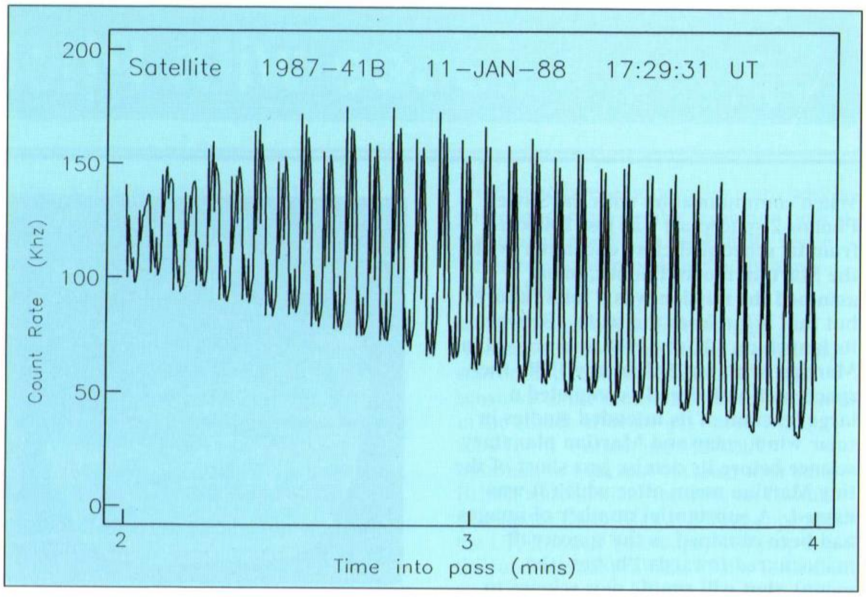


Figure 1: Sky-subtracted photomultiplier counts obtained during a pass of Cosmos 1844. The integration time was 0. ˢ2. Individual counts have been converted to rates in KHz and the plotted points have been joined by straight lines. Rapid brightness variations are apparent.

Two cameras

RGO is at present responsible for operating two satellite tracking cameras — one at Herstmonceux and one at Siding Spring in Australia — and also for running a service to provide predictions for the cameras and for a team of amateur observers who make visual positional observations of satellites. The camera observations are accurate to about 3 arcsec, and the visual observations to a few minutes of arc. These are used together with angular positions made by radar for the study of the rotation and density of the upper atmosphere, and for the determination of particular harmonics of the gravity field that are resonant with the orbits of particular satellites.

This work has been carried on for many years, and has produced valuable results. In particular the values obtained for particular gravity field harmonics have provided an important check and constraint on the various models of the gravity field that have been constructed. The work will continue, perhaps using other types of data, but it is likely that the regular operation of the cameras will cease in 1990. The camera at Herstmonceux will be maintained in operable condition for tasks for which it is the only available suitable equipment, such as determining the positions of satellites just before their decay, when the predicted orbits are highly inaccurate.

Just such a situation arose for the Soviet satellite Cosmos 1900 which decayed in October 1988. It was carrying radioactive material used as a power supply, and so the location of its re-entry was crucial. Normally the reactor would be jettisoned into a higher orbit, but this appeared not to have worked for Cosmos 1900. The Hewit camera team at RGO used the camera and their wide information network to keep track of the satellite, and they kept the responsible agencies and the press in UK, Europe and around the world informed of the demise of the satellite. In the event the reactor was successfully jettisoned just before the re-entry of the satellite.

Dr A T Sinclair
Royal Greenwich Observatory

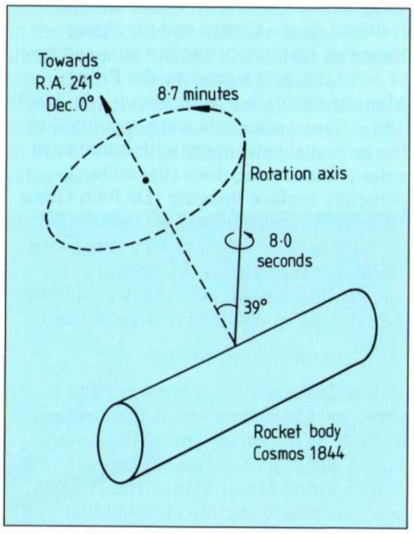


Figure 2: The rotation of Cosmos 1844, as determined from the photometric data.

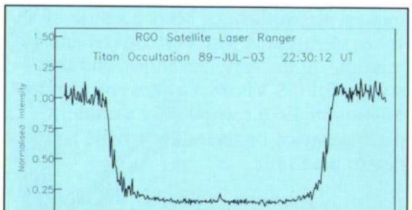


Figure 3: Photometric trace of the combined light from Titan and a star, with a reduction in intensity as Titan passed in front of the star, with gradual fading through the atmosphere of Titan, and a central spike due to lensing around Titan.

Space science with Phobos

When communication with the Soviet Phobos 2 spacecraft was lost 200 km from its scheduled close encounter with the Martian moon, Phobos, many assumed the mission was a total failure, but that is far from the truth. Between its launch on 12 July 1988 and arrival in Martian orbit on 29 January 1989, the spacecraft had already completed a large fraction of its intended studies in solar wind, solar and Martian planetary science before its demise just short of the tiny Martian moon after which it was named. A substantial number of images had been obtained as the spacecraft manoeuvred towards Phobos (the moon), that will enable new science to emerge, writes Professor David Southwood of Imperial College, London.

British scientists became involved in Phobos (the space mission) as a result of an agreement drawn up by the British National Space Centre and the Space Research Institute of the Soviet Academy of Sciences, and signed by the Prime Minister during her Moscow visit in April 1987. Three scientists were appointed to the project science team with interests in solar-planetary relations (the author), planetary surface imaging (Dr John Guest, University College London), and active probing of the Phobos surface (Professor Grenville Turner FRS, Manchester University). Of the three, only Professor Turner will be completely disappointed.

Our unknown neighbour

Before January 1989 more was known about the ionosphere and magnetosphere of a planet as distant as Uranus than was known about those of our immediate neighbouring planet Mars. The Phobos spacecraft has radically changed that by providing the first properly instrumented orbital surveys of the Martian plasma environment — and very curious it turns out to be. Little was known about the ionised atmosphere of Mars because of a series of mishaps with both Soviet and US missions in the early seventies, and the successful US Viking Orbiter and Lander mission in 1976 carried only a crude plasma device on the entry vehicle and determined little.

A critical question is whether the planet has an internal magnetic field; the Earth's field creates a cavity within the solar wind that streams out continually from the Sun and results in there being direct access for solar particles to the atmosphere only in limited ranges of latitude. No magnetometer was carried in orbit or taken to the planet surface by Viking. The presence of an internally generated magnetic field is, of course, a question of fundamental interest to all planetary

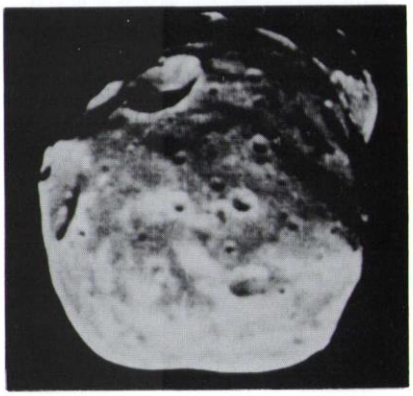


Image of the Martian moon Phobos, obtained by the Soviet Phobos spacecraft. The object, which was probably originally from the asteroid belt, is irregularly shaped (potato-like), cratered and, surprisingly, seems to have a fairly deep regolith. (Photo: Space Research Institute of Academy of Sciences of USSR).

scientists, not just the space plasma physicists. Controversies over the presence or absence of a planetary intrinsic magnetic field have raged unchecked by the sobering presence of actual data for two decades.

The first three Martian orbits by Phobos were highly elliptical with a periapsis of about 850 km altitude. It was hoped that the closeness of the approach would be sufficient to detect the presence of any planetary internal dipole field. On these orbits, a bow shock (where the solar wind is decelerated from supersonic flow), disturbed magnetosheath (the region behind the shock where the flow is diverted around the planetary obstacle) and a 'planetopause' were detected.

The planetopause

The planetopause is where the (mainly hydrogen) solar plasma disappears and ions of planetary origin such as the oxygen ion O^+ become dominant. In this respect the planetopause had many of the properties of a magnetopause, the boundary of a magnetosphere within which the magnetic pressure of the planetary field holds off the solar wind flow. However it now seems unlikely that the magnetic field inside this boundary is an internal planetary field; later analyses suggest that the boundary is not a magnetopause. On two of the first three orbits the field remained in the same direction inside the boundary as outside, but on orbit three there was some rotation through the boundary; these orbits thus left a great deal of ambiguity and certainly did not resolve the controversy concerning the presence of a planetary field.

Subsequent analysis of the tail field orientation as a function of the external interplanetary magnetic field (IMF) direction shows that the tail field direction is controlled by the IMF and thus that there is unlikely to be an intrinsic planetary field. This accords with other analyses as we mention below.

The most dramatic results from the mission are probably the analyses of outflowing ions on the nightside of the planet. During the 26 circular (Phobos rendezvous) orbits at an altitude of about 6000 km, beams of ions which appear to be O^+ were detected flowing away from the planet. Fluxes are of order $3x10^6 cm^2 s^{-1}$. Similar fluxes are in fact found leaving the Earth above the auroral zones but what is remarkable in their discovery at Mars is the potential effect on the much more tenuous Martian atmosphere. The flux integrates to a nett mass loss rate from the planet of order 2 kgs^{-1} which is sufficient to remove the atmosphere in something like 100 million years — a long time, maybe, but short compared to the life of the solar system of 4.5 billion years.

The results have created great interest at Imperial College where, with a substantial amount of luck, work was already well in hand in setting up a computer model that looks capable of explaining the distributions of material observed moving away from the planet. The model had been set up to simulate the extended cometary plasma environment encountered at Comet Halley by the Giotto probe and at Giacobini-Zinner by the NASA/ESA International Cometary Explorer spacecraft. Ironically, because of the extended nature of the environment, turbulence appears far more important in the comet environment than it is at Mars where scattering by turbulence does not seem to disrupt the underlying process.

The mirror effect

The solar wind slows in the region immediately upstream of the planet and at the same time planetary material is photoionised. The rapid slowing of the solar wind causes the solar wind field to increase where the ionisation takes place, and the consequent non-uniformity of the field causes both the newly ionised planetary material and the solar wind particles to be pushed away from the planet into the weaker field in interplanetary space by a process known as the mirror effect. Orbit calculations and simple kinematic calculations show that the heavier planetary ionised material ends up behind the planet (on the nightside) moving out away from the Sun and the planet just as the Phobos instruments detected. At the time of writing it is still

MERLIN extension project

A £5 million award from SERC will enable Manchester University's Jodrell Bank to explore new mysteries of the Universe.

The money is mainly being used to build a brand new 32-metre diameter telescope near Cambridge on a site owned by the Mullard Radio Astronomy Observatory (MRAO). The telescope, being manufactured by the West German company MAN, will be one of the most advanced in the world. It will be controlled remotely from Jodrell Bank and for most of the time will be linked with the six other telescopes, including the world-famous 30-year-old Lovell Telescope, forming the Multi-Element Radio Linked Interferometer Network (MERLIN). With the inclusion of the new telescope, MERLIN will have a resolution equivalent to a single telescope over 200 km in diameter. In addition to giving this very high resolution, the new telescope will improve the sensitivity of the network to high frequency radio waves enabling astronomers to explore new and more distant radio sources.

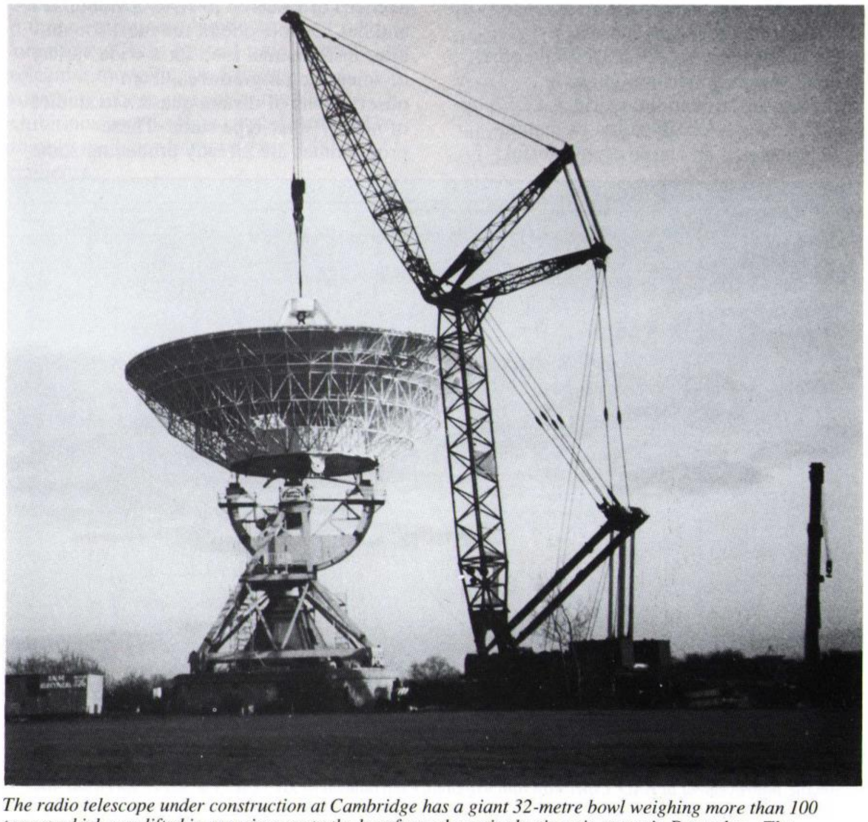
MERLIN will also be used together with other big telescopes in Europe, the whole network then being equivalent to a telescope more than 2000 km in diameter.

One reason for siting the new telescope at Cambridge, 200 km from Jodrell Bank, is that Cambridge's easterly direction complements the north-south alignment of the existing Jodrell telescopes distributed throughout England. The telescope will also be in the right position to work well with telescopes in the European network. Furthermore, the telescope will be on the same site as the UK's other major radio astronomical observatory, the MRAO.

Since Jodrell Bank facilities are already in great demand and this is likely to increase with the new improvements, it is hoped to make MERLIN a *national* radio astronomy facility which will be easy for UK and international astronomers to use.

Some key astronomical programmes for the new instrument will be:

- Studies of the inner parts of active galaxies. In some of these, many times more energy is produced from the centre of the galaxy than from all its hundreds of billions of stars put together. The major objective is to try and understand this energy-generation process. MERLIN will provide high-resolution radio maps which will complement similar resolution optical pictures obtained with the Hubble Space Telescope soon to be launched by the space shuttle.
- To open up a new field of high-resolution radio observations of stars and starforming regions. MERLIN will be sensitive to the molecular masers produced in the clouds of dense gas out of which stars form. Combining MERLIN information with that obtained with other British astronomical facilities on Hawaii (the James Clerk Maxwell Telescope and the UK Infrared Telescope) will help solve the fundamental problem of star formation.
- To study the effects of hidden matter in the Universe. Einstein's theory of general relativity predicts that light and radio waves will be deflected when they pass close to an object with a strong gravitational field. This effect shows itself in the production of multiple images of distant objects. MERLIN will be an ideal instrument for searching for small separation gravitational images which give information about the distribution of matter in the Universe, difficult to obtain in any other way.



The radio telescope under construction at Cambridge has a giant 32-metre bowl weighing more than 100 tonnes which was lifted in one piece on to the baseframe by a single gigantic crane in December. The telescope is planned to come into operation in the latter part of 1990.

Phobos continued

early days; rather complex detailed signatures are seen in the data and much comparison of data and theory is needed to see if the system is understood, but the preliminary betting at Imperial is that the planet is indeed unmagnetised.

If our first ideas are borne out, no other planet has an interaction quite like the Mars solar interaction. However, as we conclude that Mars, like Venus, has no internal magnetic field, it means that of the three terrestrial planets (Earth, Mars and Venus), in respect of internal magnetism, it is Earth that is the odd one out.

Mars and its moons remain the highest priority for the Soviet space programme. An orbiting survey mission, Mars 94, will be launched in 1994. The moon Phobos remains a scientific target of immense interest; it seems to be a captured asteroid and likely to be made of pristine primitive material processed little since the formation of the solar system. In 1996, the latest plan schedules a probe to be launched to rendezvous with Phobos to return samples of Phobos soil to Earth orbit as a prelude to the eventual return of Martian material to Earth, early in the next century.

David Southwood
Imperial College of Science, Technology and Medecine, London.

The new echelle spectrograph at the AAT

Spectroscopy, the study of how the light of astronomical objects is distributed among its component wavelengths, is one of the most powerful techniques for probing the universe. The new echelle spectrograph at the coudé focus of the Anglo-Australian Telescope (AAT) reconciles two competing requirements of spectroscopic work: wide wavelength span, so that large portions of the optical spectrum can be recorded at once, and high dispersion, whereby the light from a star is spread sufficiently to record in fine detail the characteristic features of its spectrum. The achievement of both goals simultaneously is made possible by the use of two optical elements — an echelle grating and a prism cross-disperser — to stack adjacent segments of the spectrum in a characteristic two-dimensional pattern, illustrated on the back cover. Some research highlights made possible by this new instrumentation are described here by Dr Max Pettini of the Anglo-Australian Observatory.

The AAT echelle spectrograph was built by David Walker and his team at University College London and is generally known as UCLES. While other echelle spectrographs are in use at observatories around the world, UCLES enjoys a unique combination of features which makes it an extremely powerful instrument. First, the spectrograph is highly efficient over the entire optical range of wavelengths, from the ultraviolet at 300 nanometres to beyond 1 micron in the infrared, as its transmitting optical components are of fused silica, an ultraviolet-transmitting high-quality glass. One of the spectrograph components, the set of cross-dispersing prisms, is in fact the largest ever made of fused silica. Second, the optical performance is superb, and a resolving power as high as $\lambda/\Delta\lambda = 115{,}000$ can be achieved. Third, in the stable coudé environment, mechanical and thermal drifts are reduced to a mere 1/4 micron an hour on average, allowing stellar velocities to be recorded with an accuracy of 20 - 30 m s^{-1}. Lastly, and perhaps most importantly, a photon counting detector, the IPCS, is available at the AAT for use with UCLES. With its large sensitive area and low background, the IPCS is ideally suited to record the spectra of faint objects which would otherwise be beyond the reach of high-resolution spectroscopy.

Since its successful commissioning in June 1988, the UCLES has opened many new avenues of research to AAT astronomers and has become one of the most sought after instruments, used for a wide variety of scientific programmes, from observations of distant quasars to studies of nearby solar-type stars. These programmes are already producing some very exciting results, well illustrated by the following examples.

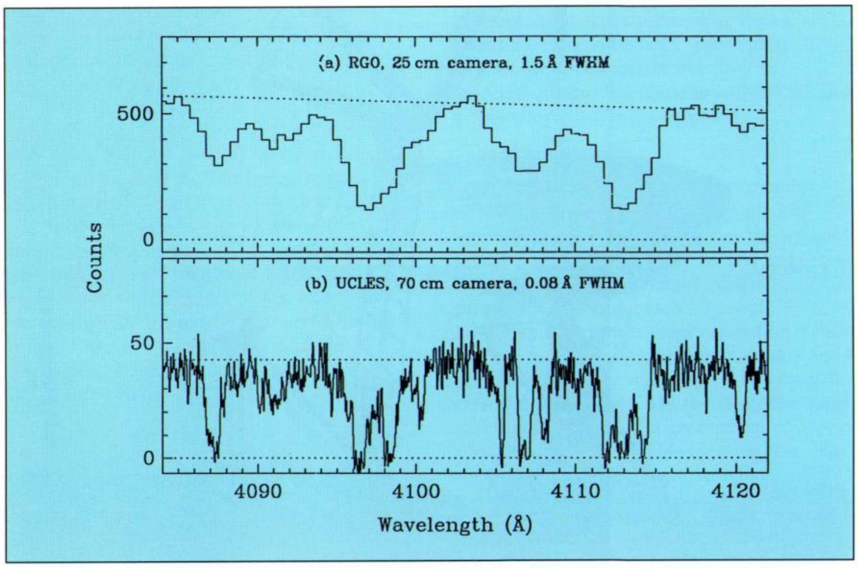


Figure 1: These IPCS observations of the high redshift ($z_{em} = 2.559$) quasar Q2206-199N highlight the dramatic improvement in AAO's spectroscopic capability introduced by UCLES. The upper spectrum was obtained at the Cassegrain focus with the 25 cm camera of the Royal Greenwich Observatory spectrograph at a resolving power generally deemed high for this type of work; the lower panel shows the same spectral features recorded with UCLES at the much higher resolution of 6 km s^{-1}.

Galaxies and intergalactic matter in the early Universe

Quasars are the most distant sources known to astronomers. As well as being fascinating objects in their own right, they provide through their spectra a powerful tool for studying the conditions of matter in the remote past, when the Universe was only a small fraction of its present age. On its journey to Earth, light emitted by a quasar is absorbed at specific wavelengths as it passes through galaxies and intergalactic gas clouds which by chance lie along the line of sight. By studying these absorption lines, astronomers can glean precious information on matter which is too distant to be observed directly. Since quasars are generally faint sources, their spectra have up to now been recorded at resolutions insufficient to separate clearly the wealth of absorption lines present. Figure 1 gives a vivid demonstration of how much easier this task has been made by the availability of UCLES.

The quasar designated as Q2206-199N, discovered in 1978 with the Schmidt telescope at Siding Spring, is at a redshift $z = 2.559$ or, to express its enormous distance in a different way, the light we see now was emitted by the quasar some 13 billion years ago. By studying the quasar spectrum we therefore have the opportunity to 'look back' over more than 85% of the age of the Universe.

Observations of Q2206-199N with UCLES by a team of astronomers from the Anglo-Australian Observatory, Sydney University and University College London, have produced surprising results concerning the intergalactic clouds giving rise to the so-called Lyman Alpha forest. This term is used to indicate a region of spectrum rich in hydrogen absorption lines which are thought to trace a population of primordial, intergalactic clouds. The clouds are known to evolve strongly with the expansion of the Universe, in the sense that they were more numerous at earlier epochs. The UCLES spectra have shown the lines to be much narrower than expected, implying that the cloud temperature is probably less than about 5,000 degrees, rather than the generally accepted value of about 30,000 degrees. This result, together with a strong indication from the data that the large-scale motions within the clouds may depend directly on their mass, suggests that the intergalactic gas being observed may be in the form of dense sheets, rather than the tenuous spherical structures considered up

UCLES continued

to now by most theoretical models. Undoubtedly, the results obtained with UCLES will lead to a revision of current ideas as to the nature and origin of the Lyman Alpha clouds.

Stellar abundance studies

The record of the early stages of chemical evolution of the Galaxy is still imprinted in the composition of the oldest stars. In order to read this record it is necessary to observe the spectra of these stars with a resolution adequate to identify and measure key absorption features. These features are generally weak, reflecting the fact that the stars formed at a time when heavy elements — or metals, as they are loosely termed by astronomers — were far less abundant than today. This is an area of study where UCLES is having a major impact, not only because its high resolving power makes it possible to distinguish absorption lines which are normally blended, but also because of its high efficiency in the ultraviolet, where some of the lines most suitable for abundance measurements in metal-poor stars are found.

A team of Australian astronomers from the Mount Stromlo and Siding Spring Observatories (MSSSO) have used UCLES observations of iron-peak elements to confirm that a number of stars, suspected of being metal-poor from earlier low-resolution surveys, indeed have abundances as low 1/100 to 1/1000 of solar values. In these stars, oxygen has been found to be overabundant relative to iron by about a factor of 3; this is consistent with the view that oxygen is produced predominantly in massive stars, which evolve rapidly, while iron has an additional source in lower mass — and therefore more slowly evolving — stars. Nitrogen was also found to be overabundant in about one-third of the stars studied, suggesting that there may be an as yet poorly understood mechanism for its production in old population stars.

In a related study, the abundance of beryllium has been measured in metal-poor stars, thereby improving earlier estimates of this quantity by more than one order of magnitude. Again, the high spectral resolution and efficiency of UCLES in the ultraviolet were key factors, because the beryllium lines sought are near 3131 Å and are normally blended with other absorption features, as can be seen from figure 2. By showing that the abundance of beryllium tracks that of iron over three orders of magnitude in metallicity — from stars of solar composition to stars with only 1/1000 of the iron content of the Sun — the MSSSO astronomers have been able to place stringent upper limits on the primordial abundance of beryllium, which in turn can be used to test recent non-uniform density models of 'Big Bang' nucleosynthesis.

Dr M Pettini
Anglo-Australian Observatory

SERC-DTI transputer initiative

The SERC/Department of Trade and Industry (DTI) Initiative in the Engineering Applications of Transputers was set up in 1987 to provide awareness of the transputer, leading to its exploitation by UK plc. The Initiative has a programme aimed at both the academic and industrial engineering communities. It is funded by SERC's Engineering Board and Computing Facilities Committee, and the Department of Trade and Industry (DTI).

One of the main components of the programme is the group of six Transputer Support Centres (see *SERC Bulletin* Volume 3 No 9, Autumn 1987). The other major component is the Coordination Team which looks after a wide range of activities aimed at general awareness of the transputer.

The main event of 1989 was the Initiative's first international conference and exhibition, which was held at Liverpool University in August. The conference was attended by 350 delegates who listened to a total of 54 papers covering subjects from signal processing in satellite communications to supercomputing with transputers.

In addition, the Initiative has so far run seven seminars and two workshops, has set up three Transputer Applications Community Clubs (in real time control, molecular modelling and image processing), been present at numerous exhibitions and displays, and distributed a monthly mailshot to more than 2000 recipients.

The Academic Loan Pool provides researchers with the facility for pump-priming investigations of transputers hardware and software before research project proposals which are then 'peer reviewed' in the normal way. If appropriate, an initial training course is also provided at the Initiative's expense at one of our Support Centres. Loans are expected to be completed with a suitable report and, where possible, the provision of any new software developed as a result of the loan.

The programme is currently close to its half-way point and the Initiative has recently commissioned a market survey to determine how the 'awareness' programme is penetrating industry, and what are the perceived needs of industry from the Initiative and the Centres. The outcome of the survey will be used to modify the programme of the Initiative to address any issues identified.

Further details of the Support Centres (at Belfast, Liverpool, Sheffield, Strathclyde, Southampton or RAL) or any of the services or facilities referred to above, can be obtained from the Coordination Unit at RAL (telephone 0235 821900) as follows:
Support Centres: Dr Raymond Fawcett, ext 5243; PROFS: RJF
Mailshot: Terry Mawby, ext 5787; PROFS: TPM
Transputer products: Cyril Balderson, ext 5660; PROFS: CB
Initiative: Dr Mike Jane, ext 5408; PROFS: MRJ

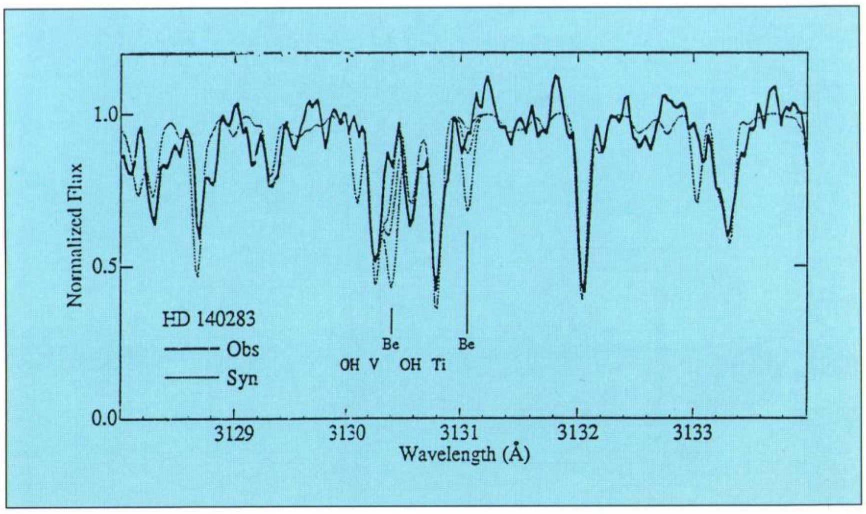


Figure 2: UCLES spectrum of the star HD 140283 in the ultraviolet region encompassing the lines of singly ionised beryllium at 3130.420 and 3131.065 Å. The observed spectrum (thick line) is compared with model predictions (thin line) for three values of the beryllium abundance, respectively 40, 130 and 400 times lower than that measured in the Sun. From the comparison it is concluded that this star has less than 1/400 of the beryllium content of the Sun.

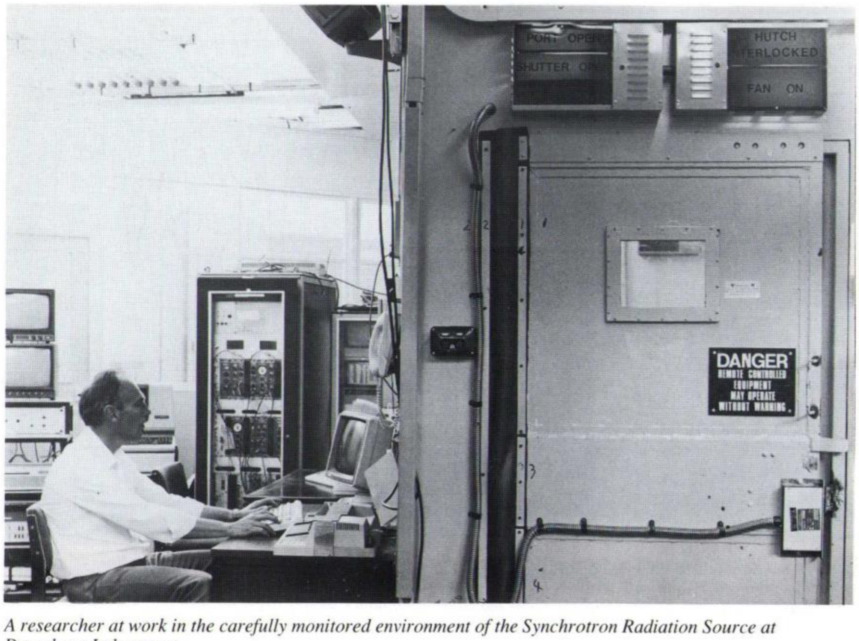
SERC and occupational safety

Recent years have seen a general strengthening of the legislation concerning health and safety at work, much of it as the result of the drive to harmonise standards within the European Community. At the same time minds have been focused by the increasing level of penalties imposed by the courts and by the greater willingness of individuals to resort to civil action following occupational death and injury. There has inevitably been a corresponding change of climate within SERC's establishments, writes Dr Robin Tait of Daresbury Laboratory.

Within the last year or so a large multinational company was fined £¾ million after pleading guilty to two charges brought by the Health and Safety Executive following accidents at one of their manufacturing sites. In another case, still before the courts, criminal charges have been laid against named individuals. Such events are bound to cause concern to even the best employers and recent increased penalties are intended to have just that effect. In the civil courts there has been greatly increased activity both in terms of a greater readiness of employees or their relatives to go to court and in the magnitude of the compensation demanded. One motor manufacturing company is facing claims from a number of its employees and ex-employees who have suffered hearing loss; these claims amount in total to several million ponds.

SERC's establishments have associated with them a particularly broad range of occupational hazards. These include those connected with chemicals, biologically active materials and radiation, both ionising and non-ionising, as well as the more conventional hazards found in workshops, offices and plantrooms. But it should be realised that although chemicals, biologicals and radiation have great potential for harm, working time is lost almost exclusively as a result of 'simple' accidents associated with the more conventional hazards. In the last five years, for example, 34 working days have been lost through back injuries from lifting and carrying accidents at Daresbury. Establishment safety policy must tackle both types of hazard and must also cope with fresh demands based on new legislation.

The most important recent legislation, resulting from EC harmonisation efforts, is that concerned with the control of substances hazardous to health (COSHH). Such legislation does not necessarily lead to fundamental changes to work practices, particularly so in SERC's establishments where, in general, safety standards are already high. It should lead to a careful review of those standards however, and usually does. The introduction of COSHH has brought about a more systematic review of hazards, a more careful documentation of safety procedures and a tighter control of access to hazardous substances. Positive management and clear instruction and training are essential in such circumstances.



A researcher at work in the carefully monitored environment of the Synchrotron Radiation Source at Daresbury Laboratory.

As far as SERC staff are concerned, acceptable safety standards have traditionally been maintained by striving to ensure that the chains of command are clear, that individuals' duties and responsibilities are carefully and unambiguously defined, by careful supervision and by providing staff with adequate training and instruction. Efforts are made to incorporate good safety practice as an integral part of the employee's job rather than as an 'add on' extra. The degree of success varies greatly from individual to individual, depending on character and motivation.

Particular care is required in maintaining safety for visitors, especially researchers using SERC facilities. Such researchers expect and must be given a working environment in which they can easily get their work done without having to follow detailed instructions or elaborate safety procedures. Although many of the older researchers will have a great deal of knowledge and experience of safe working, there will also be relatively inexperienced research students present, working sometimes on their own.

With these points in mind, user equipment is designed with particular care to be as robust and as uncomplicated as possible. Safety interlocks and fail safe devices are used to maintain safety standards without the necessity of additional procedures. In situations where this approach is not practicable — for example in a chemistry laboratory where highly reactive chemicals are to be used — careful control of access is necessary and detailed working procedures have to be agreed, although this is obviously a labour-intensive process.

A facility which illustrates well the complexities of safe operation is the Synchrotron Radiation Source (SRS) at Daresbury. The SRS operates three shifts a day, manned by crews of three operators backed by a shift fitter. It provides intense beams of electromagnetic radiation (mainly ultraviolet or X-rays) to as many as 28 beam stations simultaneously. The stations all have interlocks which prevent beam introduction under conditions where personnel might be irradiated. The X-ray stations are contained in steel- or lead-shielded hutches which must be formally searched using electronic search points, and locked, before the beam shutter can be raised. Named Daresbury staff are responsible for the safe and efficient operation of each station.

The SRS has about 1500 registered users from a wide range of research disciplines. They are all given a brief talk on laboratory emergency procedures on first arrival. At any time there may be more

Polymers Design Data Initiative

For many years, the suppliers of polymeric materials (plastics, rubber and their composites) have had an uneasy dialogue with design engineers and end-users over what constitutes property data for design purposes. Whereas the suppliers' data have often been criticised, the precise needs of the designer have not been clearly defined. But now help is at hand as a result of an industry-initiated programme, writes Dr John Lockett of the Polymer Engineering Group, the programme's leader.

The Design Data Initiative is run by the Polymer Engineering Group (PEG) on behalf of the British Plastics Federation (BPF) and the British Rubber Manufacturers Association (BRMA). PEG is the successor to the Polymer Engineering Directorate, which was a Directorate within SERC until 1986. It is now sponsored by the BPF and BRMA, with the remit to promote research and development for the plastics and rubber industries. It retains links with SERC, for which it monitors many grants in the field of polymer engineering.

To date the Design Data Initiative has involved participation by more than 60 industrial companies, including materials suppliers, processors and fabricators, designers and end-users. During 1988, four working parties, many individual discussions and a conference were used to explore the broad nature of the problems and to identify important technical areas of current difficulty. As a result, seven working groups were established early in 1989 to examine the following nine areas:

- high rate deformation of plastics products
- dimensional stability of mouldings
- effects of processing on properties
- durability of materials exposed to aggressive environments
- design properties of electrical insulation materials
- design requirements for composite construction materials
- standard design data for composites
- design of joints
- design requirements for rubber products.

The remit of these working groups was to define the precise needs of industry for relevant design methods and data, to assess current capabilities, to identify ongoing work aimed at improvements, and then to define the needs for further work. In general, these latter requirements were expected to include 'technology transfer reviews' to clarify and communicate current knowledge and research projects directed at improved procedures.

The deliberations of the working groups were completed at the end of 1989, and their combined reports provide a valuable and unique statement of industry's perceptions of its current problems in this field and of the means for their resolution. These conclusions provide important guidance for research bodies (universities, research laboratories and industry) in selecting work of high industrial value, and for funding bodies (SERC, Department of Trade and Industry and industry) in forming priorities and evaluating proposals.

In the current phase of the Initiative, a coordinated programme has been proposed for joint funding by government and industry, and composed of selected projects from the much larger number identified by the working groups. Contractors for this work are being identified, and it is hoped that other projects, not covered by this programme, will be taken up by other means. PEG will be involved in the management of the joint programme and in coordinating other actions.

Further details of the Initiative can be obtained from Miss Corinna Thomas of BPF (telephone 01-235 9483) or from the author (telephone 01-235 7286), both at 5 Belgrave Square, London SW1X 8PH.

Dr J Lockett
Polymer Engineering Group

Efficient product design requires credible design data.

Occupational safety continued

than 50 users in the experimental areas. Experimental runs can vary from two or three shifts to several days. Running time for approved experiments is requested on a six-monthly basis and possible hazards have to be declared under specified headings. Requests to use the Biology Support Laboratory and the Materials Science (Chemistry) Laboratory are made at the same time, and users have to register on each visit before access to these laboratories is granted. On registration, their precise requirements will be discussed and safe working procedures agreed. All the information gathered is available on a computer in the SRS control room where it can be referred to by the wide range of staff concerned with the safe operation of the SRS. Obviously great reliance is placed in operating these procedures on the full cooperation of the user community.

Safety standards within SERC are good, but there is no room whatever for complacency, and the contribution of the user community to the maintenance of these standards will continue to be crucial.

Dr N R S Tait
Daresbury Laboratory

Integrated Graduate Development Scheme expanded

Another two courses have been added to the Integrated Graduate Development Scheme (IGDS) portfolio. At its May 1989 meeting the Engineering Board approved two programmes to add to the existing ten IGDS courses. The new programmes are to be run at Warwick University and at Birmingham Polytechnic. In this article, Stuart Taylor of the Teaching Company Directorate, which administers the scheme, explains some of the background to these courses.

Warwick University

The Manufacturing Systems Engineering Group at the University has run the highly successful IGDS in Manufacturing Systems Engineering since the experimental days of IGDS in the early 1980s. The IGDS at Warwick has grown from two major British manufacturing companies nominating 55 participants in 1981, to more than ten core companies, plus a further 15 associated companies, who together nominated about 155 participants in 1989.

The new programme — Design Systems in Production — was conceived and born at the positive instigation of the participating companies. They were seeking to benefit their design organisations in the same way that they perceived their manufacturing organisations to have benefited from participation in the IGDS in Manufacturing Systems Engineering.

Additionally, the companies wanted their staff from these two groups to achieve greater mutual understanding through substantial commonality between the two programmes, and through positive interaction. This latter objective is achieved by staff from both groups attending each of the common modules within the IGDS.

Currently the IGDS at Warwick offers over 45 modules in the areas of Business Management, Technologies for Design and Manufacture, Design and Operations Techniques and Management, and in Information Technology. There are 25 modules common to both the Manufacturing Systems Engineering and the Design Systems in Production programmes. All of the modules are regularly reviewed and updated, reflecting the continuously developing needs of manufacturing industry.

The highly visible success story of the IGDS at Warwick is presently supported by the following companies:

British Aerospace, Dunlop Aviation Division, GKN, Istel, Jaguar, Leyland-DAF, Lucas Industries, Norcross, Plessey, Raychem, Rolls-Royce, Rover Group, SP Tyres (UK), Schlumberger, Short Brothers, Thorn EMI, Vickers Shipbuilding and Engineering, and Westland.

Birmingham Polytechnic

The need to promote high levels of competitiveness in companies in manufacturing industry, and thus secure their long-term future, has become of increasing concern in recent years in the UK. To achieve this, companies must be able to respond rapidly to changing market demands, to minimise manufacturing costs and to give satisfaction through a good delivery performance, consistent product quality and attractive prices.

All of these features are largely dependent upon having tight control over the various activities involved in manufacture. It is now accepted that this can only be achieved through the establishment of a 'total manufacturing system' which includes all of these activities and which is supported by effective management.

The new IGDS course at Birmingham Polytechnic aims to provide both theory and practice of the skills and disciplines necessary to achieve the goals set by the 'just in time' philosophy. The course is titled Logistics in Manufacturing Systems and will be run by the Faculty of Engineering and Computer Technology. It came about as a result of close collaboration between the Polytechnic, the Institute of Production Engineers, The Engineering Employers' (West Midlands) Association and the City of Birmingham Educational Development Department.

In terms of the number of people employed, the West Midlands is the second (after the South East) most important manufacturing area in the UK. Of the total workforce employed in manufacturing in Britain, 13% are in the West Midlands. The industrial environment of the region currently, and traditionally, is one in which many small and medium-sized firms operate alongside large-volume producers. The participation of the Engineering Employers' (West Midlands) Association in this course ensures that many of the small to medium-sized enterprises in the region will benefit from the course.

In the manufacturing environment Logistics Engineering is seen as "the art of getting the right goods in the right quantity to the right place at the right time and at the right cost". In terms of the regeneration of the manufacturing base of the West Midlands, this course at Birmingham Polytechnic could be described in the same way.

Stuart Taylor
Teaching Company Directorate
Sudbury House, London Road,
Faringdon, Oxon SN7 8AA,
Telephone (0367) 22822.

Aims of the Integrated Graduate Development Scheme:

- to attract recent graduates to enter key functions in industry;
- to improve the technical and managerial effectiveness of such graduates through the provision of part-time modular education specifically tailored to participating company needs;
- to prepare graduates to take on major responsibilities at an early stage in their careers;
- to increase the technical knowledge-base of UK industry, thus increasing its competitiveness;
- to foster academic/industrial collaboration in carrying out these tasks.

How the Integrated Graduate Development Scheme works

Each IGDS programme is set up and run by a partnership of companies and one or more universities and polytechnics. A management committee is formed which has responsibility for designing, developing and monitoring short modular courses that are relevant to the particular industrial sector to be served by the programme.

Graduates employed by the participating companies attend a coherent programme of these modular courses, which are interspersed with normal work periods at the parent company. A company-based project is also undertaken, with the aid of both an industrial and an academic supervisor, which is designed to relate to the individual needs of the student and their company.

Opportunities in Japan

Have you ever wanted to visit Japan or wanted to exchange ideas with Japanese researchers? If you don't know which way to turn for help, then read on!

There is a multitude of schemes to support scientists and engineers to visit Japanese universities, research institutes and industry. The extent of informal scientific contacts and collaborations supported by SERC with Japanese scientists was recognised by the signing in 1982 of the SERC-Monbusho (Japanese Ministry of Education, Science and Culture) Aide Memoire.

Aide Memoire

A revised version of the Aide Memoire was agreed between SERC and Monbusho in Autumn 1989. This sets out a number of areas in which both sides have identified a UK and Japanese contact. These are:

- Space Science — satellites;
- Ground-Based Astronomy and Geophysics;
- Molecular Science — high resolution spectroscopy, electronic structures and dynamical behaviour of excited molecules, application of synchrotron radiation to molecular spectroscopy and photochemistry, molecular computational chemistry, material chemistry, molecular electronics, scientific application of synchrotron radiation, computational science, theoretical atomic and molecular physics;
- Neutron Scattering;
- Muon Catalysed Fusion and related muon science;
- Semiconductor Physics — semiconductor physics, low dimensional structures and devices;
- Millimetric Electromagnetic Waves;
- Lasers in Engineering and Manufacturing;
- High Temperature Superconductivity;
- Free Electron Lasers; and
- Surface Science.

It is essentially an enabling document and is not supported by any specific funding arrangements, but promotes continuation and extension to existing collaborations, identifies new areas for cooperative ventures and suggests new research areas where collaborations might be started.

Personal contacts

The opportunities for worthwhile collaboration with Japanese science are considerable, with good facilities and growing opportunities for exchanges funded by various UK and Japanese schemes (see below). However it is essential that researchers have personal contacts in Japan and here the British Council and the British Embassy in Tokyo are able to help. The British Council works to lessen the problems confronting visiting UK researchers. This can be in partnership with UK Research Councils, and universities and also in helping those supported through the Royal Society and the European Community. In response to this, the British Council has increased its budget for science-related work in Japan. Its intention is that by 1991 they will be helping to fund 40 collaborative projects with an average duration of three years, and supporting exploratory visits to Japan.

Advanced Research Meetings

All SERC support mechanisms may be used to support collaboration with Japan and applications should be submitted in the normal way. In addition, SERC's International Section operates an Advanced Research Meetings scheme which may provide funding for meetings of short duration between small numbers of researchers from different countries to discuss a particular area of science with a view to possible future collaboration.

Contact: Mrs Diana Herbert, International Section, SERC Swindon Office; telephone (0793) 411480.

The schemes

There are in total some 30 schemes that exist to promote UK/Japanese collaboration. Details of those which may be of immediate interest are:

British Council: Travel grants are available for short-term visits both to and from Japan, covering the costs of travel and subsistence.

Contact: Higher Education Department, The British Council, 10 Spring Gardens, London SW1A 2BN; tel: 01-930 8466.

British Council/Monbusho: Visiting Fellowships to Japanese National Universities for senior academics from UK academic institutions. Applications should be made by the host professor in Japan to Monbusho.

Department of Trade and Industry/ Fellowship of Engineering: Visiting Engineers Scheme for UK engineers to visit Japan, aimed at the 25-35 age group.

Contact: Miss J Spring, Manager, Engineering Support, Fellowship of Engineering, 2 Little Smith Street, London SW1P 3DL; tel: 01-222 3912.

European Commission: Scientific Training Programme in Japan, for EC nationals aged 25-35 with doctorate or equivalent professional experience.

Contact: Miss A Bowen (see below), or Commission of the European Communities, DGXII/G, Rue de la Loi 200, 1040 Brussels, Belgium; telephone 010-322-235-7509.

EC/Japan Centre for Industrial Cooperation: General training programme (includes engineering option) to study technical and managerial aspects of Japanese industry and commerce.

Contact: EC-Japan Centre for Industrial Cooperation, 5th Floor, Ichibancho, Chiyoda-ku, Tokyo.

Royal Society: Study visits, travel grants for attendance at international conference or visits to specific research institutes in Japan.

Contact: Ms K Kimpton, Royal Society, 6 Carlton House Terrace, London SW1Y 5AG; telephone 01-839 5561.

Monbusho: Japanese Government scholarships and research grants for periods in any Monbusho-recognised university or Monbusho-funded research institution.

Contact: Japan Information Centre, 9 Grosvenor Square, London W1X 9LB; telephone 01-493 6030.

Science and Technology Agency (STA): International cooperative research programme; STA fellowship programme; STA Japanese Government research awards for foreign specialists; STA invitation programme for foreign researchers related to important basic research themes; support programmes; JRDC International Exchange Programmes.

For an information pack giving details of schemes to support Anglo-Japanese collaboration, contact:

Miss Alison Bowen,
International Section,
SERC Swindon Office;
telephone (0793) 411036.

Services and facilities

funded by the Chemistry and Biological Sciences Committees

There is now a great deal of instrumentation available as a service to the chemistry and biological sciences communities. In addition to the central facilities at the Daresbury and Rutherford Appleton Laboratories which are funded directly by SERC's Science Board, there are several less well publicised services located in universities and funded by the Chemistry or Biological Sciences Committees. This article describes the services that are available and how potential users can gain access to them.

Contact points

NMR spectroscopy
Leicester
Professor G Roberts
(0533) 523456

Edinburgh
Dr I Sadler
031-667 1081 ext 3676

Warwick
Dr O Haworth
(0203) 523523

Durham
B Say
091-374 2585

Oxford
Professor J Baldwin
(0865) 275671

Pulsed ESR spectroscopy
University College London
Professor M Evans
01-380 7312

X-ray crystallography
Queen Mary College, London
Professor M Hursthouse
01-980 4811 ext 3717

Mass spectroscopy
University of Wales College of Swansea
Dr J Ballantine
(0792) 205678

Amino acid sequencing
Leeds
Dr J Findlay
(0532) 333140

Aberdeen
Professor J Fothergill
(0224) 273101

Southampton
Professor P Kociraski
(0703) 595000 ext 3332.

High field NMR

The Leicester 500 MHz and 600 Mhz NMR Service, which was established primarily for the biological sciences community, comprises two Bruker spectrometers, an AM500 (500 MHz; 11.7 T) and an AMX600 (600 MHz; 14.1 T), each with the following probes: ^{1}H(5 mm), multinuclear (AM500:10 mm; AMX600: 5 mm) and inverse mode (^{1}H observe, ^{15}N — ^{31}P decouple; 5 mm). Facilities are available on both instruments for the full range of homo- and heteronuclear one-, two- and three dimensional experiments, including ^{1}H NMR in $^{1}H_2O$, selective excitation and heteronuclear indirect detection experiments. Some 30% of the time on the 500 MHz NMR and 50% of the time on the 600 MHz NMR is available for outside users. The centre also has facilities for off-line data processing which are available to external users.

The Edinburgh 600 MHz NMR service has been established for the chemistry and biological sciences communities and comprises a Varian 600 MHz NMR spectrometer, with 80% of the machine time reserved for outside use. The spectrometer is equipped to obtain one- and two-dimensional spectra from protons, ^{19}F and all nuclei whose frequencies lie in the range from that of ^{31}P to that of ^{39}K, including ^{2}H, ^{13}C and ^{15}N. Proton spectra may also be obtained with proton decoupling or decoupling of any other nucleus in the above range and ^{13}C spectra may be obtained with broad band proton and deuterium decoupling. For spectra of other nuclei, selective or broad band proton decoupling is available. A whole range of two-dimensional experiments is possible, including COSY, NOESY, TOCSY, ROESY, INADEQUATE and direct and inverse heteronuclear correlation spectra.

The Warwick 400 MHz solution state NMR service, based on a Bruker WHP 400 specrometer is available for the observation of spectra for ^{1}H, ^{13}C and all nuclei between ^{39}K and ^{31}P, as well as some proton decoupling and variable temperature facilities. However, fluorine spectra are not available. The service was established primarily for the chemistry community and 60% of machine time is available for outside use; the service is primarily postal.

Solid state NMR

A solid state NMR service is available at Durham University, primarily for the chemistry community, on which 30% of the operational time of the spectrometer, a Varian VXR 300 MHz NMR, is reserved for service work. The instrument provides high resolution capabilities for nuclei in the frequency range ^{23}Na to ^{31}P and also ^{29}Si, ^{17}O, ^{15}N and ^{95}Mo. Variable-temperature facilities are also available as well as a probe for broadline studies of nuclei in the range ^{2}H to ^{31}P, plus ^{1}H and ^{19}F. ^{1}H relaxation measurements are also available.

There is, in addition, a Bruker MSL-400 MHz NMR at Oxford University which is available for solid state structural analysis of biological molecules; 30% of the machine time is reserved for outside users. Potential users should contact Professor J E Baldwin, Dyson Perrins Laboratory, Oxford University.

X-ray crystallography

The National Crystallographic Service at Queen Mary College, London is available, primarily on a postal basis, for structural determinations of organic and inorganic compounds. The instrument is an Enraf-Nonius FAST area detector diffractometer, attached to a rotating anode generator, and 80% of its operational time is available for service work.

In addition there is a ***Siemens D500 X-ray diffractometer at Imperial College, London*** on which 25% of the machine time is available for outside use. Potential users should contact Professor L V C Rees, Department of Chemistry, Imperial College.

Seqnet

A VAX computer at Daresbury Laboratory provides a national service for molecular biology computing. Workers can use this service remotely through JANET and other networks to have access to a suite of software for sequence analysis and to the principal international databases of protein and nucleic acid sequences. Users can analyse and compare sequences with a number of well known sequence analysis packages. Enquiries should be directed to the User Interface Group, Room C12, Daresbury Laboratory; telephone (0925) 603351; EMail UIG@Daresbury.

Mass spectrometry

A mass spectrometry service is available, primarily for the chemistry community, at the University of Wales College of Swansea. There are two spectrometers: a ZAB-E, which is an ultra-high resolution, double focusing mass spectrometer with sub-nanogramme level detection limit, and a VG 12-253 spectrometer with GC-MS. The service is postal.

Electron diffraction

Gas phase electron diffraction apparatus is available at Edinburgh University for structural determination of inorganic compounds volatile at temperatures from room temperature to 500K; 40% of the equipment time is available for outside use. Potential users should contact Dr D W H Rankin, Department of Chemistry, Edinburgh University.

Pulsed ESR spectrometer service

A pulsed ESR facility is available to the chemistry and biological sciences communities at University College London. It is based on a Bruker ESP 300 spectrometer, which operates at X-band and has a versatile pulse programmer with 8 nanosecond clock, permitting a wide range of different pulse sequences. The sample may be irradiated with a YAG laser which is synchronised with the pulse sequences. The instrument is equipped with a helium cryostat, permitting measurements from 1.8K to room temperature. Maximum pulse power is 1 kW. A small preparation laboratory is available adjacent to the spectrometer facility.

Amino acid sequencing

There are currently three amino acid sequencing services supported by the committees: at Leeds, Aberdeen and Southampton Universities. Applications for use of the Leeds or Aberdeen facilities may be made at any time on forms available from Mr P Russell at SERC Swindon Office, telephone (0793) 411046.

Mossbauer spectroscopy

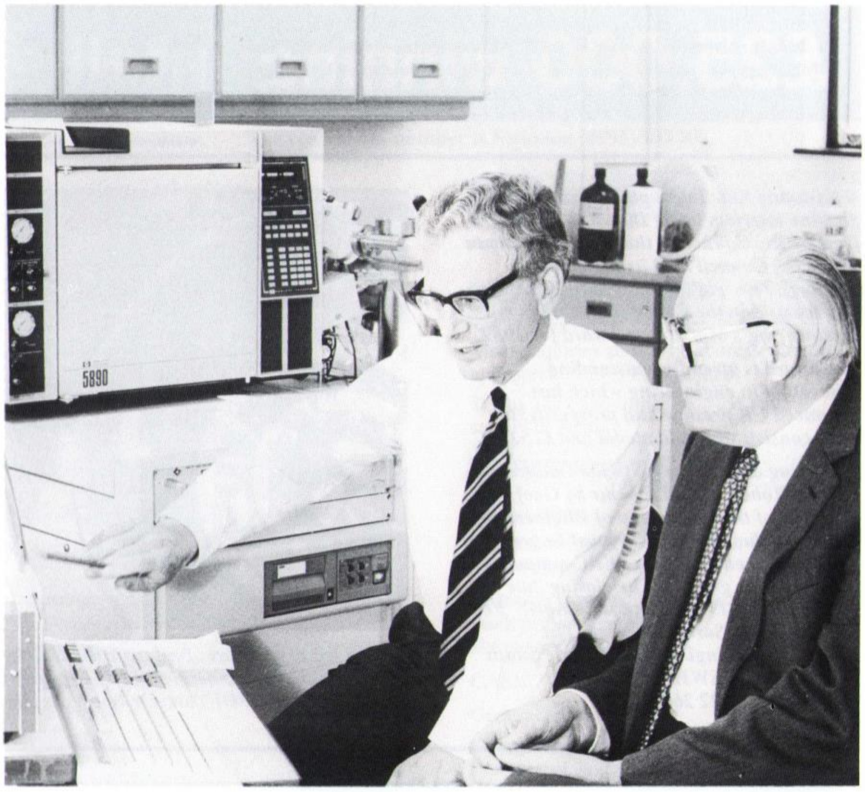
A dual channel Mossbauer spectrometer with cryostat and furnace is available at Leeds University for the determination of inorganic solid state structure; 20% of the instrument's time is available for outside use. Enquiries should be directed to Dr T C Gibb or Dr P D Battle, Department of Inorganic Chemistry, Leeds University.

Video-enhanced digital imaging microscopy

The Biological Sciences Committee and the Cancer Research Campaign have funded facilities for opto-digital imaging microscopy at Oxford University. Up to 20% of the time on the facility is available to external users.

The equipment available includes a Zeiss IM 35 inverted optical microscope, a Hamamatsu Newvicon video camera, a Colorado Video video analyser, a Dage MTI HR2000 monitor, a synoptics Imagine digital image processor, a photometrics cooled CCD array camera for low light level imaging, a Bio-Rad Lasersharp MRC-500 confocal laser scanning system, a graphics workstation with an optical disc image archive, and a Tektronics stereoscope image display facility. Users are expected to run their own experiments.

Enquiries should be directed, with a brief description of the proposed project to Dr David Shotton, Department of Zoology, Oxford University; telephone (0865) 271193.



Dr J Ballantine, Director of the Swansea Mass Spectrometry Service, demonstrates the instrumentation to former Prime Minister, the Right Honourable Lord Callaghan of Cardiff, President of University College, Swansea.

Hydrodynamic and related scattering methods

A facility for measuring the hydrodynamics of macromolecular conformation is available at Nottingham University, in collaboration with Leicester University. Up to 30% of the instrumentation time is available for outside users.

Facilities available include analytical ultracentrifugation for molecular weight, gross conformation and interaction phenomena; automatics viscometry for work on gross conformations of macromolecules and densimetry; and light scattering.

Enquiries should be directed in the first instance to Dr S Harding, Department of Applied Biochemistry and Food Science, Nottingham University, telephone (0602) 484848 ext 8365.

Laser equipment

One-third of the operational time of a picosecond laser equipped for time-resolved Raman spectroscopy at the Rutherford Appleton Laboratory is available for outside use. Enquiries should be directed to Mr W T Toner, Laser Division, RAL; telephone (0235) 445597.

Circular dichroism

Two circular dichroism facilities are available. The National Chiroptical Spectroscopy Service at Birkbeck College, London comprises a UV/visual CD spectrophotometer and a JASCO J600 spectropolarimeter. Two thirds of the instrument time is available for outside users who should first contact Dr A F Drake, Department of Chemistry, Birkbeck College.

A JASCO J600 CD is also available, primarily for users from Scottish institutions, at Stirling University. Enquiries should be directed to Dr Price, Department of Biological Sciences, Stirling University; telephone (0786) 73171 ext 2644.

Further enquiries on the above services and application procedures should be addressed to SERC Swindon Office: Chemistry — Dr A Le Masurier telephone (0793) 411263; Biological Sciences — Dr J Bentham; telephone (0793) 411421.

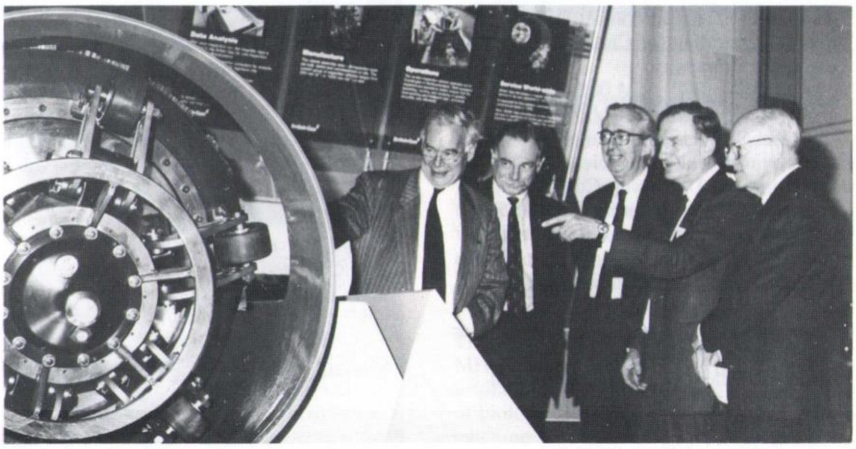
Details of other facilities funded by SERC can be found in the *SERC facilities for researchers* booklet, obtainable from the Finance Division, SERC Swindon Office; telephone (0793) 411077.

£25,000-winning intelligent pig

A six-tonne 'intelligent pig' for inspecting pipeline interiors being shown to a group from SERC Council at the Science Museum where the Council held its December meeting. The 'pig', developed by a British Gas team, won the Fellowship of Engineering's MacRobert Award for 1989.

The award is given for outstanding innovation in engineering which has enhanced UK prestige and prosperity; the prize consists of a gold medal and £25,000.

Following a presentation to the Council on the MacRobert Award scheme by Geoffrey Atkinson of the Fellowship of Engineering, it was concluded that there must be great potential for entries from SERC-supported individuals or groups. The closing date for entries for the 1990 Award is 30 April. For details contact Sarah Warwick, The Fellowship of Engineering, 2 Little Smith Street, London SW1P 3DL (telephone 01-222 2688).



Shown left to right are: Professor Bill Mitchell (Chairman of SERC), Geoffrey Atkinson (Fellowship of Engineering), Tony Egginton (Director of Programmes, SERC), Dr D A Melford (FOE) and Dr Bob Voss (Head of Engineering Division, SERC).

Some new publications from SERC

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

SERC annual report
Copies of the *Report of the Science and Engineering Research Council 1988-89* are available from Chris Sims, Public Relations Unit, ext 1384.

Environmental research
A colourful leaflet giving highlights of SERC's programme of environmental research is available from Chris Sims, ext 1384.

Fact sheet and statistics 1989
Copies of a pocket leaflet giving facts and statistics about SERC are available from Chris Sims, ext 1384.

Nuclear physics
A mailshot to schools of a 16-page full colour booklet and a poster for the 16+ age group, describing particle physics at the Large Electron Positron collider at CERN, produced an almost overwhelming response: some 18,000 copies of the booklet, *Big bang science: exploring the origins of the Universe*, have been requested. Copies are available from Chris Sims, ext 1384.

A companion volume (*not* designed for schools), *Particle physics in the United Kingdom*, is available from Pam Lennox, ext 1057.

Copies of the *Particle Physics Committee annual report* and the *Nuclear Structure Committee report* are available from Tracey McGuire, ext 1008.

Astronomy
Copies of an illustrated leaflet, *Astronomy and planetary science*, may be obtained from Jane Shepard, ext 1073.

LINK programme information packs
Information packs are available on the following LINK programmes: *Design of high speed machinery* (from Louise Johnson, ext 1117); *Power electronic devices and derived systems* (from Lesley Thompson, ext 1350); *New catalysts and catalytic processes* (from Anita Longley, ext 1476); and *Technology for analytical and physical measurement* (from Chris Horn, ext 1305).

Process engineering
Copies of two documents from the Process Engineering Committee, *Grants current at 1 July 1988* and *Reports on projects, June 1988*, and two newsletters — *Particulate technology* and *Separations processes* — are available from Brenda Fallows, ext 1449.

Environment Committee newsletters
Newsletters are available for *Building* (from Sue Charlesworth, ext 1487); *Transport* (from Jane Sykes, ext 1353) and *Civil Engineering* (from Vince Osgood, ext 1155).

Chemistry
Copies of the *Chemistry Committee report and statistical review 1987-88* are available from Kate Reading, ext 1360.

Mathematics
An illustrated brochure entitled *The remarkable world of nonlinear systems* is available from Hilary Simmons, ext 1264.

Computational science
Copies of a booklet describing the *Computational Science Initiative* are available from Andrea Blanchflower, ext 1113.

Nonlinear optics
Copies of the *Nonlinear optics update* are available from Bob Innes, ext 1441.

Biotechnology
Biobulletin Volume 9 No 1 (biannual newsletter) and *Training for employment in biotechnology: an evaluation of the Biotechnology Directorate's training and award policies* are both available from Sheila Blakeman, ext 1495.

ACME Directorate
The following publications are all available from Gay Ford, ext 1106: *Research Policy on manufacturing processes*; *Advanced production machines: research review*; *Research project status reports*; *1989 Research Conference proceedings, Loughborough University*; and the *ACME newsletter* (quarterly).

SERC enquiry points

To make it easier to find the right person when you telephone our administrative offices in Swindon (or elsewhere), we have updated our list of key contact points. Except where otherwise stated, all extension numbers are at SERC Swindon Office. The general switchboard number is Swindon (0793) 411000; to contact individual extensions, dial Swindon (0793) 41+ extension number. The central fax number is Swindon (0793) 411400.

ASTRONOMY AND PLANETARY SCIENCE DIVISION

Studentships and fellowships	R C Hodgon ext 1267
Ground-based Programme Committee	
International activities	D R Mitcham ext 1417
UK activities	Dr P W H Fletcher ext 1319
Research grants	C G Brooks ext 1359
PATT awards	M Morton ext 1198

BRITISH NATIONAL SPACE CENTRE

(SO: Swindon Office; MT: Millbank Tower, 01-217 3000 or extension)

Space Science Programme Board	
UK activities	Dr R L T Street SO ext 1265
Research grants	C G Brooks SO ext 1359
International activities	Dr P C L Smith MT ext 4263
Microgravity	Mrs Y Windsor MT ext 4297
ESA fellowship & Young Graduate Trainee scheme	Mrs J Anthony MT ext 4293
Earth Observation Programme Board	
UK activities; International activities	Dr G Thomas MT ext 3957
Research grants	C G Brooks SO ext 1359

ENGINEERING DIVISION

Building	Miss S Charlesworth ext 1487
Civil engineering	V M Osgood ext 1155
Transport	Miss J Sykes ext 1353
Electrical and power industries	Dr L A Thompson ext 1350
Aerospace	Ms P M Farrell ext 1350
Machinery, plant and vehicle	Mrs L Johnson ext 1117
Particulate and coal technology	Dr N V Pratt ext 1476
Chemical engineering; Separation processes	I J Winiarski ext 1484
Joint ESRC-SERC; Studentships & fellowships	Dr R Liwicki ext 1429
Information dissemination	I Maxwell ext 1153
Design	A Coates ext 1431

DIRECTORATES

ACME (including manufacturing processes)	Mrs G Ford ext 1106
Biotechnology	Mrs A Williams ext 1310
Information Technology	
Systems engineering	Dr D M Worsnip ext 1104
Control and instrumentation	T Willis ext 1401
Communications, distributed systems and systems architecture	R Bond ext 1436
Devices technology	P N Burnell ext 1061
VSLI design and optoelectronics	Dr A M Wilson ext 1479
Speech and vision; JFIT	N Williams ext 1478
Education and training	A Fenn ext 1224
Marine Technology	Mrs P Spence 01-321 0674
Teaching Company Faringdon (0367) 22822	Miss K Enifer ext 208

NUCLEAR PHYSICS DIVISION

Nuclear structure; studentships and fellowships	Miss C Armstrong ext 1331
Particle physics	G Richards ext 1278
CERN	M Bowthorpe ext 1271

SCIENCE DIVISION

Biological sciences	Dr S J Milsom ext 1136
Mathematics	R F Hemmings ext 1312
Neutron facilities	M J Hotchkiss ext 1222
Physics; Science-based archaeology	Miss F E Smith ext 1261
Chemistry	Dr A E A Rose ext 1496
Synchrotron radiation facility; laser facility	Miss R L Sirey ext 1061
Pharmacy	Dr G Ll Richards ext 1323
Science Board Computing Committee	Dr A Blanchflower ext 1113

MATERIALS SCIENCE AND ENGINEERING COMMISSION

Ceramic and inorganic materials	Dr D A Ward ext 1108
Metals and magnetic materials	Miss R Wilson ext 1110
Polymers and composites	Ms J S Williams ext 1338
Medical engineering and sensors	Dr A Thomas ext 1108
Semiconductors	Dr I M Scullion ext 1435
Molecular electronics	A G Buckley ext 1166
Superconductivity	Mrs C A Price ext 1361
Compound semiconductor technology	P N Burnell ext 1061
General enquiries	Mrs J Sullivan ext 1435

FINANCE

Account queries	P Bussey ext 1434

RESEARCH GRANTS

Most enquiries should be addressed to the appropriate subject committee.

Terms and conditions; supply of forms	ext 1405

STUDENTSHIPS

Applications

Advanced course studentships	ext 1414
Research studentships Studentships tenable abroad, including NATO	ext 1030
CASE	ext 1138
General enquiries	ext 1137

Current awards

For current studentships, give the switchboard the name of your institution.

FELLOWSHIPS

Postdoctoral (home, overseas and NATO); and advanced and senior fellowships	ext 1172/1403
Royal Society/SERC Industrial	ext 1206/1352

Anglo-Australian fellowships:

Royal Observatory, Edinburgh 031-668 8100	Ms K B Maunders ext 267
CERN	ext 1057
ESA	ext 1007

Visiting fellowships on grants: Enquiries should be made to the appropriate subject committee.

INTERNATIONAL COLLABORATION

Europe, Japan	ext 1036, 1315
ESF, rest of world	ext 1404, 1480
General	ext 1121, 1498

(For NATO fellowships and studentships tenable abroad, see under Studentships and Fellowships)

UK Research Councils' office in Brussels	Miss W Light 010-322-230-5275

CENTRAL COMPUTING

Dr B W Davies, Rutherford Appleton Laboratory, Didcot (0235) 821900 ext 5547

LINK	P Tomsen ext 1162
SERC BULLETIN	ext 1120
PRESS ENQUIRIES	ext 1257/1256

Daresbury Research Services

Daresbury Research Services (DRS), a new commercial venture to bring to industry the facilities of SERC's Daresbury Laboratory, was launched on 10 October 1989. DRS aims to improve the interface between the Laboratory and industry. It offers speed and confidentiality and will introduce industry's managers and scientists to the people in Daresbury who can help them most. At the same time it will generate new financial resources for SERC which will allow for further expansion of its research facilities and thus will substantially benefit the academic community.

An agreement to use the Synchrotron Radiation Source (SRS) was signed in September with Glaxo Group Research of Greenford, Middlesex, to provide a protein crystallography service. This is seen by SERC as further evidence of the role that synchrotron radiation will play in the pharmaceutical industry in the future.

Introducing the service, Daresbury Director Professor Alan Leadbetter said: "The Laboratory now takes a major step forward by making its world-beating equipment and scientific knowhow available to industry; Daresbury Research Services has now been set up as the marketing arm of the Laboratory."

The SRS has been used by British industry for several years, but with improved performance the machine is now the finest available for industrial research needing X-rays. It generates beams of X-rays that are thousands of times brighter than the previous best laboratory tools, and a million times more intense than the X-ray machines installed in hospitals and clinics.

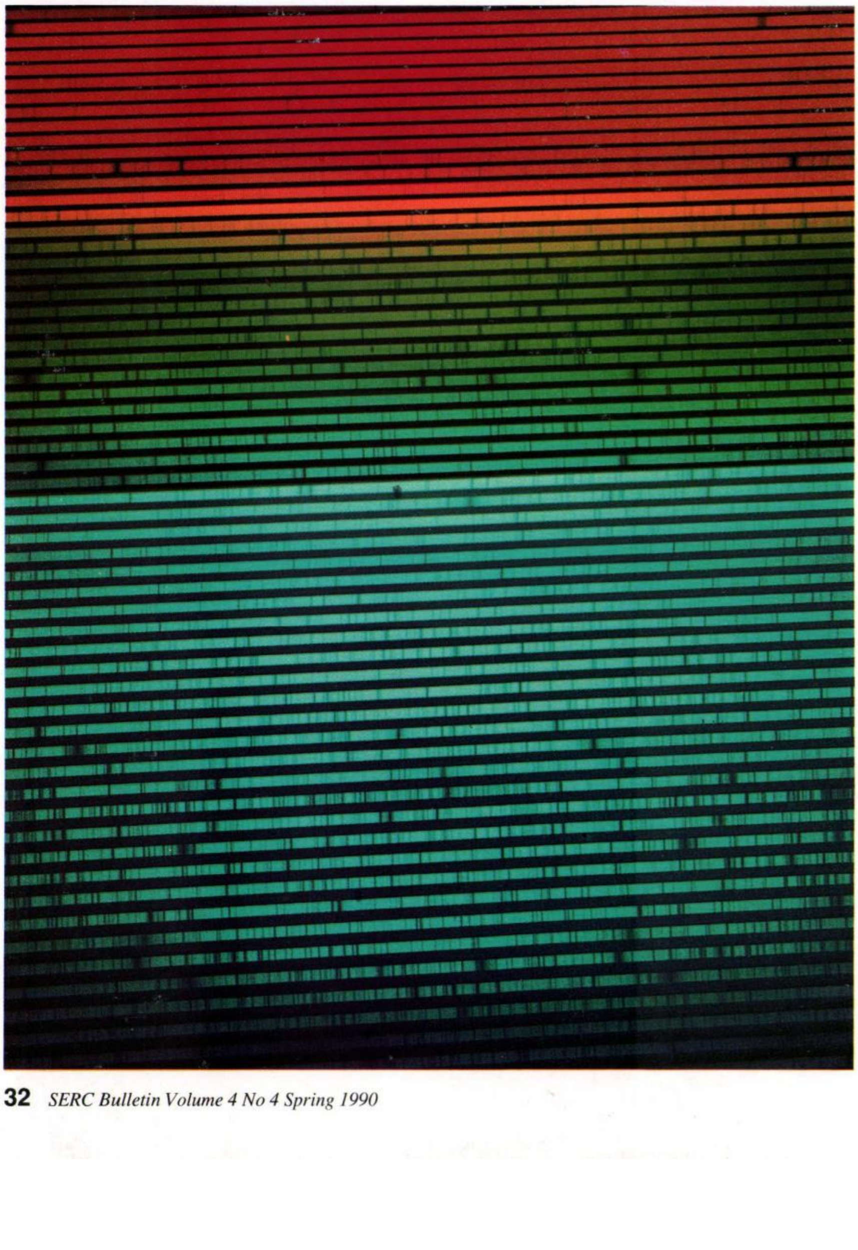
These beams are used to analyse the molecular structure of a wide range of substances, from viruses to chemicals vital to the oil industry. The SRS has revolutionised academic research in many areas of chemistry, molecular biology and materials science. Now, by applying these techniques commercially, enormous benefits are possible in the fields of catalysts and electronic materials, in plastics, food science and drug design.

Research at Daresbury is supported by world-class computing facilities, computational scientists and theorists. Work in this area which has already attracted industrial interest includes research into techniques that reproduce the power and ultra-high speed of modern supercomputers at a small fraction of the cost. Also of interest are the scientific databases held at Daresbury, and the computing and networking expertise.

Daresbury is the only laboratory in the UK which designs and builds large electron accelerators. This expertise is already being used by British industry to create a commercial version of the synchrotron radiation source, and it is expected that these will be exported widely for use in the manufacture of semiconductors.

Although initially concentrating on applications of synchrotron radiation, DRS plans to widen Daresbury's industrial connections to other fields of interest including the Nuclear Structure Facility. This tandem Van de Graaff accelerator generates over 20 million volts and is the most versatile in the world for research in nuclear physics. Spin-offs for industry include, for instance, techniques relevant to nuclear waste management.

Further information can be obtained from:
Neil Marks or Dr Paul Barnes
Daresbury Research Services,
Daresbury Laboratory;
telephone (0925) 603432.



UCLES — the new echelle spectrograph at the AAT

Echelle spectrum of the Sun, obtained with the University College London Echelle Spectrograph (UCLES), described on page 22, during the early stages of commissioning at UCL. Each strip, or echelle order, covers a small portion of the solar spectrum, about 50 Å wide in the centre of the picture. Wavelengths increase from left to right and from top to bottom; the whole spectrum shown here extends approximately from 423 to 657 nanometres. Note the wealth of narrow absorption lines in the spectrum, formed by hydrogen and other elements in the solar atmosphere.