UNIVERSITY OF CAMBRIDGE

Isaac Newton Institute for Mathematical Sciences

Annual Report for 1992-93

December 1993

ISAAC NEWTON INSTITUTE
FOR
MATHEMATICAL SCIENCES

Annual Report for 1992-93

Cover Photograph: J Austin

1. The Director's Report

The Newton Institute has now completed its first full year of scientific operation. However the Institute came formally into existence on 1st October 1990 and the intervening period was concerned with setting up the administrative structure, preparing the scientific programmes, and planning and constructing our building on Clarkson Road. This report covers the whole period from this formal beginning until 30th June 1993.

Remarkably, for a new institution set up in such haste, there have been few significant problems and no essential slippage in the time-table. The building has lived up to expectations, is widely admired and is providing an excellent environment for our activities.

The scientific programmes have covered a wide area of the mathematical sciences and have had a strong interdisciplinary flavour. We have brought together mathematicians and biologists to work together on epidemics such as AIDS, and we are just beginning with a programme on Computer Vision which includes engineers and computer scientists.

It was important, when selecting the four programmes for the first year, to demonstrate the wide scope of the Institute's coverage. We believe that this has been achieved and the variety of future programmes, now in the pipeline, is a measure of our success and will consolidate our position and reputation.

Undoubtedly the highlight of the year was the dramatic lecture series at the Newton Institute in June where Andrew Wiles announced his proof of Fermat's Last Theorem, thus disposing of the most famous unsolved problem in mathematics. Widespread international publicity followed and helped to put the Newton Institute firmly on the international map.

Our role as a national centre has been overseen and ensured by our Scientific Steering Committee, which is predominantly external. Internationally we are building links with the European Community, the USA and Japan through both governmental and private-sector agencies. While most of our long-term visitors are from abroad we make special efforts to ensure adequate UK participation at all levels.

The financial basis of the Institute is spread quite widely. We view this as a healthy state of affairs and look forward to its continuation.

Inevitably the first years of a new institution involve much dedicated work by all those concerned. In particular the staff of the Institute have carried a very heavy burden. I would like to thank everyone who has been involved with the establishment and operation of the Newton Institute for all their efforts. Above all, I must record my personal indebtedness to my Deputy, Peter Goddard, who has had a particularly heavy load and without whom the Institute could not possibly have succeeded.

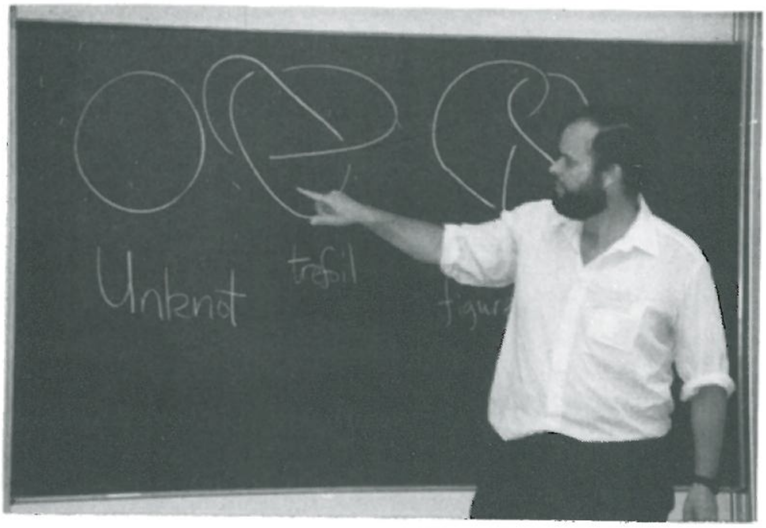
Michael Atiyah

of the Scientific Steering Committee. Dr Landshoff, who with Dr Goddard had been doing much of the detailed work towards the establishment of the Institute, was appointed Chairman of the Management Committee. The Committee of the Council of the School of the Physical Sciences and its Executive Sub-Committee, which had brought the Institute into being, were dissolved in September 1990.

Scientific planning began in earnest in the summer of 1990. A call for proposals was issued and the Scientific Steering Committee met for the first time in October. From the 23 proposals it received, it recommended the Director to select as the first programmes, to start in July 1992, *Low Dimensional Topology and Quantum Field Theory* and *Dynamo Theory.*

The local planning environment was rather difficult in Cambridge at the time but, after some nervous moments, planning permission was obtained in October 1990. The firm of John Brignell Construction Ltd was selected by tender as building contractor in March 1991, the building cost being £1,258k, to which should be added fees of £239k and the notional value of the land at £500k. The contract provided for the completion of the building on 11 May 1992. A ground-breaking ceremony was performed by Dr Garling (then President of St John's College) and Sir Michael Atiyah on 22 April 1991.

The routine administrative work of the Institute grew steadily through 1991. By the time the Institute opened in July 1992, the eight programmes for the first two years were at active stages of preparation with invitations to participants issued for nearly all of the first year and much of the second. Difficulties in agreeing the grading of some of the administrative staff with the central University authorities resulted in delays and additional strains. Mrs HM Strudwick, Computer Systems Manager, was the first member of the administrative staff to be appointed, taking up her appointment in November 1991 and the Institute had secretarial support from the same month. At this time the Institute was greatly helped by Mrs D Sulston (DAMTP librarian) and Mr J Turner (DAMTP accountant).



Vaughan Jones lecturing on Knots at the Inauguration of the Institute on 3 July 1992

To set up the Institute involved expenditure and donations of books and equipment totalling about £1 million. The University, Gonville and Caius College and the SERC each gave £100k towards the Institute's setting-up costs. Emmanuel, Jesus and Christ's Colleges also made generous contributions, as did the London Mathematical Society. The Nuffield Foundation gave £57k towards staff costs during the setting-up period. Both Sun Microsystems and Apple UK made major donations of equipment with total value about £320k. Further details about setting-up costs are given in Section 3.

The building was finally completed about 6 weeks late on 29 June 1992, just four days before the Inauguration of the Institute's scientific activities on 3 July. This took the form of a meeting with talks chosen to illustrate the intended scientific breadth of the Institute as exemplified by the first year's programmes. After the Master of St John's, Professor Robert Hinde, had opened the proceedings, Vaughan Jones (Berkeley) spoke on *Knots*, Keith Moffatt (DAMTP) spoke on *Flow*, Sir Peter Swinnerton-Dyer (Senior Fellow, Newton Institute) spoke on *Arithmetic* and Roy

Anderson (Imperial College) spoke on *Epidemics.* Following these, Allan Chapman (Oxford) spoke on *Newton* and Sir Michael Atiyah spoke about the *Institute.* The day ended with a reception in the Combination Room of St John's College followed by a dinner given by Trinity College to mark, somewhat in advance, the 350th anniversary of the birth of Newton on 25 December 1992.

The official opening of the building had to wait till 30 October 1992 when the Chancellor of the University, HRH The Duke of Edinburgh, came to the Institute and met many of the visiting members.

2.2 Management and Staff

Management Committee. The management of the Institute is the responsibility of a Management Committee consisting of the Director, the Deputy Director, the Heads of DAMTP and of DPMMS, four persons appointed by the General Board of Faculties (of whom one is nominated by Council of the School of the Physical Sciences and one is nominated by the Faculty Board of Mathematics), a Chairman appointed by the General Board, one person appointed by each of St John's College, Trinity College and the SERC and one additional person co-opted at the discretion of the Committee. It is proposed to increase this membership to include a fifth person appointed by the General Board who would be nominated by the newly-formed School of Technology.

The current membership of the Management Committee is:

Dr PV Landshoff	General Board *Chairman*
Sir Michael Atiyah, OM, PRS	Director
Professor A Baker, FRS	Trinity College
Professor JH Coates, FRS	Head DPMMS
Professor DG Crighton, FRS	Head DAMTP
Professor P Goddard, FRS	Deputy Director
Professor FP Kelly, FRS	co-opted
Professor Sir Martin Rees, FRS	CSPS
Dr GA Reid	St John's College
Dr N Viner	SERC
Dr PMH Wilson	Faculty of Mathematics
Professor JD Wright	General Board
Professor Sir Christopher Zeeman, FRS	General Board

The other persons who have served on the Committee are Dr DJH Garling (1990 – 1991, Head DPMMS), Professor HK Moffatt, FRS (1990 – 1991, Head DAMTP), Dr CMP Johnson (1990 – 1991, St John's) and Mr RF Rissoné (1990 – 1992, SERC). Sir Martin Rees acted as Chairman whilst Dr Landshoff was on leave during 1991-92.

The duties of the Committee are to promote research in the field of mathematical sciences and the publication of the results of such research, to co-operate with outside bodies in the encouragement of research in the mathematical sciences, to administer funds allocated to them for these purposes, to supervise the work of the staff of the Institute, to prepare annual estimates for submission to the Financial Board after approval by the General Board and to make an Annual Report to the General Board and to the Councils of the Schools and other bodies.

The Committee, required to meet three times per year by the constitution of the Institute, has met once in each University Term since the inception of the Institute in October 1990. At these meetings the Committee receives and comments on reports on the Institute's finances, facilities, housing arrangements and fund-raising efforts. It approves the scientific programmes which the Director proposes to it on the advice of the Scientific Steering Committee and it receives the minutes of that Committee. It is responsible for recommending to the General Board elections to Rothschild Visiting Professorships and appointments to Senior Fellowships of the Institute. It receives regular detailed reports on the progress of planning for those programmes which have been approved.

Staff. Sir Michael Atiyah, appointed Director of the Institute from its formal inception on 1 October 1990, was elected President of the Royal Society in November 1990. The duties of this office, combined with his duties as Master of Trinity, limited the time he could devote to being Director. This increased the load which would fall on Dr P Goddard, who was appointed Deputy Director from October 1991. To assist, in particular with the establishment of the library, Dr PMH Wilson was appointed as a part-time Assistant Director from October 1991.

It has already been stated that Mrs HM Strudwick, a temporary computer officer in DAMTP and DPMMS, became Computer Systems Manager in November 1991. Mr KG Smith, Administrative Assistant in the General Board Office seconded to the Clinical School, became Administrator of the Institute in March 1992. A grant from the Isaac Newton Trust provided part of the cost of the post of Librarian and Information Officer to which Mrs M Allen was appointed in June 1992. After Mrs R Coe had acted on a temporary basis for six months, Ms W Abbott was appointed Housing Officer in August 1992. Dr N Linden, who had assisted with preparations for the Inauguration, also helped with the management of the Institute's housing and was appointed a second part-time Assistant Director from October 1992.

In June 1993, following a period of ill health, Mr Smith left the Institute. It seemed desirable to restructure the administrative offices to some extent. Ms Lynne Stuart, who had joined the Institute as Principal Secretary in June 1992, became Administrative Assistant in the Director's Office. Ms Ann Cartwright, Administrative Director of the Hackney Empire Theatre, was appointed Institute Administrator from September 1993.

The staff of the Institute presently consists of:

Director	Sir Michael Atiyah, OM, PRS
Deputy Director	Professor P Goddard, FRS
Institute Administrator	Ms A Cartwright
Administrative Assistant	Ms LA Stuart
Computer Systems Manager	Mrs HM Strudwick
Librarian	Mrs M Allen
Housing Officer	W Abbott
Accounts Clerk	Miss S Haggart
Secretary	Ms J Marsters
Receptionist	Miss T Hibbitt
Catering Assistant	Miss T Secker

The Director and Deputy Director are supported by the two Assistant Directors, Dr PMH Wilson and Dr N Linden.

Evaluation. In order to seek ways of improving its management and administrative procedures, the Institute continually collects information and monitors its performance and achievements in various ways. It collects biographical information on its visiting members, some of which is tabulated in §5.1. It gets each visiting member to complete a general questionnaire, requesting an evaluation of and comments on the Institute's facilities, staff support, financial provision and coffee, lunch and tea arrangements. Visiting members are also asked to fill out a housing questionnaire. The results of these questionnaires are collated. The results, together with suggestions for improvement and problems which have emerged, are discussed at one of the regular fortnightly staff meetings. Where possible, improvements have been made. This is seen as a continuing process.

One conclusion drawn from our own evaluation of the facilities provided by the Institute to its visiting members was the need for more administrative support, leading to the upgrading of the post of Principal Secretary to that of Administrative Assistant. Another pressing need is for an Assistant Computer Officer to provide members with a higher level of computing support.

Every visiting member is required to make a report on his or her stay, giving details of work done, other institutions visited and useful interactions during the visit. On the whole the reactions of visiting members have been favourable and often very enthusiastic. A good example, reproduced here partly for the points made in his last paragraph, is the report of Jack Morava of Johns Hopkins University:

> While at the Institute I completed a paper called *Homotopical field theories*, based on the ideas of Kontsevich, Segal and Witten, and (in collaboration with M Ando at the University of Virginia and H Sadofsky at Johns Hopkins) I roughed out the major part of a paper tentatively titled *On conjectures of Mahowald and Waldhausen.*
>
> I spoke about this and other work in seminars in Oxford, Cambridge, Edinburgh, Warwick and London (King's College); but I had to pass up invitations to speak in Manchester, Glasgow, and Paris due to lack of time.
>
> I think everything worked out splendidly, and I think it is wonderful that the Newton Institute makes it possible for a visiting scientist to accomplish so much. I also think that the program (in low-dimensional topology and quantum field theory) will have a long-term lasting effect on future research at the interface of mathematics and physics.
>
> Perhaps it is worth emphasising this. A one-term program like this is all too soon over, but (when successful) its results can be seen for years. I have frequently heard visitors here comment that, given the intensity of talks and seminars, it is impossible to get any new work done; but mathematics is very often not done in 'real time'. Programs such as this stimulate research, and projects begun here will bear fruit over many years; young researchers meet others and get to know established figures in their fields, and the sociology of a scientific generation is changed. It is important not to judge the results of such a program on too small a time-scale. You won't disturb a seismograph by jumping up and down next to it; its sensitivity is to waves of much longer period. An institution such as this requires a long meter-stick to be adequately measured; a report like this is an account of the planting of a seed, not on the yield of a crop.

The staff derive considerable satisfaction from such comments but they are far from complacent and they are continually striving to improve the Institute, which still only has just over one year's experience, as a stimulating environment for research.

2.3 Programme Structure and Organisation

The Institute has adopted the pattern of having two six-month research programmes running at any one time, four per year. Each programme will have an average of 18 to 22 participants in residence at any one time, and the Institute typically has between 40 and 50 visiting members staying for two weeks or more. The total number of participants in a programme will be between 40 and 70. The statistics for the first four programmes are given in the following table:

Programme	*Visiting Members*	*Average Stay (days)*	*Average Occupancy*
Low Dimensional Topology & QFT	68	54	22
Dynamo Theory	40	78	19
L-functions and Arithmetic	62	64	24
Epidemic Models	44	84	22

During its first year of operation the Institute has been host to over 200 visiting members, staying between two weeks and six months, about two and a half months on average. Nearly 80% of these were from overseas. Within the four programmes there have been a total of 23 workshops, periods of more intense activity on specialised topics or pedagogical activities which involved an additional 400 participants, of whom 260 were from the UK. In addition, the programmes themselves attracted a large number of scientists who made short visits, including about 95 who stayed for only a few days.

The visiting members are listed in §5.1 and a chart showing the periods of their visits is given in §5.2. A breakdown of numbers by nationality is given in §5.3 and a graph showing the age distribution of visiting members is shown in §5.4. The median is 42 years with an interquartile range from 35 years to 47 years. For workshops and short-stay visits the age profile is younger. Detailed biographical records have not been compiled for all short-stay participants, but an age survey at a typical large workshop produced a median age of 38 years with an interquartile range from 30 years to 43 years.

The scientific planning for each programme is the responsibility of a team of three or four organisers. Normally these will include one or more of the authors of the proposal for the programme put to the Scientific Steering Committee. The choice of organisers is made so as to reflect the intended scope of the programme. An effort is also made to obtain a geographical spread since this should also help to maintain the breadth and international character of the Institute.

Programmes are selected about two years before they are scheduled to begin. Usually the first task of the organisers is to identify leading workers who are willing to commit themselves to participating in the programme for an appreciable period. Aided by these commitments, a wider group can then be approached in successive tranches. In the period between 18 and 6 months before the programme starts, the budget for subsistence and travel will be committed in this way. Naturally, there will be subsequent changes and withdrawals due to unforeseen circumstances, leaving flexibility in the budget to enable some invitations to be issued just before and during the programme.

A typical structure for a programme is to begin with some more pedagogical activity, for example an instructional course or advanced study institute, to have two or three more specialised workshops towards the middle of the programme, focussing on particular aspects of the programme or closely related areas, and perhaps to end with some more general meeting summarising the state of the art. Such a model is not rigidly imposed and programmes vary quite considerably in their actual structure. In addition to the workshops, *etc.*, which serve to widen the participation in the programmes, the organisers are strongly encouraged to organise less formal special days or short meetings or intensive lecture series, which can attract in daily or short-term visitors, so further increasing the impact of the Institute on the UK mathematical community.

All of this is against the background of regular series of seminars in each programme. During the year July 1992 to June 1993, there were over 650 lectures and seminars given in the Institute. A list of these seminars, which perhaps more than anything else illustrates the scope of the Institute and the intensity of its activities, is given in §5.6. Visiting members of the Institute have also given over 100 seminars in 40 departments outside Cambridge. UK universities at which visiting members have talked include Birmingham, Bristol, Cardiff, City, Durham, East Anglia, Edinburgh, Exeter, Glasgow, Heriot-Watt, Imperial College, King's College London, Leeds, Liverpool, London School of Hygiene and Tropical Medicine, Manchester, Nottingham, Open, Oxford, Queen Mary and Westfield College, Sheffield, Southampton, Sussex, Warwick and York. In many cases, there will have been talks in more than one department.

Some thought has been given as to whether the structure of four six-month research programmes each year should be varied, *eg* by having some three-month research programmes. Some topics, whilst not justifying a full six-month programme, might make excellent subjects for a three-month one. It would also help the Institute cover a wider range of the mathematical sciences. On the other hand, a more diverse pattern would present greater logistical difficulties and some problems where Visiting Fellowships and Professorships were designed for participants staying for longer periods. The conclusion has been that the Institute should obtain more experience of actually running programmes before committing itself to diversification.

2.4 Scientific Policy and Programme Selection

Scientific Steering Committee. The Director is advised on the scientific work of the Institute and, in particular, on the selection of programmes by the Institute's Scientific Steering Committee. This Committee consists of the Director, four persons appointed by the General Board on the recommendation of the Science and Engineering Research Council, two persons appointed by the General Board on the recommendation of the London Mathematical Society, six persons appointed by the General Board after consultation with the Councils of the Schools of the University and national scientific bodies (the Royal Society, the Royal Society of Edinburgh, the Royal Statistical Society, the Institute of Physics, the Royal Academy of Engineering, the Institute of Mathematics and its Applications and the Edinburgh Mathematical Society) and one additional person co-opted at the discretion of the Committee.

The current membership of the Committee is:

Professor Sir Christopher Zeeman, FRS	Oxford University	GB *Chairman*
Professor VI Arnold	Steklov Institute, Moscow	GB
Sir Michael Atiyah, OM, PRS	Newton Institute	Director
Professor JM Ball, FRS	Heriot-Watt University	LMS
Professor MV Berry, FRS	Bristol University	GB
Professor J-M Bismut	Orsay	GB
Professor PG Burke, FRS	Queen's University, Belfast	SERC
Professor GA Gehring	Sheffield University	GB
Professor IG Halliday	University College, Swansea	co-opted
Professor TJ Pedley	Leeds University	GB
Professor AFM Smith	Imperial College	SERC
Professor JT Stuart, FRS	Imperial College	SERC
Professor CTC Wall, FRS	Liverpool University	LMS
Professor DJ Wallace, FRS	Edinburgh University	SERC

[Those appointed by the General Board after consultation with national scientific bodies are denoted by GB on the list.]

Professor JCR Hunt, FRS, Director of the Meteorological Office, was a member of the Committee from 1990 to 1992. The Committee is required to meet at least once each year. In practice, it has met twice a year (in October and in February or March) since the establishment of the Institute in October 1990, so that six meetings had been held by June 1993.

Policy. At its first meeting the Scientific Steering Committee considered its general scientific policy. From the beginning it had been intended that the Newton Institute should be devoted to the Mathematical Sciences in the broad sense. In this respect the Institute would differ significantly from similar institutes in other countries (*e.g* the Mathematical Sciences Research Institute in Berkeley or the Max Planck Institute in Bonn). The range of sciences in which mathematics plays a significant part is, of course, enormous, too large for an Institute of modest size to cover adequately. In making the necessary choices important principles are that no topic is excluded *a priori* and that scientific merit is to be the deciding factor.

One of the main purposes of the Newton Institute is to overcome the normal barriers which are presented by departmental structures in Universities. In consequence, a main criterion in judging the "scientific merit" of a proposed research programme for the Institute is the extent to which it is "interdisciplinary". Usually this will involve bringing together research workers with very different backgrounds and expertise (*eg* topologists and high energy physicists); sometimes a single mathematical topic (*eg* chaos) may attract a wide entourage from other fields. Although it is undesirable to lay down any rigid guidelines, the following seem reasonable:

(a) the mixing together of scientists with different backgrounds does not *per se* produce a successful meeting: there has to be a clear common ground on which to focus;

(b) each programme should have a substantial and significant mathematical content;

(c) each programme should have a broad mathematical and/or scientific base.

Research in mathematics, as in many other sciences, tends to consist of major breakthroughs, with rapid exploitation of new ideas, followed by long periods of consolidation. For the Newton Institute to be an exciting and important world centre, it has to be involved with the breakthroughs rather than the consolidation. This means that, in selecting programmes, a main criterion should be that the relevant area is in the forefront of current development. Since the Institute's programmes have to be planned up to two years in advance, it is not easy to predict where the front line will be at that time. The best one can do is to choose fields whose importance and diversity are likely to produce long time-scales and to choose world leaders in research who are likely to be able to move speedily as ideas change.

The Newton Institute building designed by Annand & Mustoe

Although the novelty and interdisciplinary nature of a proposed programme provide important criteria for selection, these must be subject to the overriding criterion of quality. With such a wide range of possibilities to choose from, the aim must be to select programmes which represent serious and important mathematical science and which will attract the very best mathematicians and scientists from all over the world. However the desire for respectability should not deter the Institute from supporting unorthodox developments if these have a strong scientific case.

Although the Institute operates on a world-wide basis and contributes thereby to the general advancement of mathematical science, it must also be considered in the context of UK mathematics. A natural expectation of all those concerned is that each programme will be of benefit to the UK mathematical community in a variety of ways. If the UK is strong in the field, UK scientists will play a major part in the programme; if the UK is comparatively weak in the field, the programme should help to raise UK standards and instructional courses will play a vital rôle here.

2.5 Scientific Work 1992-93

Because of the wide base of support for the Newton Institute in the SERC and elsewhere, the Institute's programmes should as far as possible represent an appropriate balance between the various mathematical fields. If the Institute is to retain the backing of the mathematical and scientific community, it must run programmes in a wide variety of fields and, over the years, achieve a general balance. Such considerations however are secondary to the prime objective of having high quality programmes. If there are no exciting developments, actual or potential, in a particular field, it would be wrong to run a programme simply to maintain a balance.

Selection of Programmes. The Scientific Steering Committee conceives its rôle as involving both the consideration of proposals received and the stimulation of proposals in areas of the mathematical sciences which it considers to be potentially particularly suitable for the Institute. The Institute advertises its willingness to receive proposals in a variety of ways which have included the annual distribution of a poster containing a "Call for Proposals" to over 500 departments and institutions concerned with the mathematical sciences in the UK and abroad. At meetings, the Committee regularly considers in which areas it should stimulate proposals and the Director, the Deputy Director or individual Committee members then assume responsibility for taking action in particular areas.

In its six meetings, the Scientific Steering Committee has considered 53 proposals for programmes. Of these 14 have been selected for the Institute, constituting the programme from July 1992 to December 1995 and three remain under consideration, an acceptance rate of 1 in 3.6. Those selected so far are:

Jul–Dec 1992	Low Dimensional Topology and Quantum Field Theory Dynamo Theory
Jan–Jun 1993	L-functions and Arithmetic Epidemic Models
Jul–Dec 1993	Computer Vision Random Spatial Processes
Jan–Jun 1994	Geometry and Gravity Cellular Automata, Aggregation and Growth
Jul–Dec 1994	Topological Defects Symplectic Geometry
Jan–Jun 1995	Exponential Asymptotics Financial Mathematics
Jul–Dec 1995	Semantics of Computation From Finite to Infinite Dimensional Dynamical Systems

Proposals are requested to be no longer than two sides of A4 in the first instance and it is suggested that they should include the scientific case for the proposal (set out under the headings of the scientific background and history of the proposed topic, recent progress, possible future directions and developments, and why the topic is particularly suited to the Newton Institute at this time), the names of possible organisers and the names of 30 to 60 possible participants (listed in the categories 'essential', 'desirable' and 'reserve').

At least three opinions are obtained on each of the proposals submitted in order to help the Committee in its evaluation. It is rare that a proposal is accepted straightaway and unmodified. Usually, if it is decided to proceed with the proposal, constructive criticisms will be put to the authors and their reactions or a revised proposal invited. A few of the proposals received are weak; others, although strong, do not fit well with the Committee's criteria whilst others are ruled out by considerations of balance between subject areas, given choices already made. All in all, the Institute receives more very strong proposals than it can accept.

2.5 Scientific Work 1992-93

By the end of the first year of scientific activity the Institute had completed four programmes on *Dynamo Theory*, *Low Dimensional Topology and Quantum Field Theory*, *L-functions and Arithmetic* and *Epidemic Models*. This subsection contains brief reports on these programmes; fuller reports from the organisers are contained in §4 of this Annual Report.

Low-dimensional Topology and Quantum Field Theory *July to December 1992*

Organisers: E Corrigan (Durham), MB Green (QMW, London), WBR Lickorish (Cambridge).

The programme focussed on the spectacular developments that have occurred in recent years as a result of increasingly fruitful interactions between areas of theoretical physics and mathematics. The general aim of the programme was to build upon these advances and promote the interchange of ideas and techniques between mathematicians and theoretical physicists. The areas of interest of the participants included knot theory and the topology of three manifolds, von Neumann algebras, topological and conformal field theory, integrable massive field theories, two-dimensional statistical mechanics and elementary particle physics.

The programme brought together many of those who originated the dramatic developments, including contributions from recent Fields medallists S Donaldson, V Jones and E Witten. R Kirby came as Rothschild Visiting Professor. R Baxter took part in the first three months of the programme. J Weitsman held a Rosenbaum Visiting Fellowship and F Smirnov the Institute of Physics Visiting Fellowship intended for an Eastern European. The programme involved about 68 visiting members, with an average stay of just less than 2 months. A nucleus of 10 participants stayed 4 months or more.

The mix of international participants varied as the programme progressed, with most Japanese and US visitors participating in the summer months and a notably high proportion of overseas visitors from Europe and the CIS in the last three months. For example, during July and August there was a very powerful gathering of operator algebra specialists, mostly from the US; during October and November there was a predominance of experts in conformal field theory and allied topics, many from the former Soviet Union but now based in Europe.

Stephen Hawking and Edward Witten in discussion at the start of the Low Dimensional Topology and Quantum Field Theory programme

Highlights of the programme included work of H Murakami on invariants of 3-dimensional manifolds, identities from conformal field theory involving Rogers dilogarithm function discovered by A Kirillov and W Nahm, progress in understanding statistical mechanical models by R Baxter and J Cardy and by M Jimbo and T Miwa and progress in understanding solitons in affine Toda field theory by D Olive and collaborators.

The organisers worked hard to involve the UK community in its special days and workshops. As a result, the programme attracted a significant number of short-stay UK participants, with attendance peaking during the periods of the workshops. During September there was a 7-day NATO Advanced Research Workshop. In addition there were seven mini-workshops of shorter duration: *Topology Talks* which included talks by the recent Fields medallists Donaldson, Jones and Witten (6–17 July), *Von Neumann Algebras in Mathematics and Physics* (22–24 July), *Topological Field Theory and Quantum Gravity* (19–21 August), *Conformal and Integrable Field Theory* (27–29 October), *Computational Aspects of Topological Invariants* (16–18 November), *(Nearly) Conformal Field Theory* (8-10 December) and towards the end of the programme a workshop on the general area of *Conformal and Integrable Field Theory.*

Judged by the enthusiasm of the participants and the intensity of the discussions that grew up naturally all the time around the blackboards the programme was a tremendous success. A Belavin described the atmosphere as being reminiscent of the Landau Institute in its best days. The full effects of the programme will take time to become apparent.

Dynamo Theory *July to December 1992*

Organisers: U Frisch (Nice), HK Moffatt (Cambridge), AM Soward (Newcastle)

This programme was concerned with the fundamental problem of the origin of magnetic fields in cosmic bodies, particularly in stars and planets. The basic character of the way that electromagnetic induction in a conducting fluid in motion can give rise to spontaneous growth of magnetic field is well understood; the challenge is the construction of a self-consistent theory of this phenomenon incorporating the relevant fluid dynamics and thermodynamics. Scientists interested in dynamo theory from a variety of fields, including fluid dynamics, geophysics and astrophysics were brought together to exchange ideas and advance understanding. There were two main areas of concentration: (a) *geodynamo theory*, especially the nature of the energy supply mechanism and associated dynamical processes in the Earth's liquid conducting core; and (b) *'fast' dynamo theory*, focusing on the nature of the dynamo process in the very high conductivity limit relevant to solar and stellar dynamo processes, and even more to the galactic dynamo process.

The majority of participants spent at least two months at the Institute. A core of 10 participants stayed for four months or more. V Arnold held a Rothschild Visiting Professorship and E Knobloch held a Rosenbaum Visiting Fellowship during their stays. Altogether 40 visiting members took part in the programme, staying about two and a half months on average. The two-month visits tended to be centred either in the first half (July to September) or the second half of the programme (October to December) with a substantial overlap during the last two weeks of September, when a NATO Advanced Study Institute was held within the framework of the programme.

The programme benefited greatly from the participation of leading workers including V Arnold, S Braginsky and WVR Malkus. During the programme, AP Anufriev and I Cupal reported interesting developments of Braginsky's approach to understanding power generation in the geodynamo and R Hollerbach elucidated the inner core effects, and made progress with obtaining numerical solutions, to advance a project to find a dynamically self-consistent dynamo solution for the Earth. There was also considerable activity addressing the central issues of Fast Dynamo theory, with discussion and development of the numerical work of D Galloway, the progress towards existence proofs by M Vishik and P Collet and of the simulations by A Brandenburg and S Vainshtein of magnetohydrodynamic turbulence.

To promote the early exchange of ideas in the programme, a crash programme of 12 seminars was held during August. The backbone of the later scientific programme was a regular series of two seminars per week throughout October, November and December. Additionally, there was interaction with the astrophysical fluid dynamics group in DAMTP through a lunchtime seminar held in the Institute.

Participation in the programme was expanded by means of workshops. The largest of these was the NATO ASI on *Stellar and Planetary Dynamos*, 20 September to 1 October, directed by MRE

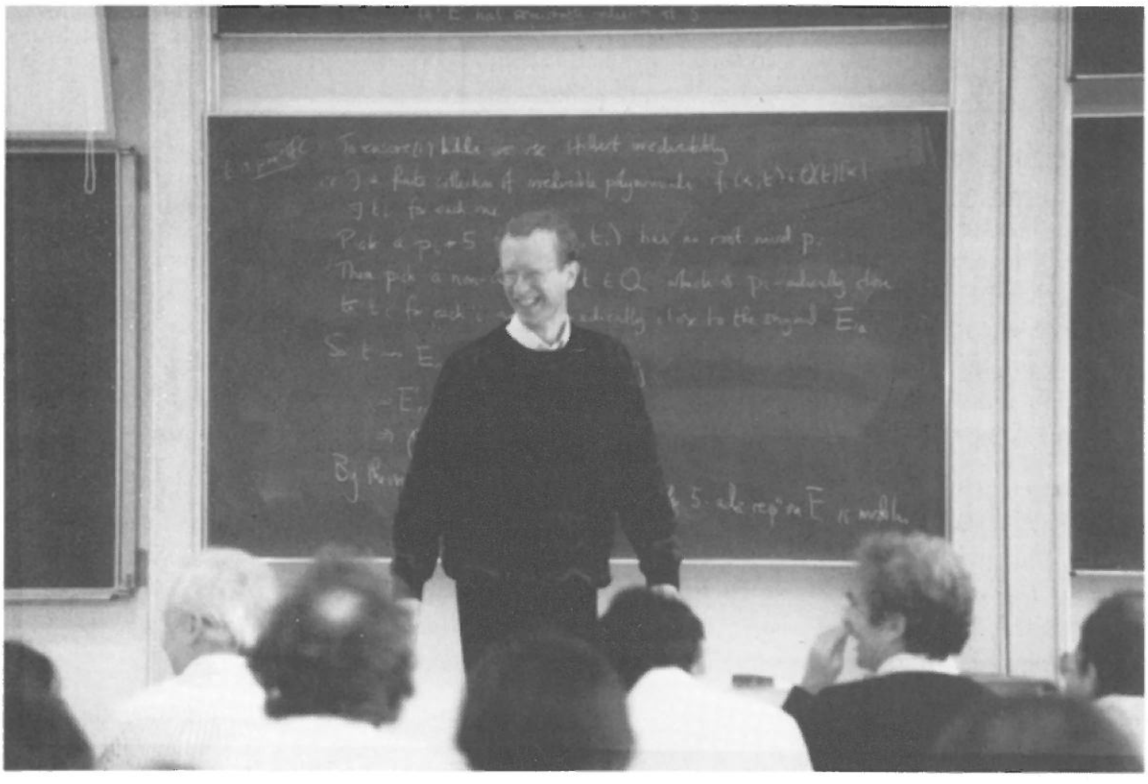
Proctor, involving about 45 additional participants. The proceedings will be published by Cambridge University Press. Four Workshops, attended by many short-term UK visitors, were held: one-day workshops on *The Geodynamo and Planetary Dynamos* (31 July), *The Fast Dynamo* (4 September) and *The Topology of Magnetic Fields* (27 November); and a three-day Workshop on *Stellar Dynamos* (19 to 21 November).

The programme aimed to encourage participants to engage in collaborative discussion and research on any topic having a bearing on the problems of dynamo theory. The reports of the individual participants indicated that the programme has been successful in this objective, with many existing research projects having been brought to fruition, and new lines of investigation opened up.

L-functions and Arithmetic *January to June 1993*

Organisers: B Birch (Oxford), D Blasius (UCLA), S Bloch (Chicago), J Coates (Cambridge), J-M Fontaine (Orsay), R Heath-Brown (Oxford), K Kato (Tokyo).

The programme aimed to bring together mathematicians from the fields of arithmetical algebraic geometry, automorphic forms, and classical analytic number theory, to work on mysterious connections between arithmetic problems and the properties of zeta and L-functions, initially discovered in the first half of the nineteenth century. In the last thirty years, these have been realised to be far more extensive than had been imagined earlier, and a vast web of overlapping conjectures has been formulated, stretching from the Riemann hypothesis and Fermat's last theorem to the Tamagawa numbers of motives.



Andrew Wiles announcing his proof of Fermat's Last Theorem to an audience containing Enrico Bombieri, Barry Mazur, Ken Ribet and other distinguished number theorists on 23 June

The programme must be regarded as having been spectacularly successful in its objectives, the crowning moment being the lectures in which Andrew Wiles announced his proof of Fermat's last theorem, an epic *tour de force* which triumphantly brought together so many of the ideas underlying the programme. It was, of course, an event which put mathematics onto the front pages of newspapers around the world and its cultural importance in stimulating interest in mathematical research is already enormous, with lecture theatres filling in many countries to hear elementary expositions of the result.

Although this historical advance rightly dominated the programme, it should not be allowed to eclipse totally a number of other breakthroughs on the connection between the arithmetic of elliptic curves, automorphic forms and L-functions which were reported during the programme and discussed with great interest by participants. Rather than being the close of a chapter, participants left the Institute with the feeling that there will be much more progress in this circle of ideas in the next few years, with similar programmes planned for the new Fields Institute in Canada and for the Institute for Advanced Study in Princeton.

The programme had 62 visiting members with a core of 10 staying for four months or more. N Boston held a Rosenbaum Visiting Fellowship. The average length of stay was just over 2 months. The number of participants could easily have been increased by half if space and resources permitted. In order to enable more research students and young mathematicians from outside Cambridge to benefit from longer stays at the programme, overflow accommodation for 12 unofficial participants was made available in DPMMS.

The structure of the scientific programme was to combine a large number of concentrated periods with many lectures per day (4 workshops, lasting $3\frac{1}{2}$ weeks in total, and an Instructional Course lasting 2 weeks), when the number of short-term visitors (particularly from the UK) would increase, and, on the other hand, to keep the remaining time relatively free of formal lectures (2 or 3 seminars per week) to allow maximal time for informal discussions amongst participants. Additionally, a Spitalfields Day was held in conjunction with the London Mathematical Society on 28 May with lectures by S Bloch, B Mazur, K Ribet and V Kolyvagin.

Efforts to secure the full participation of UK number theorists in the programme met with considerable success. A Scholl (Durham), M Taylor (UMIST), B Birch (Oxford), C Bushnell (KCL, London), R Heath-Brown (Oxford) and R Vaughan (Imperial) all visited for periods of months. In addition, the organisers offered almost every active researcher in number theory in the United Kingdom assistance with travel and subsistence for up to 5 days to participate in the programme, and this offer was almost universally accepted. Nine UK research students from outside Cambridge were offered bursaries of £300 each to attend the Instructional Course. Finally, three promising young British number theorists currently working in the United States (A Granville, Georgia; T Wooley, Ann Arbor; and the Rosenbaum Fellow N Boston, Illinois) visited for several months each.

The first large-scale activity of the programme was an instructional course on the *Langlands Programme*, 15–27 February, which turned out to be remarkably successful. Almost 60 people started the course, and over 40 were still present 48 lectures and 13 days later. The workshops: *Motives attached to Automorphic Forms*, 5–10 April, *L-functions and Classical Problems*, 12–17 April, *Galois Modules*, 27–28 April, and *p-adic representations, Iwasawa theory and the Tamagawa numbers of motives* were also highly successful (the last distinguished by Wiles' lectures).

Epidemic Models *January to June 1993*

Organisers: B Grenfell (Cambridge), V Isham (UCL, London), D Mollison (Heriot-Watt).

The problems of understanding and controlling disease present a range of mathematical challenges, from broad theoretical issues to specific practical ones. This programme brought together scientists with a wide variety of mathematical expertise (including probability, deterministic modelling and data analysis) and with close involvement in applied fields across the social, medical and biological sciences. The study of AIDS has stimulated much progress in diverse areas of epidemic modelling, better data and data analysis techniques have become available, and there have been exciting developments in relevant areas of mathematics. The programme fostered interdisciplinary co-operation and contributed to the modelling of a wide range of human, animal and plant diseases.

The programme had a large nucleus of long-stay participants with 16 spending periods of 4 months or more at the Institute. In all 44 visiting members took part with the average stay being about 3 months. M Altmann held a Rosenbaum Visiting Fellowship and K Dietz and I Nåsell were supported by Prudential Distinguished Visiting Fellowships.

The programme opened with a NATO Advanced Research Workshop on *Epidemic Models: their structure and relation to data* from 3–9 January, organised by D Mollison. There were 33 talks over five days, with a final morning devoted to discussion of directions for future research. There were many favourable comments on the content of the workshop, and on the quality and variety of scientists attending, and it prompted quite a few participants to return later in the programme.

The centrepiece of the programme was a three week 'period of concentration' from 14 March to 2 April containing two major workshops. The first of these was *Ecology of infectious diseases in natural populations*, 14–20 March, organised by B Grenfell and A Dobson (Princeton). As intended, this was an intensive workshop, involving over 50 participants, which was highly successful, both in terms of reviewing the current state of the subject, and in bringing together mathematicians and biologists from a diverse range of backgrounds. It resulted in a number of new interdisciplinary collaborations being started.

The second workshop, *Models for infectious human diseases*, 28 March–2 April, organised by V Isham and G Medley (Imperial), was attended by just over 100 participants from a wide range of subject areas and countries, many of whom have since written to say how useful they found the week and how much they enjoyed it. During the workshop there were 16 invited papers with invited discussants and more than 40 contributed papers on a variety of topics which generated substantial discussion. The papers were grouped under the following headings: *Transmissible diseases with long development times and vaccination strategies*, *Dynamics of immunity (development of disease within individuals)*, *Population heterogeneity (mixing)*, *Consequences of treatment interventions*, and *Prediction.*

During the intervening week (22–26 March) there were a number of informal seminars, and a day devoted to *Network models for epidemics.*

Books based on the two Easter workshops and the earlier NATO ARW are being produced for publication in the Institute's series. Together, these will provide a wide-ranging review of the current state of the research field.

A paper on *Epidemics: models and data*, written by the three organisers, was accepted by the Royal Statistical Society as the basis for one of their Discussion Meetings and the Institute was very pleased to act as host to this meeting on 23 June. As well as fostering links between the Institute and the RSS, this was perfectly timed for the purpose of reporting on the activities of the programme and discussing them with a wider community.

Apart from these wider activities, and equally important, was the opportunity the programme provided throughout the six months for bring together people from a wide range of disciplines, all of whom were involved in using mathematical models in studying the spread of disease. Highlights included: J Heesterbeek and M Roberts use of deterministic models to generalise the *basic reproductive ratio*, R_0, to non-autonomous systems; the development of stochastic models of infection by macroparasitic worms by K Dietz, B Grenfell and V Isham; and M Morris' finding that the discrepancy between male and female reporting rates in surveys of sexual behaviour can be attributed to the tale of the male distribution, which will have importance for the design of future surveys.

Discussions were in progress almost continually throughout the six months around the Institute's blackboards and many new collaborations started which will continue to advance understanding and contribute to the control of human and other diseases for many years to come.

2.6 Future Programmes

Computer Vision

July to December 1993

Organisers: A Blake (Oxford), D Mumford (Harvard), BD Ripley (Oxford).

Computer vision has its roots in practical engineering problems such as the visual navigation of mobile robots and vehicles and the automated analysis of medical images. A rapidly advancing interdisciplinary subject, it has reached out to mathematicians, statisticians and computer scientists for analytic tools and algorithms, and to psychologists and biologists for insight into natural vision systems. The programme is bringing together specialists from these subjects to study aspects of computer vision such as ideas from mathematical analysis applied to image analysis, using stochastic representations to guide object recognition, and active vision, *ie* the continuous guidance of motion to optimize acquisition of visual information.

Random Spatial Processes

July to December 1993

Organisers: MT Barlow (UBC, Vancouver), GR Grimmett (Cambridge), H Kesten (Cornell).

Many physical processes may be modelled using random processes involving space and (possibly) time, *eg*, the spread of disease and the structure of disordered media. Two of the principal targets of the theory of such *random spatial processes* are to understand the nature of phase transitions, and to describe the geometry of evolving processes. Recently the development of powerful and rigorous techniques has led to progress on some of the hardest problems. During this programme, probabilists and theoretical physicists will pursue such problems for interacting particle processes, percolation, random media, and models of population growth.

Geometry and Gravity

January to June 1994

Organisers: GW Gibbons (Cambridge), SW Hawking (Cambridge), CJ Isham (Imperial).

The past successes of Einstein's *classical* General Relativity have raised deep and difficult problems, involving global differential geometry and the theory of hyperbolic differential equations, whose solution would throw light on the evolution of black holes and nature of space-time singularities. The solution of many of these physical problems requires the development of a *quantum* theory of gravity. This would inevitably involve ideas from differential geometry and it would have implications for mathematics. The programme will bring together mathematicians and theoretical physicists working on both the classical and the quantum aspects of these problems to clarify the mathematical and physical questions that need addressing, and to contribute to their resolution.

Cellular Automata, Aggregation and Growth

January to June 1994

Organisers: B Derrida (Saclay), AJ McKane (Manchester), ER Speer (Rutgers).

Over the last decade, the huge increase in the scale of computer simulations has revealed the remarkably complex objects which can be grown from simple probabilistic rules. The intricacy of the growing structures (having, for instance, a fractal surface) is in marked contrast to the simplicity of the microscopic rules which generate them. Interest in these phenomena originates in a broad range of disciplines from mathematics through physics, chemistry and computer science to biology. While computer simulations have uncovered many interesting features, such as scaling and universality, the mathematical understanding of these structures is less well developed and this programme will aim to advance this by bringing together researchers working in different fields.

Symplectic Geometry

July to December 1994

Organisers: S Donaldson (Oxford), D McDuff (Stony Brook), D Salamon (Warwick) , C Thomas (Cambridge)

Surfaces known as symplectic manifolds arise in many branches of pure and applied mathematics, for example they provide the natural framework in which to discuss classical mechanics. There has been dramatic progress in recent years in understanding their properties, drawing on results from many disciplines, including differential geometry and topology, global analysis and the theory of partial differential equations. The programme will bring together mathematicians from all these fields together with theoretical physicists with the aim of further developing the theory, for example by exploiting the parallelism between Yang-Mills theory in four dimensions (which was originally constructed by physicists to describe the strong nuclear force between elementary particles) and symplectic geometry in an arbitrary even dimension.

Topological Defects

July to December 1994

Organisers: AJ Bray (Manchester), TWB Kibble (Imperial College, London), RS Ward (Durham)

Topological defects appear in a vast array of physical situations, from cosmic strings which occur in unified field theories of elementary particles at the highest energies, to vortices which occur in superfluids at temperatures approaching absolute zero. These defects exhibit remarkably similar behaviour, whether it be the breaking and joining of cosmic strings or of superfluid vortices, or the evolution of a network of defects in a liquid crystal or in an expanding universe. By bringing together experts in field theory, cosmology, condensed-matter physics and high-energy particle theory, the programme aims to exploit common themes and thus further the study of topological defects in each of these contexts.

Exponential Asymptotics

January to June 1995

Organisers: MV Berry (Bristol), CJ Howls (Bristol), MD Kruskal (Rutgers) and FWJ Olver (Maryland)

Quantities which are exponentially small as a parameter vanishes are important mathematically and arise frequently in applications but their treatment has often been unsatisfactory until recently. The new mathematical idea of *resurgence* describes how the existence of small exponentials is responsible for the divergences of asymptotic series, and how this enables the divergent tails of the series to be decoded (*eg* by resummation) to yield small exponentials. Resurgence has also had wide application in physics, for example in tunnelling phenomena, in wave physics where asymptotics describes the short-wave limit and small exponentials are complex rays or tunnelling orbits, in radioactivity, and leakage in optical fibres, and in quantum field theory where the small exponentials are determined by instantons. The programme will bring together physicists and mathematicians to study the deep mathematical issues thrown up by recent developments and clarify the rôle of asymptotics in applications.

Financial Mathematics

January to June 1995

Organisers: MH Davis (Imperial), SD Hodges (Warwick), I Karatzas (Columbia), LCG Rogers (QMW, London)

Option trading began in a big way in the mid 70s. Prior to this the business of financial markets was largely confined to trading stocks, commodities and foreign currencies. The simplest option, the European call option, gives the holder the right to buy at a specified time T in the future an asset at a specified price, called the strike price. If the spot price at time T exceeds the strike price, then the holder of the option will buy the asset and immediately sell it again, making a profit equal to the spot price minus the strike price. On the other hand, if the spot price is below the strike price at time T, the holder will do nothing. This simplest of all options can be used for at least two ends:

(a) for speculation: the holder stands a chance of making a large profit while limiting his possible loss to the cost of the option;

(b) for hedging: if an agent is committed to delivering an asset at time T, the European call option protects him against large rises in its price.

In the last ten years the volume and variety of options traded has exploded. The main questions, as far as the practitioner is concerned, are how to price these options, how to combine the various financial instruments available in order to hedge risk, and how to do this in a computationally efficient way. As well as the obvious interest to economists and the financial world, the applications have stimulated research in branches of mathematics including stochastic analysis, numerical analysis and statistics. The interaction between mathematicians, economists and practitioners which this programme will generate will have implications not only for the theoretical studies of options pricing and stochastic analysis, but also, given the great importance to Britain of the financial services industry, to the nation's economic well-being.

Semantics of Computation *July to December 1995*

Organisers: S Ambramsky (Imperial), G Kahn (INRIA, France), J Mitchell (Stanford), A Pitts (Cambridge)

Few mathematicians and scientists can be unaware of the astonishing rate at which the capabilities and use of computer systems are increasing. We are able to carry out large calculations more and more quickly and cheaply; we are able to visualise the results of such calculations with increasingly sophisticated computer graphics; we are able to communicate and collaborate with our colleagues via very complicated global computer networks. Advances in computer hardware have provided the raw material for this spiralling development. However, advances in the design of computer software have proved much harder to achieve. As a result the cost of producing and maintaining software systems is vast in comparison to hardware costs, it is often difficult to adapt a complicated piece of software to new uses, and worst of all (considering the many critical situations in which it is used) software is often unreliable. Consequently, much effort has gone into the design of new programming languages, new methods for specifying and developing programs, and new formal systems for verifying properties of programs. These developments have sought to address such key issues as:

(i) how to increase the level of abstraction in programming languages away from the details of particular computer architectures, in order to enhance portability and make code production simpler;

(ii) how to increase modularity and code reuse in large computer programs;

(iii) the design of languages for programming algorithms involving parallel threads of computation;

(iv) how to design languages that aid the use of formal proof to verify program properties, in order to increase assurance of code correctness and reliability in critical situations;

(v) how to design and reason about complex distributed systems involving non-determinism, communication and concurrent actions.

The programme aims to exploit significant recent progress both in the implementation of functional programming languages and in understanding of the theory of the semantics of computation. It will bring together mathematicians and computer scientists to support the design, development and implementation of programming languages and related verification techniques which satisfy practical demands and are soundly based in theory.

From Finite to Infinite Dimensional Dynamical Systems *July to December 1995*

Organisers: P Constantin (Chicago), J Gibbon (Imperial), J Hale (Georgia), CT Sparrow (Cambridge)

Much of the current interest in finite dimensional dynamical systems arose from work on potentially high dimensional behaviour. For example Ruelle and Takens hoped to understand turbulence and Lorenz was interested in the weather. However, much of the effort that followed was directed towards understanding nonlinearities in low dimensional systems. There has been considerable progress in this area, mainly because the proofs and numerical experiments are easier. More recently, progress is starting to be made in a number of areas concerned with the relationship between low dimensional and high dimensional (including infinite dimensional) systems. For example, there have been exciting new developments arising from the use of ideas from classical analysis which have allowed much more mathematical precision about spatio-temporal chaos. Equally, the formation and development of patterns and their stability and interaction is being investigated from a geometrical point of view. Some of the results are devoted to showing that some infinite dimensional systems (PDEs for example) are effectively finite dimensional, whilst others attempt to describe truly infinite dimensional behaviour. What the recent results have in common is that they combine the topological approach which has been so successful in the analysis of low dimensional systems and classical analytic methods. In many cases the mathematical results are motivated and suggested by experiments (both numerical and physical). The programme intends to build on these new developments and will bring together physicists and mathematicians with the aim of furthering not only the theoretical understanding of the subject but also the applications of the results to experiment and the development of numerical methods, the necessary bridge between theory and experiment.


Interior of the Institute. *Photo: J. Austin*

2.7 Facilities

Building. The Institute's building, owned by St John's College and designed by Cambridge architects Annand and Mustoe, is generally agreed to have been successful in its prime objective of encouraging interaction between the visiting members. The architectural correspondent of *the Times* wrote that

> "Inside, the solid walls you are led to expect are not there. The whole centre of the building is one large open space rising to the top of the roof, and ringed and bridged by balconies and flying staircases. It might be a stage set designed for a cast of hundreds. In a way this is what it is. ... The open, outgoing attitude of both building and institution are evident as soon as you enter the front door. The whole administration area is open to view through a glass screen, giving a reassuring feel of instant service. Staircases and balconies have the open feel of ships' decks, strengthened by the horizontal white metal balustrades."

The building contains two seminar rooms, a library, 30 offices, a General Office (for administration), offices for the Institute Administrator and the Deputy Director and common areas. Rather than have corridors, the library, seminar rooms and administrative offices are grouped round a ground-floor common area and the scientists' offices, which are on the mezzanine and galleried first and second floors, surround the mezzanine common area. Throughout the building there are places for discussion grouped around chalkboards. As with the rest of the Institute's facilities, the building has been designed with a view to quickness of assimilation, which is of prime importance given the relatively short average stay of participants compared with the members of a normal university department.

Seminar Room 1 can accommodate an audience of 96 seated at tables, with 24 or more additional seats behind if necessary. With tables removed, it can seat up to 150. Seminar Room 2 can seat 36 at tables, or up to 60 with tables removed. For use in the seminar rooms, the Institute possesses three GBI 5000 overhead projectors, three Kodak Carousel 35 mm slide projectors and a GEC CRT projector (mounted onto the ceiling in Seminar Room 1), which can project European and USA videos (in PAL, SECAM and NTSC formats) and the output, in monochrome or colour, from a Sun SPARCstation, a Macintosh Quadra or a PC. In both seminar rooms, there are six chalk boards and two overhead projector screens. In Seminar Room 1, there is also a central screen, which can be raised and lowered automatically from the lectern. It can be used for the CRT projector, one or two slide projectors (which can be controlled from the lectern) or an overhead projector.

The 30 offices (18 double and 12 single) comprise 8 on each of the first and second floors and 14 on the mezzanine. 7 of the single rooms can just accommodate a second person and two of the double rooms can take a third person. One of the double offices has been assigned to the Computer Systems Manager and also houses fileservers and other equipment; another is used as a terminal room, accessible to all members of the Institute and other visitors. One of the single offices is used by the Housing Officer and, when necessary, by the Assistant Directors. Two of the double offices (F5 and F6) were combined into a single room which can be used by up to six short-stay visitors at times of high population or as a small seminar room at the rare times when space is plentiful. This leaves space for 39 persons without exceeding the design occupancy or up to about 54 using all possibilities for doubling up.

Computer Equipment. The Institute has a scientific network consisting of 30 Sun SPARCstations, 15 Macintosh Quadra 700 workstations, a number of microcomputers and associated fileservers. Sun Microsystems donated 14 SPARCstation ELCs, 1 SPARCstation IPC, 1 SPARCserver 630 MP and 2 SPARCserver2s (each 3.1 GBytes). A further 15 SPARCstation 1 and 1+ workstations were purchased secondhand at advantageous prices. Apple UK donated the 15 Macintosh Quadras.

Each double office is equipped with two Unix workstations (SunOS and A/UX) and each single office with one. In addition, the terminal room contains a SPARCstation, a Macintosh Quadra and a PC with terminal emulation and file transfer capabilities. The large room (F5/6) is similarly equipped for use by participants without access to a computer in a specific room. All the computers are linked together on an Ethernet, with central file-storage being provided by the two SPARCserver 2 computers and the communications server, 630 MP. A connection to the University's high-speed optical fibre Granta Backbone Network provides contact with other institutions outside Cambridge on the Internet and on JANET, allowing file transfer and electronic mail to remote sites.

In addition to two HP laserprinters, the Institute also possesses a Canon CLC-10 colour printer which can print the output from the Institute's computers and can be used for colour photocopying and scanning.

The Director accepting the donation of Apple Macintosh Quadra workstations from Mr Michael Newton of Apple UK. A major donation was also received from Sun Microsystems.

The system is protected by an uninterruptable power supply (UPS) which provides battery backup to the fileservers for up to 10 minutes after a power failure. If there is a continuing loss of mains power when the battery supply is running low, the units interact with software installed on the fileservers to shut the system down in an orderly fashion. This should ensure no loss of service when power is restored.

The Institute's administration is handled on a number of IBM PC compatibles and Macintosh machines connected through a Novell network. Data relating to past, present and future participants and the commitments made to them is organised using dBASE, which is used to produce budgetary statements, lists of forthcoming visiting members, weekly telephone and room lists, office labels, *etc.*

File space housekeeping is managed centrally, with large Postscript files compressed and other large files produced during the processing of TEX being deleted each night. The file space is also backed up each evening.

The main uses of the Institute's computers are electronic mail, as remote terminals for computers in other locations, wordprocessing and mathematical typesetting, running mathematical packages, including symbolic manipulation. Software available in the Institute includes:

> *Programming languages:* C, Fortran, Gnu CC, Gnu C_{++};
>
> *Mathematical software:* Axiom, Mathematica, Matlab, Maple, REDUCE, S-Plus, GLIM, Pari-GP, gap;
>
> *Text formatting software:* TEX (including LaTEX, amsTEX, amsLaTEX, bibTEX, picTEX), OzTEX (including LaTEX, Times-LaTEX);
>
> *Desktop publishing software:* MacDraw, MacWrite, ClarisWorks, Adobe Illustrator, Pagemaker;
>
> *Database software:* dBASE IV, Hypercard.

Library. The Institute's library aims to provide a good selection of current and classic books, at the graduate text level, covering the mathematical sciences. It also acquires, using the advice of the organisers, books of a more specialised nature relating to each of the current programmes. The Library receives approximately 60 scientific periodicals as well as the major abstracting journals. In the case of 16 titles, the library has copies covering at least the last ten years. Over half the periodicals are the result of donations. Photocopies of the title pages of journals taken elsewhere in Cambridge and of particular relevance to the current programmes are displayed in the library. There is also a reference section containing dictionaries, encyclopedias, etc.

Of course, it is not possible for the library of a new Institute to provide a comprehensive coverage of the entire range of the mathematical sciences and members have access to the central libraries of the University and the libraries of relevant University departments. The distance of these libraries from the Institute causes inconvenience but it is hoped that this will eventually be removed when with the relocation of the University mathematics departments onto the Clarkson Road site.

Mathematical Reviews is available on CD-ROM as well as hard copy enabling the text to be searched by computer and for abstracts to be printed to files or to paper. This facility has proved very popular.

The library's stock of monographs and serials has been increasing at a steady rate. Some 2700 monographs are now held in the library and the records for these have been sent for inclusion in the 'Union Catalogue' of libraries in the University. As a result of this, participants are able to access the library catalogue, as well as the catalogue of the University library and some other relevant Cambridge libraries from their own terminals. The library also has access to the BIDS information database in Bath.

The Library takes national daily newspapers, and a collection of leaflets about places to visit and arts and leisure activities in Cambridge and further afield, is maintained there.

Housing. The Institute provides housing for its participants in 11 flats (at Mordell Court, Chesterton High Street) and a listed building containing six study bedrooms (at 1 Chapel Street), all situated about a mile and three quarters from the Institute and rented from St John's College, and an average of 14 other dwellings (mostly private houses and flats).

For a single person, prices vary from £14 to £18 per night, with accommodation ranging from single study bedrooms, sharing bathroom facilities, to self-contained one-bedroom flats. For accompanied participants, prices range from £22 to £25 per night for those coming with one other person and from £24 to £27 per night for those coming with larger families. In each case, prices reflect the size of the property and the length of stay.

All the accommodation that the Institute has arranged is fully furnished and of good quality and the rent charged includes local taxes (community charge or council tax) and maintenance costs but not telephone, electricity or gas charges. The prices reflect the fact that, in order to be able to guarantee accommodation for its relatively short-stay members, the Institute often has to rent properties for periods when they will be unoccupied and the rent must cover these voids. The rent charge must bear a sensible relation to the subsistence allowances the Institute pays, currently £30 per day. This allowance is primarily designed to cover the accommodation and basic food costs for a single person. It should also cover the cost of accommodation for a participant accompanied by his or her family, though not in this case the food costs as well.

In practice, taking into account the Christmas break, it is difficult to get occupancy rates much above 280 days per year. The housing office is in effect a small business with an annual turnover of £200,000 which has to run at very close to zero margin, neither making a substantial profit nor being an appreciable drain on the Institute's finances.

2.8 Funding and Fellowships

The initial funding for the Institute was provided by St John's College, in the form of a subvention totalling £750,000 to cover most of the first 5 years' rent and by Trinity College, through the agency of the Isaac Newton Trust, which provided a grant of £1 million for other expenditure over this period. (Although no allowance for inflation was made in the Isaac Newton Trust grant, the annual instalments have been paid one year in advance so that the actual value to the Institute is more than £200k *pa* because of the interest accrued.) The Trust has also given the Institute a grant of £10k *pa* for five years towards the cost of the post of Librarian and Information Officer. The Institute has received generous financial support from other Cambridge Colleges: Gonville and Caius College gave £100k towards setting-up costs; Emmanuel College gave £30k towards setting-up costs and has also established a John Harvard Visting Fellowship to be held by a Visiting Fellow at the Institute; Jesus College has given the Institute £5k *pa* for five years; and Christ's College gave £5k towards setting-up costs.

Financial support from outside Cambridge came first from the London Mathematical Society, which gave £20k towards setting-up costs and £10k *pa* for five years to support UK mathematicians taking part in the Institute's activities. Further support has come from, amongst others, the Institute of Physics, which has given £10k *pa* for five years to finance a Visiting Fellow (with preference to be given to a physicist from Eastern Europe), the Nuffield Foundation, which provided £57k towards salary costs during the setting-up period, NM Rothschild & Sons, who have provided funds to establish a Visiting Professorship for five years, Daiwa Anglo-Japanese Foundation, which has given funds to support Japanese visiting members of the Institute, the French CNRS, which is giving 400k FF *pa* to enable members of the CNRS to visit the Institute, the Paul and Gabriella Rosenbaum Foundation (USA), which is giving $70,000 *pa* to support Visiting Fellows from the

US, and the Prudential Corporation plc, which is giving £25,000 *pa* for four years to support a Prudential Distinguished Visiting Fellowship.

The backbone of the Institute's finances is the "rolling" grant it receives from the UK Science and Engineering Research Council to provide contributions towards the subsistence and travel costs of visiting members and salary support where necessary for organisers and other key participants. The current value of the grant is about £396,000 per year (supplemented by a total of £134,000 *p.a.* for direct and indirect overhead costs) for four years in the first instance, together with a grant of £100,000 towards setting-up costs. The SERC grant will be reviewed before December 1993, to give consideration to extending the horizon by two years, to December 1997, and to reassess the support provided for the period January 1994 to December 1995.

By the time the first programmes started, over £5 million had been firmly promised but efforts are continuing all the time to secure more funding for visiting professorships and fellowships. However, since the initial financial support was intended as 'pump-priming', the Institute needs to continue to seek substantial funds to secure its future, in particular to replace the funding provided by St John's and Trinity for the first five-year period.

2.9 Publicity

The Institute has been reviewing its distribution of publicity regularly, extending and updating the various leaflets and notices it uses to disseminate information about the Institute and the means by which this is done. It has tried to automate and systematise its procedures as much as possible, both in the interests of efficiency and in order to make as much useful and up-to-date information available as possible.

Each week the Institute prepares a list of forthcoming seminars. At present these lists are distributed in two ways: a limited number are sent by post to individuals and departments in Cambridge and elsewhere in the UK; the lists are also distributed by e-mail. For financial and organizational reasons, it is easier to use an electronic distributional system and the Institute is building a rapidly-growing database of institutions to whom seminar information is being sent (a letter was recently sent to a large number of departments in the UK asking whether they would like to be included in this database).

The Institute has also set up a system by which seminar and other information can be accessed remotely via 'anonymous ftp'. To access this information, it is necessary to `ftp` to `newton.newton.cam.ac.uk`, entering `ftp` as the username and your usual email address as the password. All of the information is contained in the directory `ftp/pub` and the directories below that. The directory `ftp/pub/programmes` contains newsletters and charts and lists of expected participants in present and future programmes. The directory `ftp/pub/seminars` contains the seminar lists. The directory `ftp/pub/general` contains the list of current visiting members with telephone numbers and office assignments, their accommodation addresses in Cambridge, the Institute's General Information booklet, travel information and information on how to submit proposals to future programmes. Much of this information is updated automatically at regular intervals from the Institute's databases. The information should also be available in the near future through a `gopher` front end, which is being tested at present on the Institute's communication server.

The most recent large-scale mailing took place in May when the Institute distributed a poster advertising forthcoming programmes and containing a 'call for proposals', to over 200 institutions in the UK and 300 others overseas. The information also included a general information booklet about the Institute (including maps and photographs), a newsletter containing one-paragraph summaries of future programmes, the programme newsletters and details of how to get information about the Institute through email or `ftp`. The Institute also regularly publicises this information through the newsletters or bulletins of the London Mathematical Society, the European Mathematical Society, the Institute of Mathematics and its Applications, the American Mathematical Society and the Institute of Physics.

2.10 Other Activities

So far as is permitted by its main scientific programmes, the Institute tries also to have lectures, seminars and courses of interest to a wider community. A programme of *Institute Seminars* has been run on Mondays during university terms aimed at a general mathematical audience. Some of these seminars set themselves the task of explaining aspects of the programmes to a wider audience; others have been on subjects very broadly within the mathematical sciences. Speakers have included Sydney Brenner on *What theories are we looking for in biology?*, Vladimir Arnold on *Newton's Principia read 300 years later*, Roger Penrose on *Computability and the mind* and John Maynard Smith on *Game theory and animal communication.* Also included as part of this series was the 1992-93 David Marr Lecture, given by Francis Crick on *Thinking about the brain* to an audience totalling 550, many watching on close-circuit television, which completely filled the building.

A successful three-day course on *Flow Instability, Chaos and Turbulence*, targeted at industry was mounted in association with the Dynamo Theory programme. There was also a *Chaos Day* and a day school on *Space, Time and Matter* run by the Board of Continuing Education attracting about one hundred interested lay people on each occasion. Additionally, the Mathematics Faculty has made use of the building for its annual mathematics teachers' colloquium.

3. Financial Report

The grants and expenditure on establishing the Institute are summarised in §3.1. Grants received for recurrent costs from the first year onwards are summarised in §3.2.

§3.3, prepared in connection with the fundraising for the Institute, gives a picture of the funds which are necessary for the Institute to continue to operate at the best possible level. SERC funding, through a "rolling grant" is assured until 31 December 1995 and is to be reviewed before the end of the second year of the grant on 31 December 1993. It will then be considered for extension for a further two years, to 31 December 1997, and the resources provided for 1994 and 1995 will be reviewed. The subvention of the rent (by £150k *p.a.*) provided by St John's and the grant of £200k *p.a.* from the Newton Trust will last until June 1997. The most urgent funding objective is to obtain funds to purchase the Institute's building (or a long lease on it).

3. Financial Report

3.1 Setting-Up Costs

Apple UK donated computer equipment worth about £108,000.

Donations of books and journals worth about £232,000 were received from individuals. Donations of money totalling £17,221 were also received.

Donations of books were received from Cambridge University Press, Princeton University Press, Springer-Verlag and other publishers totalling about £25,000 in value.

Grants of £5,000 from Christ's College, £30,000 from Emmanuel College, £100,000 from Gonville and Caius College were received towards the costs of establishing the Institute. Jesus College gave a grant of £5,000 *pa* for 5 years.

The London Mathematical Society provided a grant of £20,000 towards establishing the Institute.

The Nuffield Foundation provided a grant of £57,298 to meet the salary costs of the Deputy Director and some secretarial and other support during the setting-up period.

A grant of £100,000 was received from the SERC towards the costs of establishing the Institute, £70,000 for computing equipment and £30,000 for the library.

Sun Microsystems donated computer equipment worth about £213,000.

A grant of £100,000 was received from the University of Cambridge towards the cost of furniture and equipment for the building. A further grant of £21,000 was also provided out of anticipated income from the UFC associated with the Institute.

Setting up costs for the Institute are summarised in the following table:

Income		*Expenditure*	
Apple UK	108,000	Audio Visual Aids	27,743
Books (Individuals)	232,000	Consumables	16,000
Books (Publishers)	25,000	Computing Equipment	409,086
Cambridge University	121,000	Furniture & Equipment	139,727
Cambridge Colleges	140,000	Library	305,930
Individuals	17,221	Office Equipment	40,437
London Math. Soc.	20,000	Inauguration	5,704
Nuffield Foundation	57,298	Security Systems	15,715
SERC	100,000	Staff Costs	84,644
Sun Microsystems	213,000		
Interest	11,467		
Total	£1,044,986	Total	£1,044,986

3.2 Grants Received for Recurrent Expenses

The Agricultural and Food Research Council gave a grant of £2,000 to support the programme on *Epidemic Models.*

The American Friends of Cambridge University gave a grant of $50,000 (£32,416) which has been used to initiate a fund to purchase the Institute's building (or a long lease on it).

The Applied Probability Trust gave a total of £10,000 over 3 years to support the work of the Institute.

The Cambridge Philosophical Society gave a grant of £1,000 *pa* for 5 years to provide Cambridge Philosophical Society Bursaries to enable young scientists to attend meetings at the Institute.

Le Centre National de la Recherche Scientifique gave a grant of 400,000 FF *pa* for 5 years to support visitors to the Institute from CNRS laboratories and visits by members of the Institute to CNRS laboratories.

The Daiwa Anglo-Japanese Foundation provided a grant of £16,000 towards the cost of establishing Daiwa Visiting Fellowships for Japanese scientists at the Institute.

The Institute of Physics gave a grant of £10,000 *pa* for 5 years to establish an Institute of Physics Fellowship for a physicist, with preference to be given to scientists from Eastern Europe.

The Isaac Newton Trust, established by Trinity College, donated £200,000 *pa* for 5 years towards the infrastructure costs of the Institute and £10,000 *pa* for 5 years towards the cost of a Librarian and Information Officer.

The London Mathematical Society gave £10,000 *pa* for 5 years to enable mathematicians from British universities to visit the Institute.

The National Enviroment Research Council gave £5,000 towards the costs of participants in the *Wildlife Diseases Workshop* in the *Epidemic Models* programme.

NATO gave a grant of £11,100 towards the cost of an advanced research workshop on *Low Dimensional Topology and Quantum Field Theory*, a grant of £32,316 for an advanced study institute on *Theory of Solar and Planetary Dynamos* and a grant of £15,909 for an advanced research workshop on *Epidemic Models: their Structure and Relation to Data.*

NM Rothschild and Sons gave £333,300 to fund a Rothschild Visiting Professorship at the Institute for 5 years.

The Gabriella and Paul Rosenbaum Foundation gave a grant of $70,000 *pa* for 3 years towards the costs of establishing Rosenbaum Visiting Fellowships for scientists from the USA visiting the Institute.

The Prudential Corporation plc gave £25,000 *pa* for 4 years to support Prudential Distinguished Visiting Fellows at the Institute.

St John's College donated £150,000 *pa* for 5 years towards the cost of the rent of the building.

The Science and Engineering Research Council gave a grant totalling £840,000 over 4 years towards the subsistence and travel costs of participants, a grant totalling £663,216 over 4 years for salary costs for key participants and a grant of £60,000 over 18 months towards administrative costs.

Trinity College donated £10,000 towards the support of Visiting Scientists from Eastern Europe and the former Soviet Union.

The Wellcome Trust gave £4826 for the support of participants in the *Epidemic Models* programme.

3.3: Future Funding Needs

Notes		91-92	92-93	93-94	94-95	95-96	96-97	97-98
	BUILDING							
1	Setting-up cost	£234k						
2	Rent		£184k	£184k	£184k	£184k	£184k	
3	Capital Cost							£2900k
4	*Funding secured*	*£234k*	*£184k*	*£184k*	*£184k*	*£184k*	*£184k*	
	Funding Need: building							**£2900k**
	EQUIPMENT							
5	Computers	£418k	£112k	£115k	£121k	£126k	£128k	£134k
6	Books	£290k	£26k	£27k	£29k	£30k	£32k	£34k
7	*Funding secured*	*£708k*	*£108k*	*£110k*	*£117k*	*£121k*	*£124k*	*£131k*
	Funding Need: equipment		**£30k**	**£32k**	**£33k**	**£35k**	**£36k**	**£37k**
	POSTS							
8	Core posts	£117k	£215k	£222k	£233k	£244k	£256k	£269k
9	Visiting posts		£685k	£783k	£867k	£955k	£1055k	£1078k
10	*Funding secured*	*£117k*	*£900k*	*£945k*	*£984k*	*£1020k*	*£1067k*	*£1117k*
	Funding Need: posts			**£60k**	**£116k**	**£179k**	**£244k**	**£230k**
	Total Annual Need		**£30k**	**£92k**	**£149k**	**£214k**	**£280k**	**£3167k**
	Cumulative Total Need		**£30k**	**£122k**	**£271k**	**£485k**	**£765k**	**£3932k**

NOTES:

1. The settin-up costs include fitting out, furniture, office equipment and audio-visual equipment.

2. Funds have been secured to rent the building for the first five years from 1 July 1992.

3. By the end of five years, the Institute must find the capital cost of the building to purchase it at the then current value from St John's College, who have paid for its construction. Inflation of 20% over the actual 1991-92 cost has been allowed for.

4. Includes £750k from St John's College towards the first five years' rent, and grants of £121k from the SERC and £100k from Gonville and Caius College.

5. Includes the cost of maintaining and renewing the hardware and software necessary for the first class computing and electronic communication system which is essential for the Institute.

6. The Library needs to maintain a collection of the most important texts and the key journals over a broad range of the mathematical sciences.

7. Computer workstations have been donated by Sun Microsystems and Apple UK; software has been donated by NAG, Claris and Wolfram Research. Over 4000 books and journals have been donated by a large number of publishers and individual members of the mathematical community. Emmanuel, Jesus and Christ's Colleges have made grants.

8. Core posts include the Deputy Director and administrative staff.

9. Visiting posts include the research programme organisers, visiting professorships and fellowships, as well as basic subsistence allowances for most of the 240 scientists who come as visiting members of the Institute each year.

10. Funding has been obtained as follows:

Institute of Physics	£50k over 5 years
Prudential Corporation plc	£100k over 4 years
NM Rothschild & Sons	£333k over 5 years
Isaac Newton Trust	£1050k over 5 years
London Mathematical Society	£70k over 5 years
French CNRS	£200k over 5 years
Rosenbaum Foundation	£140k over 3 years
Daiwa Anglo-Japanese Foundation	£16k over 1 year
SERC	£2008k over 4 years

4. Programme Reports

4.1 Low Dimensional Topology and Quantum Field Theory *(July to December 1992)*

Report from the organisers:

E Corrigan (Durham), MB Green (QMW, London), WBR Lickorish (Cambridge).

Introduction. Recent years have seen very dramatic developments in mathematics and theoretical physics based on the interchange and cross-fertilisation of concepts and techniques. The aim of the programme was to build upon these advances and promote the interchange of ideas between mathematicians and theoretical physicists, in areas ranging from knot theory and the topology of three manifolds, von Neumann algebras, topological and conformal field theory, integrable massive field theories, through to two-dimensional statistical mechanics and elementary particle physics.

The list of participants (see §5.1) demonstrates that the programme brought together leading researchers from many countries, including a high proportion of those responsible for initiating these exciting developments. The mix of international participants varied as the programme progressed, with most Japanese and US visitors participating in the summer months and a notably high proportion of overseas visitors from Europe and the CIS in the last three months. For example, during July and August there was a very powerful gathering of operator algebra specialists, mostly from the US; during October and November there was a predominance of experts in conformal field theory and allied topics, many from the former Soviet Union but now based in Europe.

An important function of the programme was to involve the UK community in its special days and workshops. For this reason, efforts were made to advertise the activities extensively by means of regular e-mail messages to most UK University departments of mathematics and theoretical physics and to a number of individuals. Funds from the London Mathematical Society contributed to the expenses of short-stay UK visitors and a considerable number attended, especially during the 'mini-workshops'. Although impossible to quantify precisely, the wide range of national and international participation created a continuous atmosphere of vitality and activity.

Graduate students made an important contribution to the programme. In addition to Cambridge students from DAMTP and DPMMS, three students from Durham and three students from Berkeley made extended visits. In addition, a number of other students from Liverpool, QMW, Warwick, Manchester and Durham visited for shorter periods. Many of the participants, particularly those from overseas, gave a number of talks at other institutions, including three series of lectures at UK summer schools.

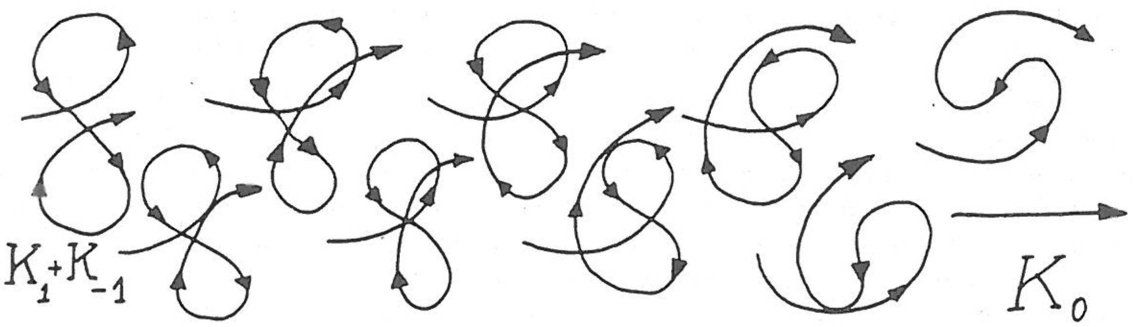
The programme appears to have been an outstanding success, judging by the enthusiasm of the participants and the range of activities undertaken. Furthermore, the presence of a separate programme in a somewhat related field (Dynamo Theory) further enhanced the atmosphere at the Institute. Although the two sets of participants did not have a great deal of explicit scientific overlap (with the notable exception of Arnold and Khesin, who participated actively in both programmes), the layout of the Institute encouraged a significant interaction over coffee and lunch in addition to the organized general seminar on Monday afternoons. We should like to take this opportunity to thank the Director, Deputy Director and the staff of the Institute for all their patient help and support during the programme.

Knot Theory and Invariants. In the past few years the theory of 3-dimensional topology has been confronted by a plethora of new invariants. Of these, the first and the simplest is the polynomial invariant for classical links in the 3-sphere discovered by VFR Jones. For him this was a by-product of work on von Neumann algebras, obtained by taking a trace on a representation of the classical braid group. A methodology of producing this type of invariant evolved into the theory of quantum groups, which employs ideas from statistical mechanics, to gain solutions to the

Yang-Baxter equations and thence obtain knot invariants.

The meaning of these invariants, and in particular their interpretation in terms of the fundamental group, has remained something of a mystery. However, the interpretation by E Witten in terms of a 'topological' quantum field theory, using the Chern-Simons operator as a Lagrangian in a path integral, has been of profound significance. In this, based on an arbitrary representation of a Lie algebra, the link invariant is regarded as part of a more general theory of 3-dimensional manifold invariants. Allied to this is the 3-manifold invariant of Turaev and Viro that is expressible as a state sum of quantum 6j-symbols.

During the programme at the Institute there was extensive study of all these topics and of the interaction between them, this being stimulated by talks from many of the pioneers themselves. Talks by E Witten and S Donaldson had emphasised the relevance of Floer theory to the Chern-Simons theory. Floer theory contains (and grew from) the Casson invariant of a homology 3-sphere, and results of R Kirby and P Melvin had indicated a connection between Casson's invariant and Witten's SU(2) invariant. The relevant conjecture, much discussed during the programme, has now been proved by H Murakami, one of the participants (who lectured on his unfinished work whilst at the Institute). Thus there is now an established theory connecting the Witten invariant with the fundamental group of the homology 3-sphere.



The index 0 perestroika of $K_1 + K_{-1}$ into K_0
from *Plane curves, their invariants, perestroikas and classifications* by V Arnold

C Taubes came to give a series of lectures on the work of Kontsevich. The exposition by D Bar-Natan of the link invariants of Vassiliev (which essentially include all invariants in the style of Jones, whose presence acted as a focus for much of the work at the start of the programme) became available during the programme. It was studied by a special group which benefited greatly from a visit by Bar-Natan himself, who gave a series of lectures. Following this, S Willerton, a Cambridge graduate student, rectified a serious error in Bar-Natan's work adding in the process considerable elegance to part of his theory. Similarly, discussion at the Institute of the Turaev-Viro invariant has led indirectly to an impressive simplification of that theory by JD Roberts, another Cambridge graduate student. His work gives a new surgery-based method of describing that invariant and makes very clear the fact that it is indeed the square of the modulus of Witten's invariant.

String Theory and Conformal Field Theory. Developments in string theory have led to a greater appreciation of the rôle of topology in theoretical physics. For the first time, there was also felt by some physicists to be a genuine framework within which there might be a chance of unifying gravity with the other forces of nature. String theory has been closely interrelated with conformal field theory since its inception. Conformal field theories also describe the behaviour of certain statistical systems at critical temperatures. For these reasons they have been extensively studied although their classification remains elusive. Efforts to understand their structure have involved extended conformal symmetries, such as W-algebras and progress on the study of these was made during the programme by P West, C Hull, T Eguchi and H Ooguri. A number of interesting new identities in the context of conformal field theory involving Rogers dilogarithm functions were discovered by W Nahm and A Kirillov and formed major topics of discussion both during the NATO workshop and during the final 'mini-workshop'. String theory itself was the subject of work by M Green, who investigated the possibility of a string theory description of the large-N limit of $U(N)$ Yang–Mills theory, which would make a link back to the original work on string theory in the context of strong interactions, and G Moore (interacting with M Green), who studied the way in which space-time diffeomorphisms are encoded in closed-string field theory.

Statistical Mechanics and Integrable Systems. The study of exactly solvable statistical mechanics models in two dimensions has provided deep and surprising links to many branches of mathematics. R Baxter, who was responsible for much of this pioneering work, was present for much of the programme. Further impetus to this study has come from the connections to invariants of knots, links and manifolds already mentioned. During the programme, Baxter and Cardy made interesting progress with conjectures concerning the chiral Potts model. M Jimbo and T Miwa, who with their Kyoto group have made seminal contributions to establishing the relationship between statistical mechanical models and quantum groups, made considerable progress in understanding the XXY model during their time at the Institute. They and their collaborators like to work together in the open, using extensive blackboard space, and the Institute suited this style very well.

Related both to conformal field theory and statistical mechanical models is the subject of integrable quantum field theories. A further large grouping involved those interested in integrable quantum field theory. This work focussed on problems in perturbed conformal field theory and affine Toda field theory. D Olive in collaboration with his student J Underwood and with M Saveliev and N Turok significantly developed the understanding of solitons in affine Toda field theory. F Smirnov continued to make progress in the difficult problem of form factors. P Dorey and F Ravanini studied the relationship and flows between various field theories using the Thermodynamic Bethe Ansatz technique. Outstanding and difficult problems in understanding the remarkable features of the quantum affine Toda field theories were aired extensively by A Belavin, V Fateev, E Corrigan, P Dorey, GMT Watts and others.

Weekly Pedagogical Seminars. The central scheduled activity was a seminar lasting about two hours, with a tea interval in the middle, aimed in part at facilitating communication between the theoretical physics and mathematics components of the participants. The first part was intended to be non-technical and aimed at communicating an overview of the subject to non-experts (who could then leave at the interval). The second half would then proceed as in a regular research seminar with a discussion of more technical and recent results. By and large these met with widespread approval, though the format raised some problems for a small number of speakers who over-estimated the expertise of the audience.

These seminars were also used by a number of speakers to air new ideas and conjectures. For example, G Segal outlined his ideas concerning the possible mathematical structure of massive quantum field theory; R Baxter ended his seminar with a remarkable conjecture on the structure of correlation functions within the chiral Potts model; J-B Zuber described an intriguing possible generalisation of Verlinde's formula; W Nahm described the new identities concerning the Rogers dilogarithm function; A Connes described his ideas concerning the use of non-commutative geometry to try to understand the structure of the 'Standard Model' in particle physics; S Hawking considered what happens ultimately to a black hole.

Workshops. An important way of widening participation in the programme was by means of the workshops held throughout the programme. These comprised a NATO Advanced Study Workshop and a series of 'mini-workshops'. The NATO workshop, held from 7 to 13 September and organised by A Bais, E Corrigan, L Kauffman, W Nahm and H Osborn, concentrated on the themes of the programme itself, but more from the physicist's view point. 32 participants who came specifically for the workshop joined the longer-term visiting members of the Institute. There were one-hour talks by established experts, including many excellent surveys of particular topics, and shorter, more informal talks of a more specialised nature. Because the workshop was part of a larger programme, younger participants had the opportunity to speak to a very strong audience, many of whom were not actually speaking at the workshop. This and the convenient housing and eating arrangements in Wolfson Court, adjacent to the Institute, helped to facilitate excellent informal discussions.

The series of 'mini-workshops' was:

> 6–17 July. *Topology Talks* (organised by WBR Lickorish). A series of 20 seminars (including Donaldson, Kauffman, Turaev, Viro and Witten).
>
> 22–24 July. *Von Neumann Algebras in Mathematics and Physics* (organised by VFR Jones and AJ Wassermann). A short workshop with expository talks on operator algebras and their applications in knot theory.
>
> 19–21 August. *Topological Field Theory and Quantum Gravity* (organised by E Corrigan and MB Green). A short seminar series concentrated on topological field theory.
>
> 9 October. *Spitalfields Day.* Held in conjunction with the London Mathematical Society, this was widely advertised and intended to be accessible to a wide audience. The speakers were chosen to represent the themes of the programme: S Donaldson, T Miwa and D Olive.
>
> 27–29 October. *Conformal and Integrable Field Theory* (organised by E Corrigan and DB Fairlie).
>
> 16–18 November. *Computational Aspects of Topological Invariants* (organised by E Corrigan and HR Morton).
>
> 8–10 December. *(Nearly) Conformal Field Theory* (organised by E Corrigan).

The talks given at these workshops are listed in §5.6.

4.2 Dynamo Theory *(July to December 1992)*

Report from the organisers:

U Frisch (Nice), HK Moffatt (Cambridge), AM Soward (Newcastle).

Introduction. The aim of this programme was to gather together specialists in dynamo theory covering a range of fields, particularly fluid mechanics, geophysics, and astrophysics. Several applied mathematicians knowledgeable in differential geometry and topology were also involved. The principal objectives were to share expertise and advance understanding in two main fields: the field of geodynamo theory, with particular emphasis on the nature of the energy supply mechanism and associated dynamical processes in the Earth's liquid conducting core; and the field of 'fast' dynamo theory, which focuses attention on the nature of the dynamo process in the very high conductivity limit relevant to solar and stellar dynamo processes, and even more markedly to the galactic dynamo process. Activities within these two fields are summarised below.

The majority of participants spent at least two months at the Institute, during either the first half (July to September) or the second half of the programme (October to December). There was a substantial overlap during the last two weeks of September, when the NATO Advanced Study Institute *Stellar and Planetary Dynamos* was held within the framework of the programme. This NATO ASI was directed by MRE Proctor, and the Proceedings will be published under his editorship by CUP. A report was published in the SEDI (Study of the Earth's Deep Interior) Bulletin, November 1992.

Four workshops were held on concentrated themes as follows: one-day workshops on *The Geody-*

namo and Planetary Dynamos (31 July), *The Fast Dynamo* (4 September) and *The Topology of Magnetic Fields* (27 November); and a three-day workshop on *Stellar Dynamos* (19 to 21 November). Programmes for these workshops are contained in §5.6 *List of Seminars*.

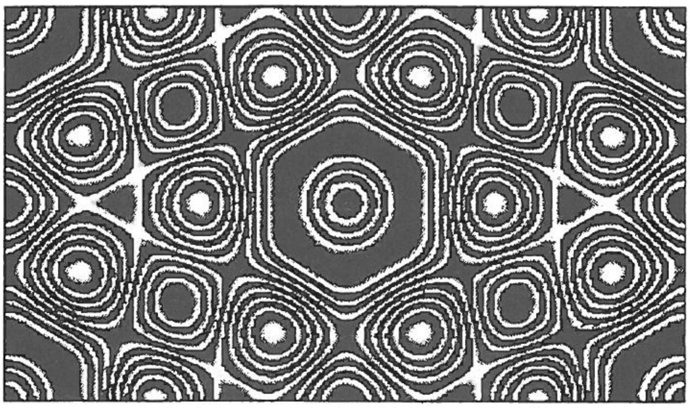
A crash programme of twelve seminars was held during August, and a regular seminar programme (two per week) was maintained during October, November and December. A Tuesday lunchtime seminar was arranged in conjunction with the astrophysical fluid dynamics group of the Department of Applied Mathematics and Theoretical Physics, and involved close cooperation with the Department.

Apart from provision of these workshops and seminars, the philosophy of the programme was to encourage participants to engage in collaborative discussion and research on any theme having a bearing on the problems of dynamo theory indicated above. We have every indication from the reports of the individual participants that the programme has been successful in this respect, that many existing research projects have been brought to fruition, and that a number of new lines of investigation have been opened up.

We are extremely grateful to the Director and staff of the Isaac Newton Institute for making this programme possible, and for providing an ideal research environment for this type of endeavour.

Geodynamo Problem. Dynamo theory seeks to explain the origin of magnetic fields of planets (including the Earth), stars (including the Sun) and galaxies. One property of fluid motion (usually turbulent) which is known to be highly conducive to dynamo action (*ie* to the spontaneous growth of magnetic field from an arbitrarily weak initial level) is the helicity of the flow, *ie* the correlation between fluid velocity and vorticity (spin); another is differential rotation. Both properties are induced by the action of Coriolis forces in a convecting rotating fluid.

In the case of the Earth (radius $R_E \simeq 6000$ km), the seat of this dynamo action is the liquid part of the core of the Earth extending from the inner core boundary (at radius $r = 0{\cdot}2\,R_E$) to the core-mantle boundary (at $r = 0{\cdot}5\,R_E$). Convection is driven by buoyancy forces associated partly with the slow cooling of the Earth (creating a potentially unstable temperature gradient) and partly with slow gravitational sedimentation of the heavier constituents of the liquid core towards the inner core boundary at which solidification occurs. There are other possible sources of energy for core motions associated with precession of the Earth's angular velocity vector $\mathbf{\Omega}$ and with Earth-tides, both induced by the gravitational pull of the Sun and Moon; until recently these latter effects have been regarded as too weak to be effective for the geodynamo process; however interest was revived in these mechanisms during the programme by a lecture by WVR Malkus who demonstrated that tidal straining can induce violent inviscid instability in a rotating fluid, periods of strong turbulence alternating with periods of relative quiescence. A huge source of energy (associated with the Earth's rotation) is available here, but the difficulty is in identifying the mechanism by which this energy may be made available for convective core motion and hence to power the geodynamo. The new Malkus mechanism may yet provide the answer, but much detailed analysis is now required to put this mechanism on a firm theoretical basis.



Streamlines of the basic flow from
Proving the existence of negative isotropic eddy viscosity
by M Vergassola, S Gama and U Frisch

The scenario for the source of power for the geodynamo that is most widely accepted among geophysicists today is that first proposed by Braginsky in a series of papers dating from 1964: in this scenario, buoyancy is created at the inner core boundary due to preferential solidification of the heavier metallic ingredient of the liquid, with associated slow growth of the inner core. We were fortunate to have S Braginsky as a long-term (4-month) participant in the programme, and he gave several lectures concerning his 'model Z' in which the core magnetic field is nearly aligned with the z-axis parallel to the rotation vector. This provides a means of circumventing a fundamental constraint (the 'Taylor constraint') associated with gross angular momentum balance. The theory is however still at an 'intermediate' stage, at which only partial account is taken of the governing dynamical equations: in such intermediate models, the buoyancy and/or helicity distributions are prescribed, and the resulting mean flow field and dynamo-generated magnetic field are determined. Ultimately, the aim is to find self-consistent solutions for which the buoyancy and helicity are also determined, rather than prescribed, but this objective has not yet been realised, either by Braginsky, or in the rival theories ably described by D Fearn in his lectures to the NATO ASI. One of the problems with the Braginsky theory is in fact the rather artificial distribution of helicity (or equivalently of the 'α-effect') that has to be assumed to provide dynamo solutions (*ie* solutions with non-vanishing magnetic field). Another problem relates to the effects of turbulence on small-scales (smaller than about 10 km), since this presumably determines the effective diffusivities of temperature, chemical composition and momentum, about which little is as yet known. Despite these problems, AP Anufriev and I Cupal reported some interesting developments of the Braginsky approach during the programme.

Alternatives to model-Z which do respect the Taylor constraint were also explored; in particular R Hollerbach developed the approach to mean-field dynamos that is part of the collaborative Cambridge-Exeter-Newcastle-Glasgow project aimed at finding a dynamically self-consistent dynamo model for the Earth. Hollerbach's achievement was to elucidate the influence of the solid inner core in the angular momentum balance constraints, and to find (numerically) a solution of the mean-field dynamo equations including these inner core effects.

Finally, at a more basic level, D Loper and HK Moffatt continued their investigation of the dynamics of individual parcels (plumes or blobs) of buoyant fluid released from the dendritic layer near the inner core boundary. On the assumption that a blob remains spherical, and under the magnetostrophic approximation (which ensures that the Taylor constraint is satisfied), it can be shown that it follows a trajectory on a paraboloid of revolution about the rotation axis. The influence of small-scale turbulence on the mixing of such a blob with its denser environment remains a challenging problem.

The Fast Dynamo. In most astrophysical dynamos, the fluid is almost perfectly conducting and ohmic diffusion is largely negligible. This is the case for solar, stellar and galactic dynamos, and is the limit which concerns us in this section. The alternative limit, in which ohmic diffusion plays a more prominent rôle, is the case for the Earth and other planetary dynamos described above. To appreciate some of the complications of high conductivity dynamos it is first necessary to understand how the simpler difficulties associated with low conductivity dynamos are overcome. The key obstacle to all dynamo theories is that the magnetic field generated must be fully three-dimensional. To overcome this mathematical difficulty, various averaging methods have been employed to simplify the theory. A particularly successful method has been to distinguish motion and magnetic field on two distinct length scales. On the short turbulent length scale, it can be argued that, for sufficiently large conductivity, ohmic diffusion plays a significant rôle. Then the small scale magnetic field can be calculated as a small perturbation to the large-scale magnetic field. By averaging over the short-length scale a mean magnetic induction equation can be derived from which the basic properties of the dynamo can be calculated. The main result which emerges is the existence of a so-called 'α-effect' characterising the magnitude of a contribution to the mean electromotive force parallel to the mean magnetic field. Such an approach is possibly appropriate to planetary dynamos. On the other hand, the concept of an "α-effect' is regularly invoked for other astrophysical dynamos in which the effects of ohmic diffusion may be negligible even on the short turbulent length scale.

An immediate consequence is that the fluctuating short length scale magnetic field is likely to be an order of magnitude larger than the mean field and the mean field development ceases to have a firm mathematical basis.

The lack of a robust mean field dynamo theory for highly conducting fluids prompts the question "Can magnetic fields grow on the convective time scale of the motion independent of the magnetic diffusivity?" This is the Fast Dynamo problem. It is important because it focuses our attention on the key issues concerning high conductivity dynamos. For example, its resolution will hopefully clarify the status of commonly accepted mean field concepts such as the 'α-effect'. Even the kinematic aspects of the Fast Dynamo problem for a given velocity field has proved hard to solve. The reasons for the mathematical complications stem from the small magnetic diffusivity. As a result, the partial differential equation governing the advection-diffusion of our passive vector field is stiff. Evidently the problem is of fundamental physical importance but it is also one of considerable mathematical interest. It, therefore, provided a focus for the activity of our programme by stimulating an interest common both to the mathematicians and astrophysicists. Indeed, we were particularly fortunate in benefiting from VI Arnold's participation for three months, especially in view of his continuing interest and significant contributions which stretch back at least two decades.

There have been three principal lines of attack on the Fast Dynamo problem, identified by the key words numerical, asymptotic and theorems, which have been actively pursued during the programme. In the case of the numerical solution of kinematic dynamos with given steady or temporally periodic flows the evolution of a seed field is followed. D Galloway has been particularly successful in this area and his contributions to the programme were very useful. The importance of the numerical results is that they provide a guide as to whether or not Fast Dynamos are possible. In the case of temporally periodic flows they have provided convincing evidence of their existence. Furthermore the nature of the magnetic fields predicted by the numerics identify processes which the theoretical approaches need to address. A Gilbert and A Soward have been concerned with deriving asymptotic solutions which make use of the small parameters of the system and reduce the mathematical problem to the study of maps. The main obstacle to the analytic approach is that as the diffusivity tends to zero, so does the length scale of the magnetic structures which compose the bulk of the field. As time proceeds, in the perfect conductivity limit, the magnetic field develops fractal and self-similar structures which the analytic theories attempt to encapsulate. A proof of the existence of Fast Dynamos remains lacking. In the case of steady flows that is essentially a problem in Spectral Theory. M Vishik and P Collet have made significant steps in that direction. Indeed, asymptotic methods underlie many of the procedures upon which Vishik's theorems are based.

A key ingredient necessary for Fast Dynamo action is exponential stretching linked to a positive Liapunov exponent in finite regions of the flow. Since properties of the particle paths are important, concepts from dynamical systems are central to our understanding of Fast Dynamos. For example, in the case of steady flows the streamlines in large regions of the flow often lie on KAM surfaces, where the Liapunov exponent vanishes. Due to the absence of exponential stretching no Fast Dynamo action occurs in those regions. Consequently, the magnetic field develops spatially intermittent structures with magnetic flux concentrated in ropes and sheets.

The dynamical behaviour of flux ropes and sheets is of considerable interest and has important astrophysical implications both to large scale MHD convection (*eg* sunspots) and MHD turbulence. Not only was research on flux ropes undertaken at the programme, but lively debates also ensued about turbulent dynamos. Both A Brandenburg and S Vainshtein had performed simulations of MHD turbulence. The latter work, however, led to a particularly controversial view about the dynamic equilibration of the dynamo. The issues highlighted by these simulations and others led to many excited discussions at the various seminars and workshops, which took place during the programme. One of the central issues raised concerned the concept of the filling factor. On the one hand, given the velocity field one can predict, in principle, the fraction of the flow occupied by the flux ropes and sheets. On the other, when the flow responds to the magnetic field via the Lorentz force it is far from clear what the size of the filling factor will be. Its size is crucial in determining equilibrium values. Another important aspect from an astrophysicist's point of view is that the observed large-scale magnetic fields may be much weaker than the small-scale fluctuating field which cannot be resolved.

Related to the Fast Dynamo question are the topological aspects of frozen magnetic fields. Specifically, in the absence of dissipation, magnetic field lines are material lines. Consequently during motion their topological properties like linkage and knottedness are preserved. These properties cease to be preserved once the effects of ohmic diffusion are included. Specifically reconnection can occur which alters the connections of the field lines. The MHD reconnection problem has long been an important problem of particular interest to solar physicists concerned with the energy source for solar flares. In this general area the programme benefited considerably from the contributions from F Pegoraro and E Priest, with their widely differing backgrounds in controlled thermonuclear fusion and solar MHD respectively.

In conclusion, we remark that considerable activity took place during the programme addressing the central issues of Fast Dynamo theory and related topics. We have not attempted to summarise here all the significant contributions made by the participants. Rather, we have attempted to convey a general idea of the issues addressed. Details of individual progress can be extracted from the summaries provided by the participants themselves. From a general point of view the research area has benefited significantly. The interchange of ideas by world leaders in their respective research areas has led to the rapid consolidation of recent results (interpretation and context) and has stimulated new research (some collaborative).

4.3 L-functions and Arithmetic *(January to June 1993)*

Report from the organisers:

B Birch (Oxford), D Blasius (UCLA), S Bloch (Chicago), J Coates (Cambridge), J-M Fontaine (Orsay), R Heath-Brown (Oxford), K Kato (Tokyo).

Introduction. The aim of the programme was succinctly explained beforehand as follows:

> "Over the last thirty years, number theorists have come to realise that the mysterious connections between arithmetic problems and the properties of zeta and L-functions, initially discovered in the first half of the nineteenth century, are far more extensive than had been imagined earlier. A vast web of overlapping conjectures has now been formulated, stretching from the Riemann hypothesis and Fermat's last theorem to the Tamagawa numbers of motives. The programme will bring together mathematicians from arithmetical algebraic geometry, automorphic forms, and classical analytic number theory to work on several of these conjectures."

Happily, the programme turned out to be the culmination point of much international effort in this direction by mathematicians from France, Germany, Japan, Russia, the United Kingdom, and the United States. In particular, the imagination of the whole world was stirred by Andrew Wiles' announcement of, and lectures on, his proof of Fermat's last theorem by the very ideas underlying the programme. This great piece of mathematical work rightly ended up dominating the programme. But is should not be forgotten that a number of other recent major breakthroughs on the connection between the arithmetic of elliptic curves, automorphic forms and L-functions were also reported on and discussed with great interest by participants. It is striking that most participants left the Newton Institute feeling that there will be much further progress in this circle of ideas in the next few years. Both the new Fields Institute in Canada and the Institute for Advanced Study in Princeton are already planning similar programmes to the one in Cambridge in the near future.

of the people who had contributed to these ideas were taking part in the programme when Wiles gave his lectures. The work leading up to Wiles' solution had indeed been truly international and harmonious in a sense, which is probably rarely seen in other areas of science. However, British number theory can be proud of its rôle. The study of the L-functions of elliptic curves became a major theme of research in modern number theory thanks largely to the discovery by B Birch and P Swinnerton-Dyer in the early 1960's of their celebrated and still unproven conjecture linking the basic arithmetic invariants of the curve to the behaviour of its L-series at $s = 1$. Both Wiles and Flach did their doctoral studies in Cambridge in a mathematical atmosphere that remains dominated by this remarkable conjecture, and the mathematics which has grown out of it.

General Scientific Programme. The overall thrust of the scientific programme was to investigate all possible connections between arithmetic problems (*ie* problems concerning the integers or the rational numbers, usually of a diophantine nature) on the one hand, and L-functions and automorphic forms on the other. Why such connections exist is one of the mysteries of number theory. The scientific programme stressed the connections between these apparently very different mathematical objects, rather than the study of each individually. Thus, for example, it was decided from the beginning not to pursue the very latest developments in the representation theoretic approach to automorphic forms (which is also a major theme of current research internationally), but instead to concentrate on those aspects which had so far been specifically related to arithmetic questions.

The mathematical techniques discussed in the programme were very varied, and included Sieve theory and classical estimates on the distribution of zeros of L-functions, the arithmetical theory of automorphic forms via both classical and representation-theoretic methods, K-theory, the theory of p-adic Galois representations, Iwasawa theory and, of course, questions of pure arithmetical algebraic geometry. Every effort was made to create an open atmosphere for the exchange of ideas between specialists in these areas. In general, the strategy seems to have worked well. In this direction, for example, it was striking to see the growing overlap between Sieve-theoretic methods and the more sophisticated techniques of Galois cohomology (such as Wasawa theory) in studying the L-functions of elliptic curves.

Highlights. Needless to say, it is very difficult to quantify meaningfully the final scientific outcome of such a programme. Some very brief indication is given in the individual reports of participants. All we propose to give here now are several highlights, which created much discussion, and will undoubtedly greatly influence the future of the subject. These are:

K Kato (Tokyo) gave a series of lectures on his deep new work which at last provides a direct link between Galois cohomology and the value at $s = 1$ of the L-series of a modular elliptic curve over $\mathbb{Q}$. Such a connection has been known for about 15 years for elliptic curves with complex multiplication, but the non-complex multiplication case had remained a mystery until now. The work already implies the finite generation of the group of points of such a curve which are rational over the cyclotomic $\mathbb{Z}_p$-extension of for every prime p (an old conjecture of Mazur). It will undoubtedly be a fundamental tool in future efforts to attack the conjecture of Birch and Swinnerton-Dyer.

B Perrin-Riou (Paris) gave a series of lectures on her new formulation of the main conjectures of Iwasawa which are valid for all primes (and not just the good ordinary primes), both for elliptic curves and more generally for motives. She also raised tantalising questions about the p-adic L-functions of elliptic curves by combining her ideas with those of Kato.

R Taylor (Cambridge) lectured on his deep new results which attach Galois representations to automorphic forms for GL_2 of imaginary quadratic fields. In particular, he deduced for the first time (avoiding trivial situations which arise from curves defined over $\mathbb{Q}$ or with complex multiplication) that certain elliptic curves defined over imaginary quadratic fields are also modular and so, in particular, one can analytically continue and prove the conjectured functional equation for their L-series. This is a very mysterious result because, unlike the case of elliptic curves over $\mathbb{Q}$, there

4.3 L-functions and Arithmetic

Approximately 60 mathematicians were long term official participants in the programme, although this figure could easily have been increased by 50% had resources and space been available at the Newton Institute. Indeed, the Institute did all it could to help the Organisers accommodate as many participants as possible, and the Organisers wish to express their warm gratitude to the Deputy Director and his staff for their efforts on these difficult practical problems. In an effort to help research students and young mathematicians from outside Cambridge to benefit from the programme, the Department of Pure Mathematics and Mathematical Statistics provided overcrowded office space in its basement and the use of its facilities to about 12 unofficial participants. The countries of origin of those attending was very varied, but the vast majority came from France, Germany, Japan, the United Kingdom, and the United States. At nearly all seminars in the programme, over 40 mathematicians were present.

The overall plan for the scientific programme was to have on the one hand a large number of concentrated periods with many lectures per day (4 workshops, lasting $3\frac{1}{2}$ weeks in total, and an Instructional Course lasting 2 weeks), and on the other hand to keep the remaining time relatively free of formal lectures (2 or 3 seminars per week) to allow maximal time for informal discussions amongst participants. In addition, the London Mathematical Society kindly offered the Organisers the possibility of holding a Spitalfields Day, and this was held on Friday, 28 May, with lectures by S Bloch, B Mazur, K Ribet and V Kolyvagin (and a visit by Professor Mordell's ghost!).

The Organisers were particularly happy with the full participation of United Kingdom number theorists in the programme. The Institute paid the full salaries for several months of A Scholl (Durham) and M Taylor (UMIST), and subsistence for long term visits by B Birch (Oxford), C Bushnell (King's, London), R Heath-Brown (Oxford), R Vaughan (Imperial). In addition, the Organisers wrote to almost every active researcher in number theory in the United Kingdom offering assistance with travel and subsistence for up to 5 days to participate in the programme, and this offer was almost universally accepted. Nine British research students from outside Cambridge were offered bursaries of £300 each to attend the Instructional Course. Finally, three promising young British number theorists currently working in the United States (N Boston, Illinois; A Granville, Georgia; T Wooley, Ann Arbor) were provided with funding for visits of several months each.

The Organisers are extremely grateful to the Director, the Deputy Director, and the staff of the Institute both for making the programmes possible, and for creating an Institution which can only be described as remarkable by the highest international standards.

Fermat's Last Theorem. In his historic three lectures on 21, 22 and 23 June during the workshop on *p-adic Galois representations, Iwasawa theory, and the Tamagawa numbers of motives*, A Wiles outlined his proof of the Taniyama–Weil conjectures for semi-stable elliptic curves over $\mathbb{Q}$ (*ie* those curves whose reduction at the bad primes is always of multiplicative type). It had been known since the mid-1980's, thanks to the work of G Frey and K Ribet, that this result would imply Fermat's last theorem. Thus, the solution of Fermat's last theorem had at last been found via the broad conceptual framework linking the arithmetic of elliptic curves to L-functions and automorphic forms. While there are a number of difficult technical problems concerning the diophantine geometry of modular curves in Wiles' proof, the simplicity of the structure of the argument was immediately apparent to his audience. The heart of the proof is Wiles' use of B Mazur's theory of p-adic deformations of Galois representations to reduce the Taniyama. Weil conjecture to the Tamagawa number conjecture for the motive attached to the symmetric square of a modular form. Happily, this latter conjecture had been studied by M Flach in his 1990 Cambridge PhD thesis. Flach had already shown the key result that the generalised Tate-Shafarevich group attached to the motive was finite, and indeed that it was annihilated by its conjectural order. Wiles explained his ingenious strengthening of Flach's method, which enabled him to establish the full Tamagawa number conjecture in the cases he needed. Needless to say, a major milestone had been reached in the efforts of many number theorists over the last 30 years to understand conjectures whose beauty and mystery had beguiled all who had studied them. It was particularly appropriate that many is no associated modular algebraic variety, but instead a 3-dimensional non-algebraic manifold. The work is a breakthrough on this important question, and perhaps the most striking, arithmetic application to date of Langlands' philosophy.

Instructional Course. One of the most successful activities of the programme was the Instructional Course on the Langlands' Philosophy, which was held from 15-27 February (see attached schedule of lectures). The detailed schedules of the lectures and the overall planning for the Course were carried out by Richard Taylor, and the Organisers wish to thank him for the magnificent job he did. After bitter experiences at earlier conferences on this theme, the Organisers adopted the policy that no lecturer should be an expert in the subject (this was relaxed slightly to allow J-P Labesse to give 3 lectures on his recent simplified proof of the Fundamental Lemma). There was universal agreement that this policy worked remarkably well. Over 60 people began the Course, and about 40 were still present at the final lecture, 13 days and 48 lectures later. The best thing about the Course was the enthusiastic participation by many research students. The Institute offered 10 bursaries of £300 each to assist United Kingdom research students to attend. In addition, a good number came from Europe, and even several from Harvard and Princeton. The Organisers have since been inundated with requests from publishers to produce a written version of the Course. While there is no question that the detailed preparation of such a course is very time consuming for those involved, we believe that this type of activity can be carried out very successfully at the Newton Institute, and we hope subsequent programmes will follow our example.

Workshops. The aim of the workshops was to provide concentrated periods, usually with 4 lectures a day, on specific areas of research. These were open for anyone to attend, with the Institute providing modest financial help to some of the external participants. These were very well attended, and the overall policy seems to have worked well. The only error in the organisation was to have two workshops in successive weeks near Easter, which resulted in too heavy a schedule of lectures for the long term participants. The titles and dates of the workshops were as follows:

5-9 April. *Motives attached to automorphic forms* (organised by R Taylor and D Blasius).

12-16 April. *L-functions and classical problems* (organised by B Birch and R Heath-Brown).

27-28 April. *Galois modules* (organised by M Taylor).

21-25 June. *p-adic representations, Iwasawa theory, and the Tamagawa numbers of motives* (organised by S Bloch, J Coates and JM Fontaine).

4.4 Epidemic Models *(January to June 1993)*

Report from the organisers:

B Grenfell (Cambridge), V Isham (UCL, London), D Mollison (Heriot-Watt).

Introduction. The aim of this programme was to bring together individuals with a wide range of mathematical expertise (including applied probability, deterministic modelling, and data analysis) and with close involvement in applied fields across the social, medical and biological sciences, to address a wide variety of challenging mathematical problems arising in understanding and controlling the spread of disease.

In the last few years there has been much progress in diverse areas of epidemic modelling, particularly with regard to the treatment of heterogeneity, both between individuals and in the mixing of subgroups of the population. At the same time, better data sets and improved data analysis techniques have become available, and there have been exciting developments in relevant theory, ranging from random graphs and spatial stochastic processes to the structural stability of difference and differential equations.

The objective of the programme was to build upon and extend this progress in specific areas by interdisciplinary cooperation aimed at elucidating relations between the widely varying types of model that have been found useful, so as to determine their strengths and limitations in relation to basic aims such as understanding, prediction, and evaluation and implementation of control strategies. Such inter-disciplinary work could be expected to make major contributions to the modelling of a wide range of human, animal and plant diseases, as well as to general biomathematical theory. Some of the more immediate outcomes of the programme are outlined in the following section.

There were 44 long-term participants of the Epidemic Models programme who spent periods of at least one month and up to six months at the Institute. These were augmented by large numbers (about 200) of those who spent shorter periods of time there, mostly taking part in one or more of the intensive workshops. The first of these, held in the first week of the programme at the beginning of January, was a NATO Advanced Research Workshop: *Epidemic Models: Their Structure and Relation to Data.* The aim of this workshop was to bring those involved up to date with current research in different disciplines and to identify common issues and outstanding problems.

Over a three week period from mid-March to early April, three separate workshops were held on distinct (and more specialised) topics, though with some participants in common. The first of these, *Ecology of Infectious Diseases in Natural Populations* was partially funded by NERC and AFRC. The third workshop, *Models for Infectious Human Diseases* benefited from the support of the Wellcome Trust, which also funded successful visits by a number of research workers from developing countries to enable them to take part in the programme. Both of these two workshops attracted large numbers of active participants. In between these two highly intensive weeks, a smaller-scale one-day meeting *Network Models and Epidemiology* was held.

Detailed programmes of all the workshops are contained in §5.6. The proceedings of the NATO ARW and the two major workshops outlined in the previous paragraph are being published in three separate volumes by Cambridge University Press in the Institute Series.

Throughout the six months of the programme, regular research seminars and lectures were given at the Institute by programme participants and other invited speakers. These were advertised, and often attended by members of related groups in Cambridge (especially the Statistical Laboratory and the MRC Biostatistics Group with both of which close working links were established) and elsewhere. An instructional course of eight double lectures on various aspects of epidemic models was given, particularly aimed at postgraduate students of mathematics and statistics in Cambridge.

The programme ended with a Royal Statistical Society Discussion Meeting *Epidemics: Models and Data* held at the Institute. This was a public meeting with invited and contributed discussion contributions following the main paper. The paper and all the following discussion will appear in Series A of the Society's Journal.

In addition to all the formal activities of the programme outlined above, and arguably the most important part of the whole six months, was the opportunity that the programme provided to bring together people involved in tackling a broad range of problems across a variety of disciplines but all of them involved in using mathematical models for the spread of disease. Mathematicians have had their knowledge of the practical problems increased substantially while the applied practitioners have become more aware of the possibilities that rigorous mathematical studies can provide. Informal discussions were almost always in progress among small groups of participants centred on the blackboards with which the Institute is liberally endowed, and many collaborations have been initiated which will continue to advance understanding and contribute to the control of human, other animal and plant diseases.

The excellent environment for stimulating research collaboration, provided by the Isaac Newton Institute both in terms of its architecturally carefully designed and well-equipped building and in the congenial atmosphere generated by its invariably helpful and friendly administrative staff, have contributed immeasurably to the success of the Epidemic Models programme. We are most grateful to the Director and staff of the Institute for the opportunity to hold the programme and for the facilities which have been afforded to us.

Theoretical challenges in epidemiology. Epidemiology is one of the most important and fast-growing branches of applied ecology. As well as its importance in specific applications, the area provides significant fundamental challenges to mathematics. Epidemics occur at all scales, from the global population, through the individual level, right down to the behaviour of the immune system. The resulting dynamical systems are characteristically highly nonlinear, stochastic and subject to natural selection. The corresponding mathematical problems concern both the structure of models that are needed to describe this dynamical diversity, and also the modelling and statistical methods required to deal with heterogeneity, in space, time, social contact and so on. A third, vital and complementary area of work is the adaptation of developments in these areas to particular applied problems.

The Epidemic Models programme has made significant progress in all these areas, as described under the following headings.

Model structure. The crucial dichotomy in epidemic modelling has been between stochastic and deterministic approaches. A major thrust of the programme has been to synthesise these two strategies. The spread of disease through a population is inherently a discrete stochastic phenomenon. Nevertheless, for suitably large populations, acceptable approximations may often be obtained by treating the integer-valued variables as varying continuously, and assuming that the actual changes of state occurring are simply the expected changes given the current state of the system. In simple epidemic models, with homogeneous populations and homogeneous mixing, the possibility of a large outbreak of cases depends simply on whether or not the *basic reproductive ratio*, R_0, which is defined as the mean number of infectious contacts made by an infective introduced into an uninfected population, exceeds unity. This idea has been extended significantly during the programme by J Heesterbeek and M Roberts, who have used deterministic models to generalize R_0 to non-autonomous systems, and J Jacquez who has looked at the connection between R_0 for the population as a whole and those values within heterogeneous subgroups.

Clearly, such deterministic approaches will not give good approximations when the values of any of the integer-valued variables involved become small, so that the corresponding subpopulations become close to extinction. Also such models can only predict an approximation to the mean behaviour of the system and give no idea of the shape of the probability distribution about that mean, even when many sources of variability are incorporated into the models. The problem of combining the tractability of deterministic models and the more accurate representation of uncertainty of stochastic approaches is particularly acute for macroparasitic worms. For these important parasites of human and animal populations, the intensity of infection (and its variability) are the important quantities. K Dietz, B Grenfell and V Isham have developed tractable approximations to stochastic models to address these problems. The resulting formulations (which were introduced in several seminars during the programme), promise significant advances in modelling immunoepidemiology and the impact of parasite control strategies.

Important technical progress has also been made in studying the shape of the final size distribution for stochastic SIR epidemics (F Ball, I Nåsell), on the strong convergence of epidemic processes to a limiting branching process (F Ball, P Donnelly), on the use of hidden Markov models to model the natural history of HIV (I Longini, S Richardson), on the use of frailty models in modelling vaccine efficacy (A Svensson, I Longini) as well as a number of theoretical developments in modelling host and parasite heterogeneity (A Dobson, J Heesterbeek, M Roberts).

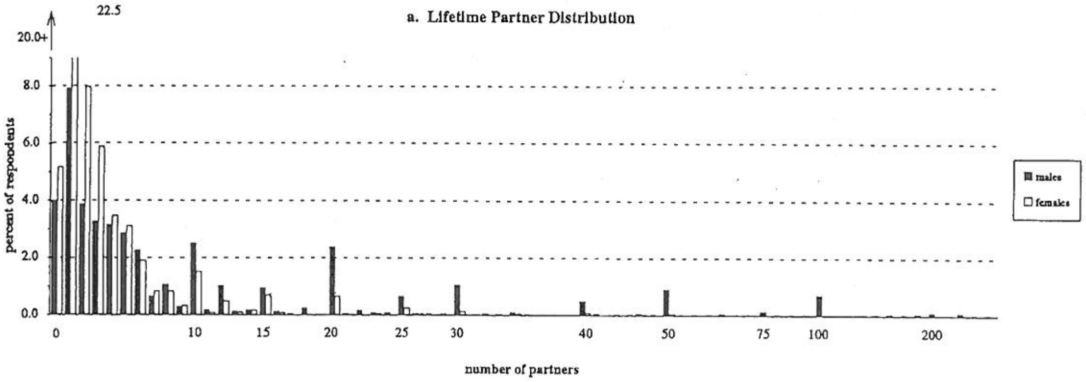
Heterogeneity. This is both the central problem and chief fascination of epidemiology. It is vital for successful modelling to take appropriate account of both *population heterogeneity*, that is, variations between individuals in parameters such as their contact rate or susceptibility, and *heterogeneity of mixing*, that is, how the pattern of contacts depends on spatial location or on the connectivity of social networks. Heterogeneity is also often the cause of non-stationary epidemic behaviour, for example, the seasonal aggregation of children in schools which causes nonlinear (and possibly chaotic) behaviour in measles dynamics.

Population and mixing heterogeneity often march together. The fundamental theoretical problem is how to represent the effects of individual behaviour on aggregate dynamics accurately but parsimoniously. A fruitful approach here has been the application of random graph theory, which was the subject of a 1 day workshop organized by M Morris and L Sattenspiel. Progress on modelling contact structures has been made particularly by M Altmann and M Morris, linking random graph formulations to attribute-mixing models, and also by C Castillo-Chavez, with regard to the rôle of social structures in a variety of applied problems. D Mollison, F Ball and G Scalia-Tomba approached the heterogeneity problem by modelling hierarchies of mixing within and between families; a random graph formulation is illuminating for this situation as well.

Another key source of heterogeneity is the spatial arrangement and movement of hosts and their parasites. This was a major preoccupation of the programme, with a number of symposium and workshop contributions and associated manuscripts. L Sattenspiel and K Dietz made a significant contribution to the linkage of spatial models and data for human diseases by clarifying the relationship between the average degree of cross contact between centres and the resulting matrix of spatial cross infection rates. More empirically, D Nychka and B Grenfell explored the observed dynamics of measles in England and Wales, in terms of local deviations from an overall attractor, describing the aggregate dynamics.

There was also technical progress by S Ellner in developing methods to detect evidence of chaos, and other nonlinear effects, arising from seasonal forcing of measles dynamics. He approached the problem by using 'smart embedding' techniques to combine models and nonparametric nonlinear time series methods. Preliminary results from the resulting framework indicate significantly improved predictability and promise to shed more light on the measles/chaos debate.

Applications. Many of the above theoretical developments are directly relevant to problems relating to real world diseases. There was new applied work on a variety of human infections (based around the Human Diseases workshop): notably malaria (S Richardson and I Longini), polio (M Eichner), Chagas' disease (J Velasco), Leishmaniasis (C Dye) and, of course STDs, notably AIDS (A Cairns, J Jacquez, I Longini, S Richardson). In the latter case, M Morris's finding that the discrepancy between total male and female reporting rates from sexual surveys can be attributed to the tail of the male distribution is important, both theoretically and in terms of future survey design.



Lifetime Distribution of Reported Sexual Partners for Males and Females
from *Telling tails explain the discrepancy in sexual partner reports* by M Morris

Diseases of animal and plant populations are a relatively neglected field theoretically and so were a special focus of the programme. This work was centred around a successful workshop and the associated volume will provide the first major synthesis in this area. Longer term developments during the programme were significant in the theory of parasite competition (M Roberts and A Dobson) and applied issues, such as the management of red grouse (P Hudson) and cattle (G Smith) in the face of parasitism, and vaccines and herd immunity(M de Jong). The use of stochastic processes to model the spread of disease in plants is a rather new area of application of epidemic models, being actively and successfully pursued by L Billard.

Communication. As intended, this programme was highly interdisciplinary, bringing together mathematicians, social scientists, biologists and veterinary and medical clinicians. Apart from the basic scientific progress noted above, we hope that the resulting improvement in communication will have a lasting effect on the field. The initial epidemic of cross-field collaboration augurs well for this.

5. Annexes

5.1 Visiting Members 1992-93

Low Dimensional Topology and Quantum Field Theory

Participant	**Nationality**	**Residence**	**Home Institution**	**Visits**
Baxter, RJ	UK	Australia	Australian National Univ, Canberra	15 Jul - 14 Oct
Belavin, A	Russian	Russia	Landau Institute, Moscow	22 Nov - 4 Dec
Bernard, D	French	France	CEA, Service de Physique Théorique de Saclay	1 Sep - 13 Sep
Broda, B	Polish	Poland	Dept of Theoretical Physics, Univ of Lodz	1 Nov - 15 Dec
Cardy, J	UK	USA	Dept of Physics, Univ of California, Santa Barbara	15 Jul - 19 Dec
Cherednik, IV	Russian	USA	Dept of Maths, Univ of N Carolina at Chapel Hill	10 Aug - 14 Aug
Corrigan, EF	UK	UK	Dept of Math Sciences, Univ of Durham	15 Jul - 26 Aug, 6 Sep - 15 Dec
Da Costa, G	Irish	Eire	Dublin Inst for Advanced Studies	5 Aug - 17 Aug
Date, E	Japanese	Japan	Dept of Math Science, Univ of Osaka	19 Oct - 14 Nov
De Vega, HJ	French	France	LPTHE, Univ de Paris VII	15 Sep - 30 Sep, 15 Nov - 30 Nov
Di Francesco, P	French	France	CEA, Service de Physique Théorique de Saclay	1 Sep - 20 Sep
Dijkgraaf, RH	Dutch	Netherlands	Dept of Maths, Univ of Amsterdam	23 Nov - 15 Dec
Dorey, PE	UK	France	Theory Division, CERN, Geneva	15 Nov - 10 Dec
Dotsenko, V	Russian	France	LPTHE, Univ de Paris VII	19 Nov - 25 Nov
Eguchi, T	Japanese	Japan	Dept of Physics, Univ of Tokyo	1 Aug - 31 Oct
Evans, D	UK	UK	Dept of Maths & Comp Sci, Univ College, Swansea	6 Sep - 23 Sep
Fairlie, DB	UK	UK	Dept of Math Sciences, Univ of Durham	1 Oct - 15 Dec
Fateev, V	Russian	France	Univ of Paris VI-VII	25 Nov - 15 Dec
Feigin, B	Russian	Russia	Landau Institute, Moscow	22 Nov - 16 Dec
Felder, GSV	Swiss	Switzerland	Mathematik, ETH-Zentrum, Zürich	29 Aug - 26 Sep
Frenkel, I	American	USA	Dept of Maths, Yale Univ	23 Jul - 5 Sep
Garoufalidis, S	Greek	USA	Dept of Maths, Univ of Chicago	5 Aug - 25 Aug
Ginzburg, V	Russian	USA	Dept of Maths, MIT	11 Sep - 15 Sep
Goodman, FM	American	USA	Dept of Maths MLH, Univ of Iowa	15 Jul - 23 Aug
Gordon, CMcA	UK	USA	Dept of Maths, Univ of Texas at Austin	15 Jul - 15 Aug
Green, MB	UK	UK	Dept of Physics, QMW College, London	15 Jul - 15 Dec
Hull, CM	UK	UK	Dept of Physics, QMW College, London	16 Aug - 29 Aug, 1 Oct - 15 Dec
Itzykson, CG	French	France	CEA, Service de Physique Théorique de Saclay	2 Aug - 15 Aug
Jimbo, M	Japanese	Japan	Dept of Maths, Univ of Kyoto	1 Sep - 30 Sep
Jones, VFR	Australian	USA	Dept of Maths, Univ of California, Berkeley	1 Jul - 25 Jul
Kauffman, LH	American	USA	Dept of Maths, Univ of Illinois at Chicago	1 Jul - 25 Jul, 16 Aug - 12 Sep
Kearton, C	UK	UK	Dept of Math Sciences, Univ of Durham	15 Jul - 14 Aug, 2 Sep - 30 Sep
Killingback, TP	UK	Switzerland	Theory Division, CERN, Geneva	5 Jul - 1 Aug, 1 Nov - 30 Nov
Kirby, RC	American	USA	Dept of Maths, Univ of California, Berkeley	1 Jul - 30 Jul, 1 Sep - 16 Dec
Kirillov, AN	Russian	Russia	Math Inst (LOMI), St Petersburg	15 Sep - 31 Dec
Lickorish, WBR	UK	UK	DPMMS, Univ of Cambridge	15 Jul - 15 Dec

5.1 Visiting Members 1992–93

Mac Lane, S	American	USA	Dept of Maths, Univ of Chicago	20 Jul - 24 Jul
Masbaum, G	German	France	Univ de Paris VII	6 Jul - 15 Aug, 13 Oct - 15 Dec
Melvin, P	American	USA	Dept of Maths, Bryn Mawr College	15 Jul - 6 Aug, 1 Sep - 12 Dec
Miwa, T	Japanese	Japan	Research Inst for Math Sciences, Univ of Kyoto	5 Sep - 10 Sep, 20 Sep - 24 Oct
Moore, G	American	USA	Dept of Physics, Yale Univ	15 Jul - 23 Aug
Morava, J	American	USA	Dept of Maths, The Johns Hopkins Univ	15 Jul - 15 Dec
Morton, HR	UK	UK	Dept of Pure Maths, Univ of Liverpool	15 Sep - 15 Dec
Mussardo, G	Italian	Italy	SISSA, Trieste	30 Nov - 15 Dec
Nahm, W	German	Germany	Physikalisches Institut, Univ Bonn	8 Sep - 30 Sep
Ocneanu, A	American	USA	Dept of Maths, Pennsylvania State Univ	15 Jul - 15 Aug, 29 Aug - 31 Aug
Olive, DI	UK	UK	Dept of Maths & Comp Sci, Univ College, Swansea	15 Jul - 13 Sep, 24 Sep - 30 Nov
Ooguri, H	Japanese	Japan	Research Inst for Math Sciences, Univ of Kyoto	1 Sep - 21 Sep
Popa, S	American	USA	Dept of Maths, UCLA	15 Jul - 15 Aug
Ravanini, FGM	Italian	Italy	Inst of Physics, Univ of Bologna	15 Oct - 30 Nov
Reina, C	Italian	Italy	SISSA, Trieste	15 Nov - 27 Nov, 4 Dec - 11 Dec
Rosso, MR	French	France	Centre de Maths, Ecole Polytechnique, Palaiseau	1 Sep - 3 Oct
Saveliev, MV	Russian	Russia	Theory Div, Inst for High Energy Phys, Protvino	15 Oct - 15 Dec
Sklyanin, EK	Russian	Russia	Steklov Math Institute, St Petersburg	12 Sep - 15 Dec
Smirnov, FA	Russian	Russia	Steklov Math Institute, St Petersburg	15 Jul - 15 Dec
Temperley, HNV	UK	UK	Dept of Physics, Univ College, Swansea	31 Aug - 12 Sep
Thaddeus, M	American	UK	Math Institute, Univ of Oxford	26 Jul - 9 Aug
Thistlethwaite, MB	UK	USA	Dept of Maths, Univ of Tennessee	6 Jul - 27 Jul
Traczyk, P	Polish	Poland	Dept of Maths, Univ of Warsaw	15 Jul - 11 Oct
Turaev, V	Russian	France	Dept de Mathématiques, Univ Louis Pasteur	15 Jul - 10 Sep
Verlinde, H	Dutch	USA	Dept of Physics, Princeton Univ	21 Jul - 3 Aug
Viro, O	Russian	Russia	Leningrad State Univ	6 Jul - 19 Jul
Voiculescu, DV	Romanian	USA	Dept of Maths, Univ of California, Berkeley	15 Jul - 7 Aug
Weitsman, J	American	USA	Dept of Maths, Columbia Univ	15 Jul - 15 Dec
Wenzl, HG	German	USA	Dept of Maths, Univ of California, San Diego	15 Jul - 15 Aug
West, PC	UK	UK	Dept of Maths, King's College, London	7 Sep - 4 Oct, 7 Oct - 31 Oct
Witten, E	American	USA	School of Natural Sciences, IAS, Princeton	1 Jul - 11 Jul
Zuber, JB	French	France	CEA, Service de Physique Théorique de Saclay	1 Oct - 11 Oct

Dynamo Theory

Participant	Nationality	Residence	Home Institution	Visits
Anufriev, AP	Russian	Bulgaria	Geophysical Institute, Bulgarian Academy of Sciences	20 Sep - 19 Dec
Arnold, VI	Russian	Russia	Steklov Math Institute, Moscow	1 Sep - 20 Dec
Bayly, BJ	American	USA	Dept of Maths, Univ of Arizona	15 Jul - 2 Oct
Braginsky, SI	Russian	USA	Inst of Geophysics and Planetary Physics, UCLA	15 Jul - 30 Nov
Brandenburg, A	German	Denmark	Nordita, 2100 Copenhagen	1 Aug - 30 Nov
Busse, FH	German	Germany	Physikalisches Institut, Univ Bayreuth	1 Oct - 15 Oct
Childress, S	American	USA	Courant Inst of Math Sciences, Univ of New York	23 Sep - 1 Oct

5.1 *Visiting Members 1992–93*

Collet, PML	French	France	Centre de Physique Théorique, Ecole Polytechnique, Palaiseau	1 Sep - 24 Oct
Cupal, I	Czech	Czechoslovakia	Geophysical Institute, Prague	20 Sep - 19 Dec
Eltayeb, IA	Sudanese	Oman	Dept of Maths and Computing, College of Science, Sultan Qaboos Univ	15 Jul - 30 Aug
Fearn, DR	UK	UK	Dept of Maths, Univ of Glasgow	16 Aug - 2 Oct
Friedlander, S	American	USA	Dept of Maths, Univ of Illinois at Chicago	15 Jul - 30 Aug
Frisch, U	French	France	Observatoire de Nice	1 Sep - 30 Oct
Gailitis, A	Latvian	Latvia	Inst of Physics, Latvian Academy of Sciences	20 Sep - 19 Dec
Galloway, DJ	UK	Australia	School of Maths and Stats, Univ of Sydney	20 Sep - 19 Dec
Hollerbach, R	American	UK	Dept of Maths, Univ of Exeter	1 Nov - 30 Nov
Hughes, DW	UK	UK	Dept of Applied Math Studies, Univ of Leeds	1 Sep - 2 Oct
Kambe, T	Japanese	Japan	Dept of Physics, Univ of Tokyo	19 Sep - 8 Oct, 5 Nov - 18 Dec
Khesin, BA	Russian	USA	Dept of Maths, Yale Univ	20 Sep - 19 Dec
Kimura, Y	Japanese	USA	National Center for Atmospheric Research, Boulder, Colorado	20 Jul - 10 Oct
Knobloch, E	UK	USA	Dept of Physics, Univ of California	1 Jul - 20 Dec
Loper, DE	American	USA	Geophys Fluid Dynamics Inst, Florida State Univ	15 Jul - 19 Aug
Malkus, WVR	American	USA	Dept of Maths, MIT	2 Jul - 15 Jul, 21 Sep - 2 Oct
Moffatt, HK	UK	UK	DAMTP, Univ of Cambridge	15 Jul - 19 Dec
Pegoraro, F	Italian	Italy	Dept of Theoretical Physics, Univ of Turin	15 Jul - 9 Sep
Priest, ER	UK	UK	Dept of Math and Comp Sci, Univ of St Andrews	15 Jul - 15 Aug
Proctor, MRE	UK	UK	DAMTP, Univ of Cambridge	15 Jul - 20 Dec
Roberts, PH	UK	USA	Dept of Maths, UCLA	12 Sep - 26 Sep
Ruzmaikin, AA	Russian	Russia	ITP, Univ of California, Santa Barbara	15 Jul - 15 Oct
Shukurov, A	Russian	Russia	Physics Dept, Moscow State Univ	20 Sep - 1 Oct
Sokoloff, D	Russian	Russia	Physics Dept, Moscow State Univ	20 Sep - 19 Dec
Soward, AM	UK	UK	Dept of Maths and Stats, Univ of Newcastle	15 Jul - 19 Dec
Spiegel, EA	American	USA	Dept of Astronomy, Columbia Univ	20 Sep - 31 Oct
Vainshtein, SI	Russian	USA	Dept of Astron & Astrophys, Univ of Chicago	15 Jul - 30 Sep
Vergassola, M	Italian	France	Observatoire de Nice	1 Sep - 30 Oct
Vishik, MM	Russian	USA	Dept of Maths, Univ of Texas at Austin	15 Jul - 27 Aug
Weiss, NO	UK	UK	DAMTP, Univ of Cambridge	15 Jul - 20 Dec
Zhang, K	Chinese	UK	Dept of Maths, Univ of Exeter	15 Jul - 2 Oct
Zheligovsky, O	Russian	Russia	International Inst of Earthquake Prediction, Moscow	15 Aug - 19 Dec
Zheligovsky, V	Russian	Russia	International Inst of Earthquake Prediction, Moscow	15 Aug - 19 Dec

L-functions and Arithmetic

Participant	Nationality	Residence	Home Institution	Visits
Agboola, A	American	USA	Dept of Maths, Univ of California, Berkeley	13 Feb - 1 Mar
Antoniadis, JA	Greek	Greece	Dept of Maths, Univ of Crete	1 Jan - 31 Jan
Berthelot, P	French	France	IRMAR, Univ de Rennes	1 Jun - 30 Jun
Birch, BJ	UK	UK	Math Institute, Univ of Oxford	11 Jan - 10 Mar, 26 Mar - 30 Jun
Blasius, D	American	USA	Dept of Maths, UCLA	1 Apr - 28 Jun
Bloch, S	American	USA	Dept of Maths, Univ of Chicago	1 Apr - 30 Jun
Bombieri, E	Italian	USA	School of Maths, IAS, Princeton	1 Jun - 30 Jun

5.1 Visiting Members 1992–93

Boston, N	UK	USA	Dept of Maths, Univ of Illinois	3 Jan - 26 Jun
Bushnell, CJ	UK	UK	Dept of Maths, King's College, London	1 Apr - 23 Apr
Cassels, JWS	UK	UK	DPMMS, Univ of Cambridge	1 Jan - 30 Jun
Clozel, L	French	France	Mathématique, Univ de Paris-Sud	11 Apr - 25 Apr
Coates, JH	Australian	UK	DPMMS, Univ of Cambridge	1 Jan - 30 Jun
Colmez, P	French	France	DMI, Ecole Normale Supérieure, Paris	1 May - 31 May
Deninger, C	German	Germany	Fachbereich Mathematik, Univ Münster	15 Feb - 14 Apr
De Shalit, E	Israeli	Israel	Dept of Maths, Hebrew Univ, Jerusalem	1 Jun - 30 Jun
Fontaine, J-M	French	France	Mathématique, Univ de Paris-Sud	1 May - 30 Jun
Fröhlich, A	UK	UK	DPMMS, Univ of Cambridge	1 Jan - 30 Jun
Granville, A	UK	USA	Dept of Maths, Univ of Georgia	1 Jan - 30 Jun
Greenberg, R	American	USA	Dept of Maths, Univ of Washington, Seattle	1 May - 30 Jun
Hanamura, M	Japanese	USA	Dept of Maths, Univ of Chicago	15 Jun - 30 Jun
Haran, S	Israeli	Israel	Dept of Pure Maths, Technion, Haifa	15 Mar - 30 Jun
Harder, G	German	Germany	Math Inst der Univ Bonn	21 Mar - 10 Apr
Harris, M	American	USA	Dept of Maths, Brandeis Univ	1 Apr - 30 Apr
Harrison, M	UK	UK	Loughborough Inst of Technology	1 Jan - 30 Jun
Heath-Brown, DR	UK	UK	Math Institute, Univ of Oxford	1 Apr - 15 Jun
Henniart, G	French	France	Mathématique, Univ de Paris-Sud	3 Apr - 25 Apr
Hida, H	Japanese	USA	Dept of Maths, UCLA	29 Mar - 30 Apr
Ihara, Y	Japanese	Japan	Research Inst for Math Sciences, Univ of Kyoto	1 Jun - 29 Jun
Illusie, L	French	France	Mathématique, Univ de Paris-Sud	20 Jun - 26 Jun
Jannsen, U	German	Germany	Math Inst der Univ zu Köln	15 Feb - 14 Apr
Kato, K	Japanese	Japan	Dept of Maths, Tokyo Inst of Technology	15 Mar - 15 Apr
Kolyvagin, V	Russian	Russia	Steklov Math Institute, Moscow	1 May - 23 Jun
Kudla, SS	American	USA	Dept of Maths, Univ of Maryland	1 Apr - 30 Apr
Kurihara, M	Japanese	Japan	Tokyo Metropolitan Univ	4 May - 28 Jun
Labesse, J-P	French	France	DMI, Ecole Normale Supérieure, Paris	14 Feb - 28 Feb
Laumon, G	French	France	Mathématique, Univ de Paris-Sud	5 Apr - 17 Apr
Lichtenbaum, S	American	USA	Dept of Maths, Brown Univ	27 Mar - 4 Apr
Mazur, B	American	USA	Dept of Maths, Harvard Univ	1 May - 30 Jun
Messing, W	American	USA	School of Maths, Univ of Minnesota	1 May - 30 Jun
Mori, A	Italian	Italy	Dipartimento de Matematica, Univ di Torino	15 Feb - 6 Mar
Nelson, AM	Australian	Australia	School of Maths and Stats, Univ of Sydney	25 Jan - 30 Apr
Neukirch, J	German	Germany	Fakultät für Matematik, Univ Regensburg	1 Apr - 9 Apr
Perrin-Riou, B	French	France	Lab de Math Fondamentales, Univ Pierre et Marie Curie	1 Jun - 30 Jun
Ram Murty, M	Canadian	Canada	Dept of Maths and Stats, McGill Univ	15 Mar - 15 Apr
Ramakrishnan, D	Indian	USA	Dept of Maths, California Inst of Technology	22 Mar - 13 Apr
Rapoport, M	Austrian	Germany	Mathematik, Bergische Univ, Wuppertal	23 Mar - 17 Apr
Ribet, KA	American	USA	Dept of Maths, Univ of California, Berkeley	27 May - 30 Jun
Rubin, K	American	USA	Dept of Maths, Ohio State Univ	30 May - 26 Jun
Schmidt, C-G	German	Germany	Math Inst II, Univ Karlsruhe	22 Mar - 15 Apr
Schneider, P	German	Germany	Math Inst der Univ zu Köln	15 Feb - 8 Apr
Scholl, AJ	UK	UK	Dept of Math Sciences, Univ of Durham	20 Jan - 17 Apr
Swinnerton-Dyer, HPF	UK	UK	DPMMS, Univ of Cambridge	1 Jan - 30 Jun
Tate, J	American	USA	Dept of Maths, Univ of Texas, Austin	4 Jun - 18 Jun

Taylor, M	UK	UK	Dept of Maths, UMIST	15 Feb - 28 Feb, 20 Mar - 15 May
Taylor, RL	UK	UK	DPMMS, Univ of Cambridge	1 Jan - 30 Jun
Vaughan, RC	UK	UK	Dept of Maths, Imperial College, London	1 Feb - 30 Apr
Wach, N	French	France	Mathématique, Univ de Paris-Sud	1 May - 30 Jun
Wiles, A	UK	USA	Dept of Maths, Princeton Univ	7 Jun - 30 Jun
Wingberg, K	German	Germany	Math Institut, Univ Heidelberg	8 Mar - 8 Apr
Wooley, TD	UK	USA	Dept of Maths, Univ of Michigan	1 Mar - 30 Apr
Yui, N	Japanese	Canada	Dept of Maths and Stats, Queen's Univ, Kingston, Ontario	1 Jan - 31 Mar
Zhang, S	Chinese	China	Dept of Maths, Univ of Peking	15 Feb - 30 Jun

Epidemic Models

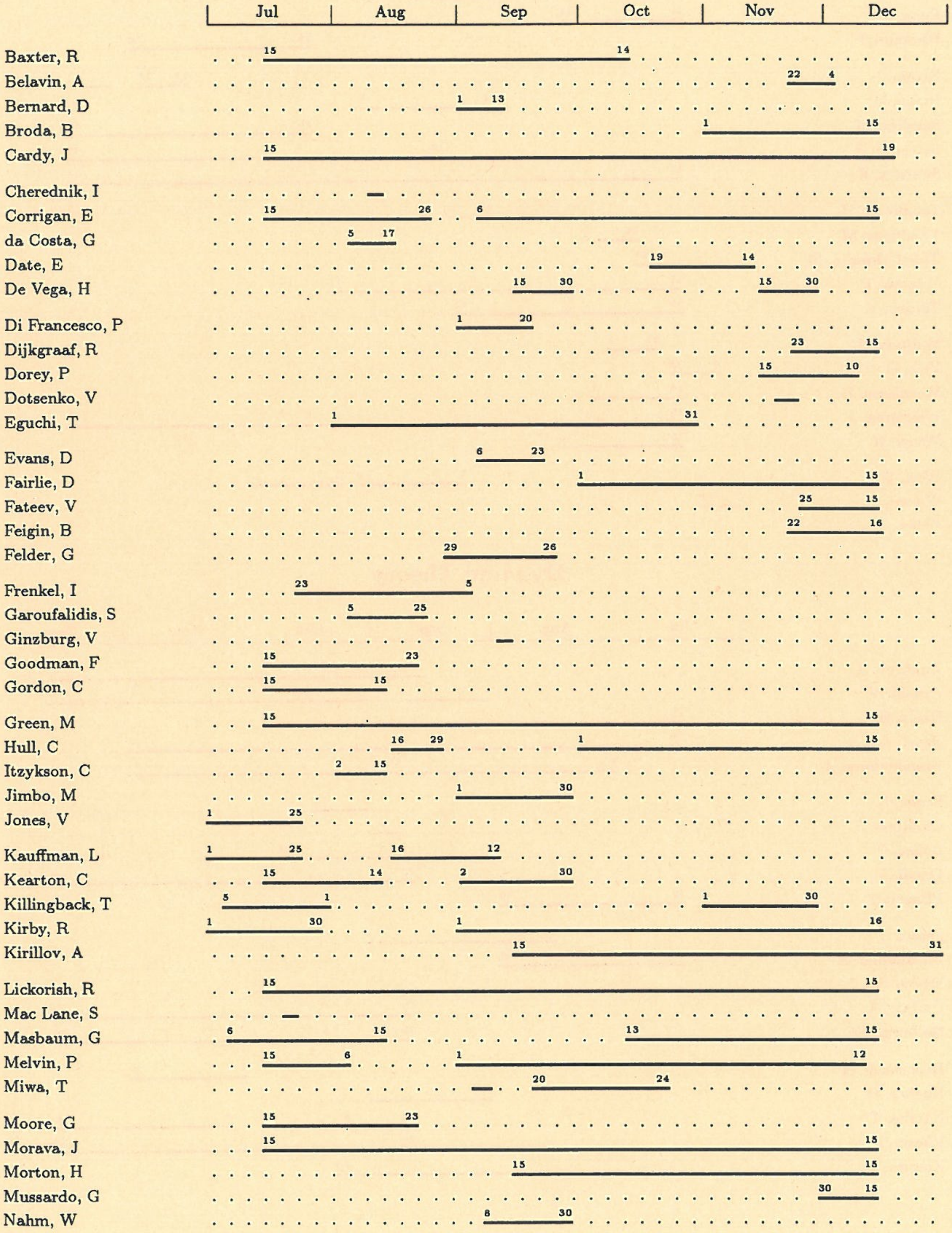
Participant	Nationality	Residence	Home Institution	Visits
Altmann, M	American	USA	UMHC, Minneapolis	3 Jan - 26 Jun
Awerbuch, T	American	USA	Harvard School of Public Health	21 May - 1 Jun
Azevedo Neto, RSd	Brazilian	Brazil	Dept of Pathology, Univ of Sao Paulo	14 Jan - 28 Feb
Bailey, NTJ	UK	Switzerland	Retired	2 Jan - 10 Jan, 21 Mar - 2 Apr, 17 Jun - 25 Jun
Ball, FG	UK	UK	Dept of Maths, Univ of Nottingham	15 Feb - 26 Jun
Barradas, I	Mexican	Mexico	Cent de Investigación en Matematicas, Guanajuataro	15 Mar - 14 Apr
Becker, NG	Australian	Australia	Dept of Stats, La Trobe Univ	2 Jan - 28 Jan
Billard, L	Australian	USA	Dept of Stats, Univ of Georgia	3 Jan - 30 Jun
Cairns, A	UK	UK	Dept of Actuarial Maths and Stats, Heriot-Watt Univ	15 May - 12 Jun
Castillo-Chavez, C	American	USA	Biometrics Unit, Cornell Univ	2 Jan - 18 Jan, 20 May - 12 Jun, 26 Jun - 30 Jun
De Jong, MCM	Dutch	Netherlands	Central Veterinary Institute, Lelystad	1 Jan - 30 Apr
De Zoysa, APK	Sri Lankan	Sri Lanka	Open Univ, Sri Lanka	1 Apr - 30 Apr
Dietz, K	German	Germany	Inst für Medizinische Biometrie, Univ Tübingen	1 Jan - 30 Jun
Dobson, A	UK	USA	Ecology and Evolutionary Biology, Princeton Univ	1 Jan - 31 Jan, 1 Mar - 15 Apr, 1 Jun - 30 Jun
Donnelly, P	Australian	UK	School of Math Sciences, QMW College	17 May - 21 May, 13 Jun - 18 Jun
Dye, CM	UK	UK	School of Hygiene and Tropical Medicine, London	3 Jan - 30 Apr
Eichner, M	German	Germany	Inst für Medizinische Biometrie, Univ Tübingen	1 May - 31 May
Ellner, SP	American	USA	Dept of Stats, N Carolina State Univ	2 Jan - 31 Jan
Grenfell, BT	UK	UK	Dept of Zoology, Univ of Cambridge	1 Jan - 30 Jun
Halloran, ME	American	USA	Emory Univ School of Public Health, Atlanta	3 Jan - 9 Jan
Hasibeder, G	Austrian	Austria	Abteilung für Mathematische Biologie, Technische Univ Wien	1 Feb - 31 May
Heesterbeek, JAP	Dutch	Netherlands	Isaac Newton Institute, Univ of Cambridge	2 Jan - 26 Jun
Heiderich, KR	Canadian	Canada	Biometrics Unit, Cornell Univ	2 Jan - 18 Jan
Hethcote, HW	American	USA	Dept of Maths, Univ of Iowa	12 Mar - 12 Apr
Hudson, P	UK	UK	The Game Conservary, Newtonmore, Aviemore	1 Mar - 31 Mar
Isham, VS	UK	UK	Dept of Statistical Science, Univ College, London	1 Jan - 30 Jun

5.1 Visiting Members 1992–93

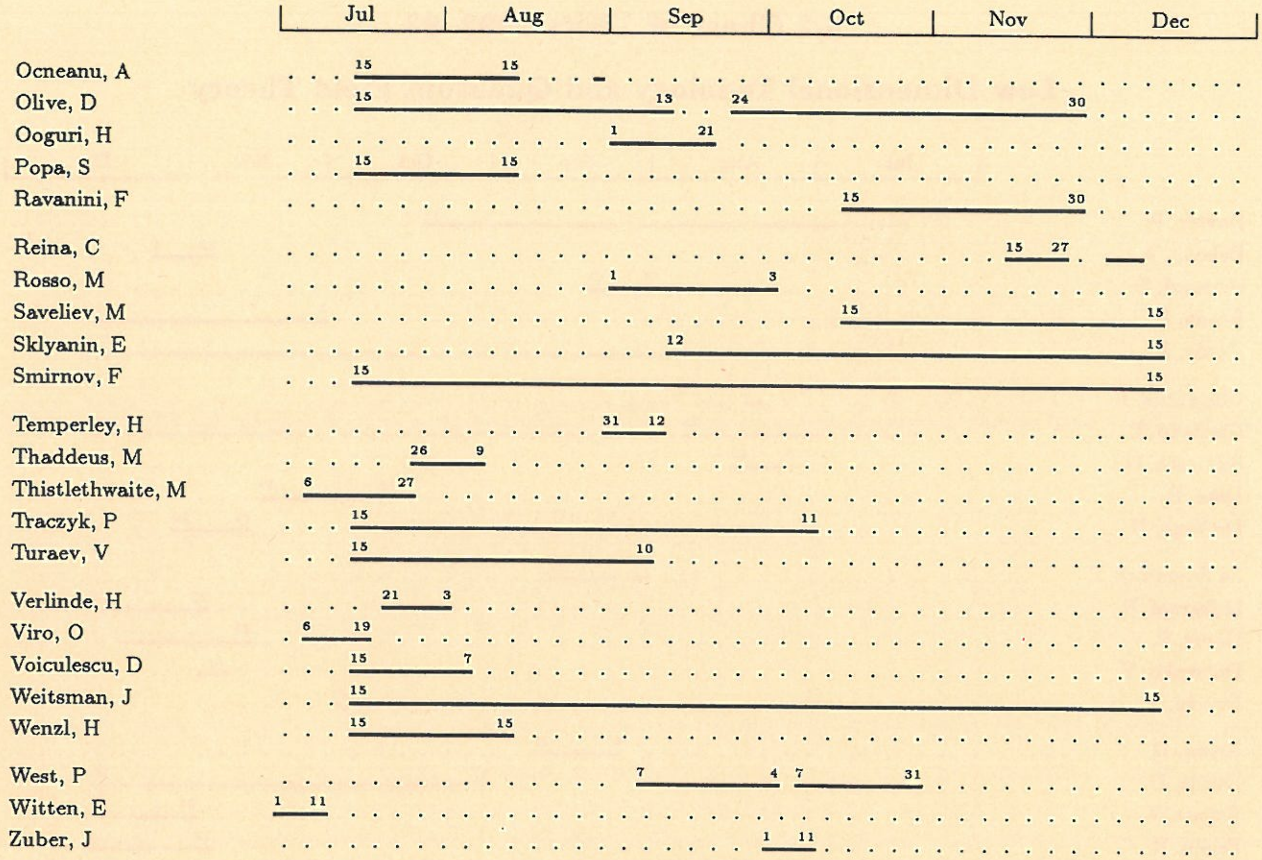
Jacquez, JA	American	USA	Dept of Physiology, Univ of Michigan	1 Mar - 15 Apr, 7 Jun - 25 Jun
Longini, IJM	American	USA	Biostatistics Division, Emory Univ	1 Jan - 5 Feb, 15 Mar - 15 Apr, 6 May - 30 Jun
Martin-Löf, A	Swedish	Sweden	Dept of Math Sciences, Univ of Stockholm	1 Jan - 30 Jun
Massad, E	Brazilian	Brazil	School of Medicine, Univ of Sao Paolo	18 Jan - 8 Mar
McLean, A	UK	UK	Dept of Zoology, Univ of Oxford	14 Mar - 2 Apr
Metz, J	Dutch	Netherlands	Inst of Theoretical Biology, Rijksuniversiteit Leiden	15 Mar - 26 Mar
Mollison, D	UK	UK	Dept of Actuarial Maths and Stats, Heriot-Watt Univ	1 Jan - 30 Jun
Morris, WM	American	USA	Dept of Sociology, Columbia Univ	1 Jan - 30 Jun
Nasell, EOI	Swedish	Sweden	Dept of Maths, Royal Inst of Technology, Stockholm	3 Jan - 21 Jun
Nychka, D	American	USA	Dept of Stats, N Carolina State Univ	1 Jun - 26 Jun
Richardson, ST	French	France	INSERM, Villejuif	13 Apr - 16 Apr, 19 May - 31 May
Roberts, MG	UK	New Zealand	Wallaceville Animal Research Centre, Upper Hutt	3 Jan - 26 Jun
Sattenspiel, L	American	USA	Dept of Anthropology, Univ of Missouri-Columbia	2 Jan - 26 Jun
Scalia-Tomba, G	Italian	Italy	Univ "La Sapienza", Rome	3 Jan - 16 Jan, 21 Mar - 3 Apr
Smith, G	UK	USA	School of Vet Med, Univ of Pennsylvannia	1 Mar - 30 Jun
Struchiner, CJ	Brazilian	Brazil	Oswaldo Cruz Foundation, Rio de Janeiro	16 Jan - 21 Mar
Velasco Hernandez, JX	Mexican	Mexico	Dept de Matematicas, UAM-Iztapalapa, Mexico	29 May - 12 Jun
Wolff, RC	UK	UK	Dept of Stats, Univ of Glasgow	21 Jun - 27 Jun

5.2 Chart of Visits 1992–93

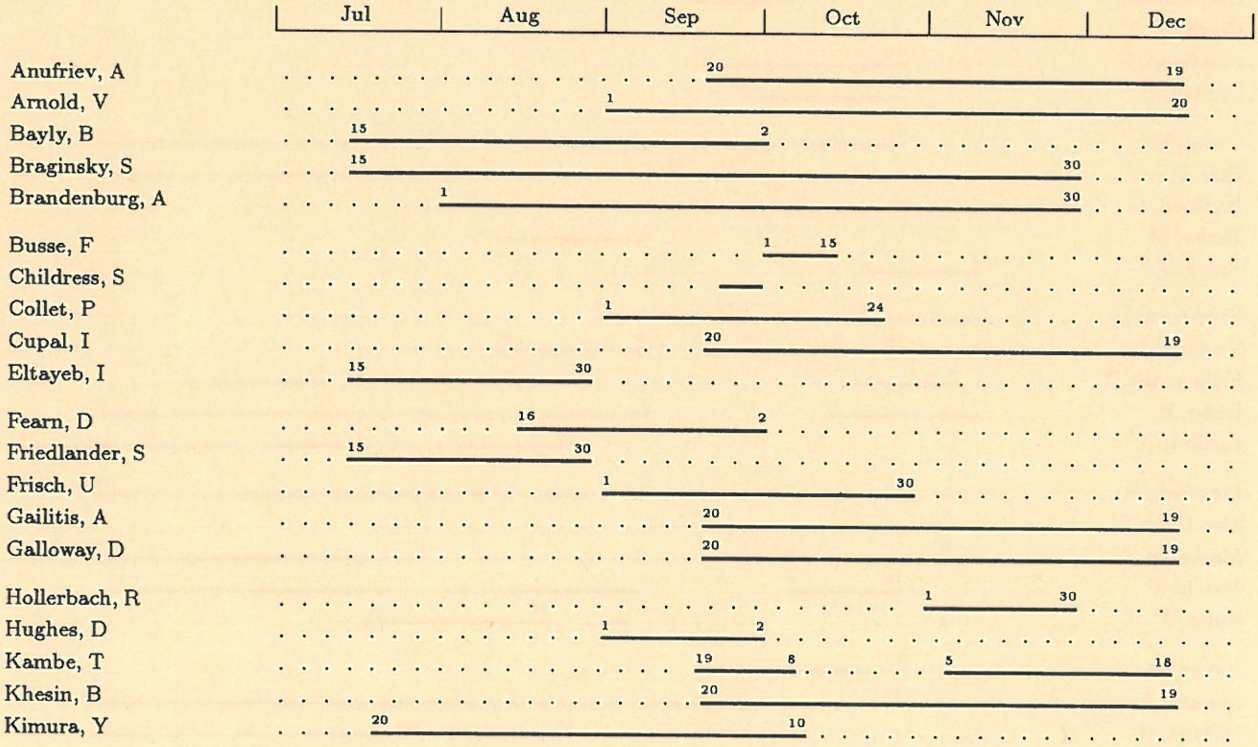
Low Dimensional Topology and Quantum Field Theory



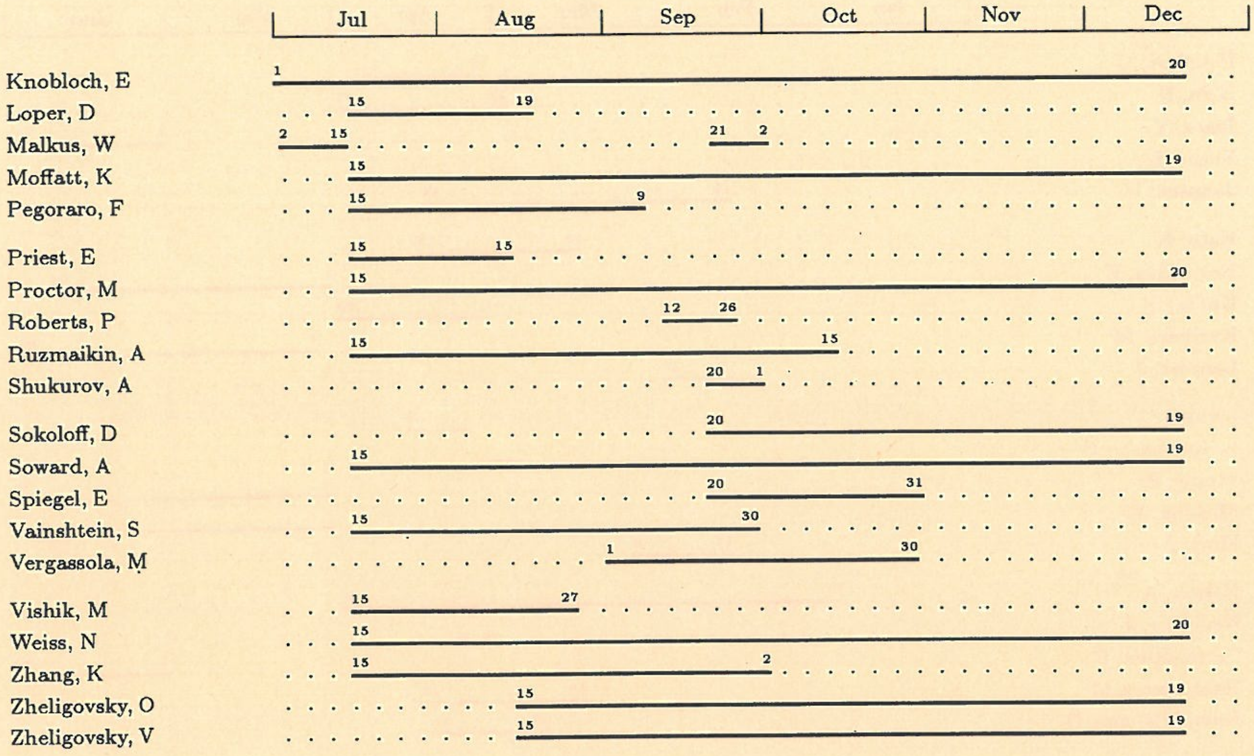
5.2 Chart of Visits: 1992-93



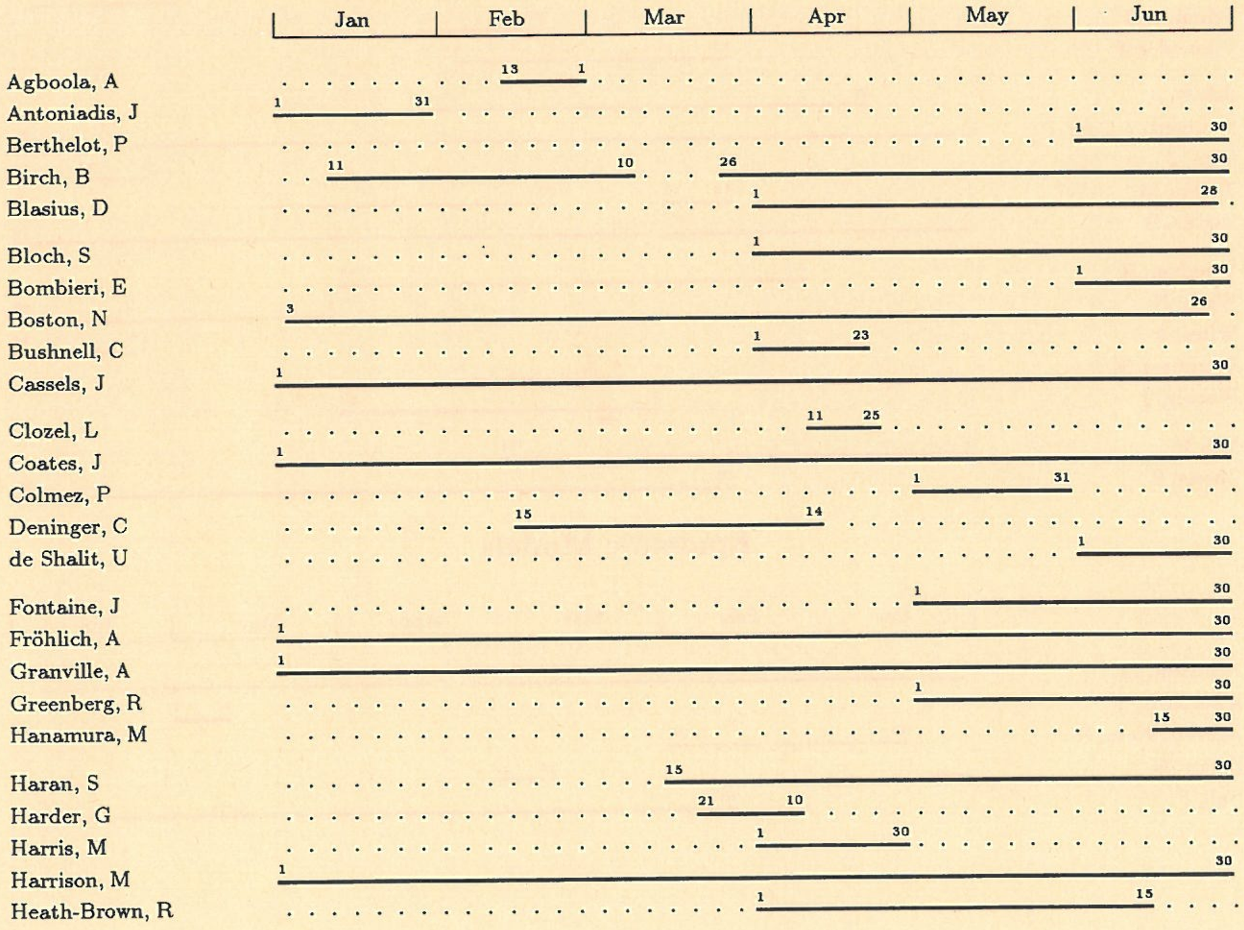
Dynamo Theory



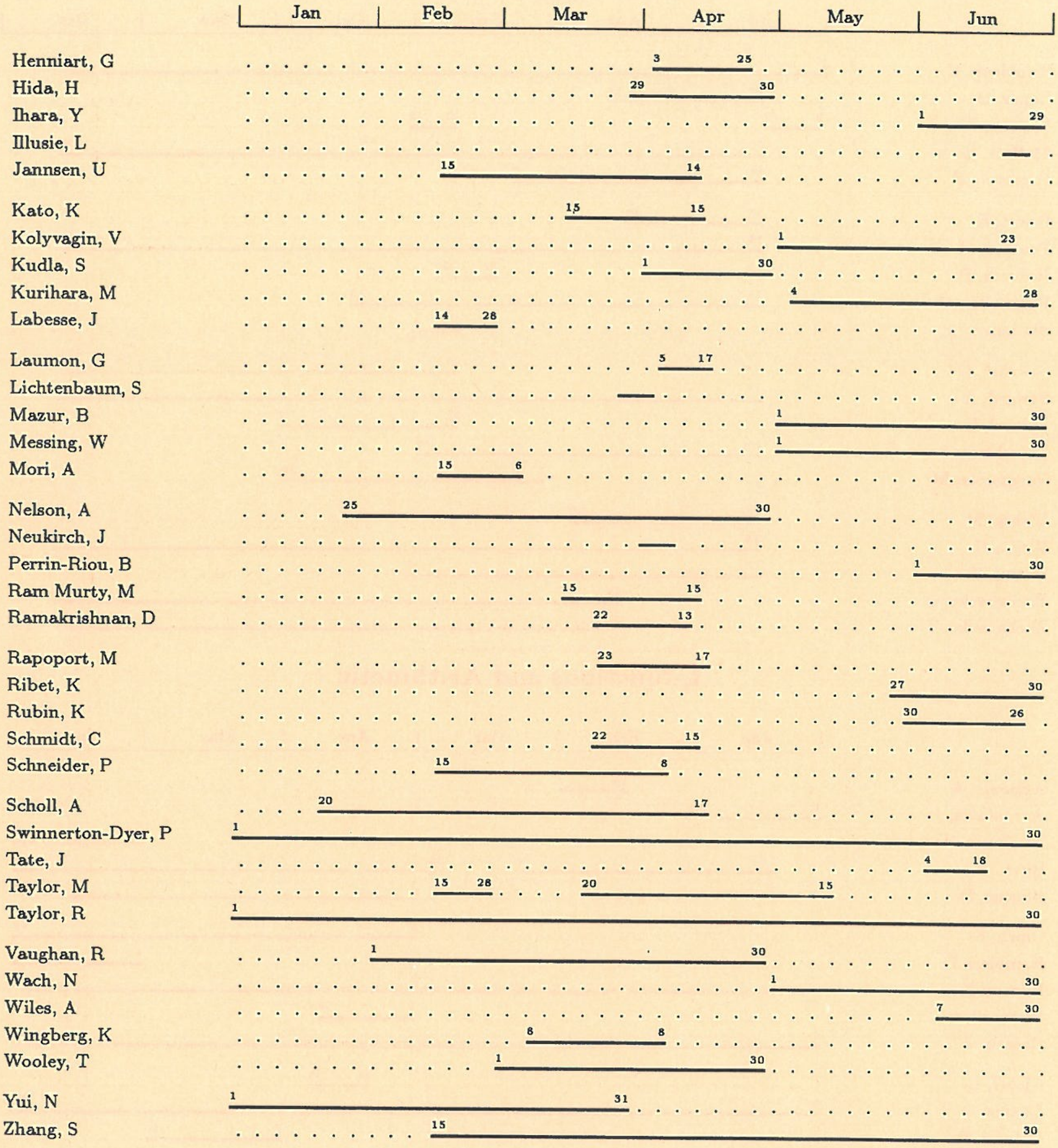
5.2 Chart of Visits: 1992-93



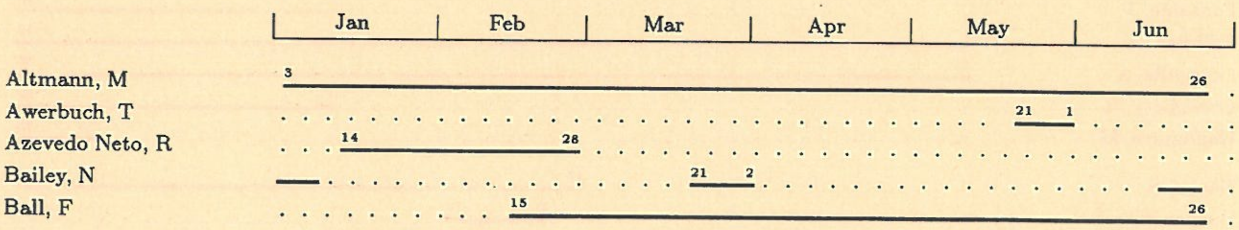
L-functions and Arithmetic



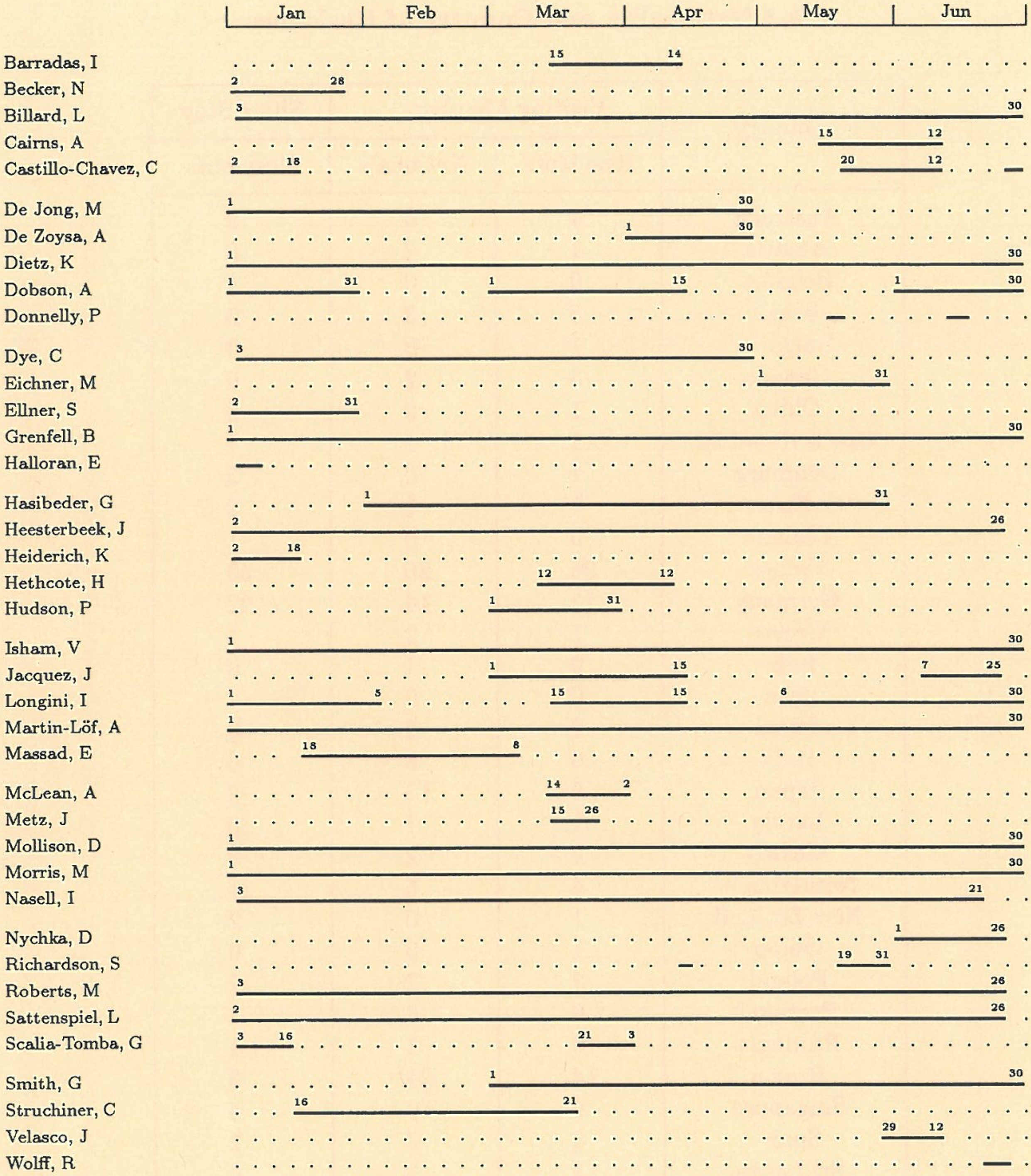
5.2 Chart of Visits: 1992-93



Epidemic Models



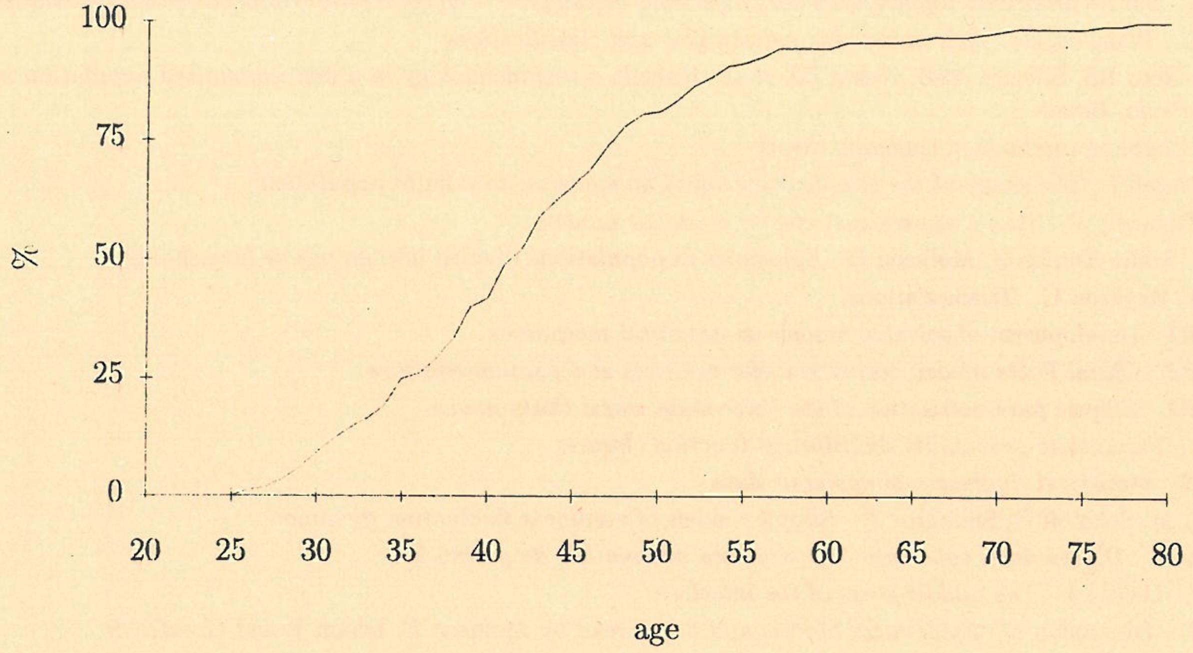
5.2 Chart of Visits: 1992-93



5.3 Nationality and Country of Residence

Country	Visiting Members		Short Stay
	Residents	Nationals	Residents
Australia	4	6	2
Austria	1	2	0
Belgium	0	0	1
Brazil	3	3	0
Bulgaria	1	0	0
Canada	3	2	0
China	1	2	0
Czech Republic	1	1	1
Denmark	1	0	3
Eire	1	1	2
Finland	0	0	1
France	26	20	33
Germany	12	14	22
Greece	1	2	1
India	0	1	0
Iran	0	0	1
Israel	2	2	0
Italy	6	8	6
Japan	9	13	2
Latvia	1	1	0
Mexico	2	2	0
Netherlands	4	5	17
New Zealand	1	0	2
Oman	1	0	0
Poland	2	2	2
Portugal	0	0	1
Rumania	0	1	1
Russia	14	24	3
Singapore	0	0	4
Spain	0	0	2
Sri Lanka	1	1	0
Sudan	0	1	0
Sweden	2	2	4
Switzerland	3	1	5
UK	43	55	321
USA	68	42	56
Total	214	214	493

5.4 Cumulative Frequency Graph of Ages of Visiting Members



5.5 Papers Produced by Visiting Members

Ahn C, Delfino G, Mussardo G *Mapping between the sinh-Gordon and Ising models*

Anufriev A, Cupal I *Taylor state and other types of solution*

Anufriev A, Cupal I, Hejda P *Taylor state, model Z and large dynamo numbers*

Anufriev A, Hollerbach R, Sokoloff D *Fractal properties of geodynamo models*

Arnold V *Sur les propriétés topologiques des projections lagrangiennes en géométrie symplectique des caustiques*

Arnold V *Plane curves, their invariants, perestroikas and classifications*

Azevedo Neto RS, Silveira ASB, Nokes DJ *et al* *Rubella seroepidemiology in a non-immunized population in Sao Paulo, Brazil*

Ball F *Coupling methods in epidemic theory*

Ball F, Nasell I *The shape of the size distribution of an epidemic in a finite population*

Ball F, Donnelly P *Strong approximations for epidemic models*

Ball FG, Scalia-Tomba G, Mollison D *Epidemics in populations divided into groups or households*

Bauer M, Itzykson C *Triangulations*

Baxter RJ *Development of solvable models in statistical mechanics*

Baxter RJ *Chiral Potts model: corner transfer matrices and parametrisations*

Baxter RJ *Elliptic parametrisation of the three-state chiral Potts model*

Bayly B *Parametric probability distribution function closures*

Becker N *Statistical challenges of epidemic data*

Belyanin M, Sokoloff D, Shukurov A *Simple models of nonlinear fluctuation dynamo*

Berthelot P $\mathcal{D}^{\dagger}_{\mathbf{Q}}$*-modules coherents I: Operateurs differentiels de niveau fini*

Billard L, Gentle J *The middle years of the interface*

Billard L *Discussion of "Epidemics: Models and data" read by Mollison D, Isham V and Grenfell B*

Billard L *Review of "Analytical population dynamics" by T. Royama*

Billard L, Dayananda PWA, Zhao Z *Epidemic plant diseases: A stochastic model of leaf and stem lesion growth*

Billard L, Zhao Z *Projecting the number of AIDS cases*

Billard L, Smith D *Homogeneity tests for grouping of AIDS patient classifications*

Billard L *Comment: Crowley and Reid Committee Reports on doubleblind refereeing*

Billard L, Summers AO, Wireman J *et al* *Mercury released from dental silver fillings provo kes an increase in mercury and antibiotic resistan t bacteria in the primate oral & intestinae flora*

Billard L, Zhao Z *A review and synthesis of the HIV/AIDS epidemic as a multi-stage process*

Billard L, Zhao Z *The stochastic general epidemic model revisited and a generalization*

Billard L, Zhao Z *Multiple stage nonhomogeneous Markov models for the AIDS epidemic*

Billard L *A different path to print*

Billard L, Dayananda PWA, Chakraborty S *Estimation of rate parameter and its relationship with latent and infectious periods in plant disease epidemics*

Billard L, Chakraborty S *Quantitative relationships between Collectotrichum gloeosporioides infection of Stylosanthes scabra and weather factors under field conditions*

Billard L, Kaluba J, Cooper T *A statistical remedy to gender and race based salary inequities*

Billard L, Meshkani MR *Estimation of a Markov chain*

Billard L *Case Studies in Biometry*

Bloch S *The moving lemma for higher chow groups*

Boston N *A refinement of the Faltings-Serre method*

Boston N *A programme parallel to that of Serre, Mazur, Ribet...*

Boston N, Ose DT *A function field analogue of Serre's conjecture*

5.5 Papers Produced by Visiting Members

Boston N, Dabrowski W *A problem on generation of finite groups*
Bouma A, De Jong MCM, Kimman TG *Experimental support for one type of mass-action assumption in epidemic models*
Braginsky S *The nonlinear dynamo and model-Z*
Brandenburg A, Krause A, Nordlund F *et al* *On the magnetic fluctuations produced by a large scale magnetic field*
Brandenburg A, Jennings A, Nordlund F *et al* *Magnetic structures in a dynamo simulation*
Brandenburg A *Simulating the solar dynamo*
Brandenburg A *Nonlinear dynamos: computational aspects*
Brandenburg A, Donner K, Moss D *et al* *Vertical magnetic fields above the discs of spiral galaxies*
Brandenburg A, Moss A, Reiutor M *et al* *Does the solar differential rotation arise from a large scale instability?*
Brandenburg A, Procaccia I, Segel D *et al* *Multifractality, near-singularities and the role of stretching in turbulence*
Broda B *A path-integral approach to polynomial invariants of links*
Cardy J, Mussardo G *Universal properties of self-avoiding walks from two-dimensional field theory*
Cardy J *Critical exponents of the chiral Potts model from conformal field theory*
Cardy J, Guttmann A *Universal amplitude combinations for self-avoiding walks, polygons and trails*
Castillo-Chavez C, Brauer F *Studies in theoretical epidemiology*
Castillo-Chavez C, Fridman S, Luo Xiaolong *Stochastic and deterministic models in epidemiology*
Castillo-Chavez C, Blythe SP, Busenberg S *Affinity in paired event probability*
Castillo-Chavez C *On the evolution of marriage functions: It takes two to tango*
Castillo-Chavez C, Velasco-Hernandez JX, Fridman S *Modeling contact structures in biology*
Castillo-Chavez C, Hsu-Schmitz SF *Parameter estimation in non-closed social networks related to the synamics of sexually-transmitted diseases*
Castillo-Chavez C, Velasco-Hernandez JX *Modelling vector-host disease transmission and food web dynamics through the mixing/pair formation approach*
Castillo-Chavez C, Fridman S, Hsu-Schmitz SF *Simulation studies on stochastic models with heterogeneously mixing contact structures*
Castillo-Chavez C, Li J, Huang W *Competitive exclusion in gonorrhea models and other sexually transmitted diseases*
Castillo-Chavez C, Hadeler KP *A core group model for disease transmission*
Chen I, Yui N *Singular values of Thompson series*
Cherednik I *The Macdonald constant term conjecture*
Cherednik I *The Macdonald conjecture*
Clune T, Knobloch E *Pattern selection in rotating convection with experimental boundary conditions*
Coates JH, McConnell G
Cohen P, Itzykson C, Wolfart J *Fuchsian triangle groups and Grothendieck dessins: variations on a theme of Belyi*
Corrigan E, Dorey PE, Sasaki R *On a generalised bootstrap principle*
Corrigan E *Toda's amazing lattice*
Corrigan E *Aspects of affine Toda field theory*
Cox DR, Isham V *Stochastic models for precipitation*
De Jong MCM, Diekman O, Heesterbeek JAP *The computation of R_0 for discrete-time epidemic models with dynamic heterogeneity*
De Jong MCM, Diekmann O, Heesterbeek JAP *How does transmission of infection depend on population size*
De Jong MCM *Vaccines and herd immunity: Consequences for vaccine evaluation*
De Jong MCM, Diekmann O, Heesterbeek JAP *How does transmission of infection depend on population size?*

5.5 Papers Produced by Visiting Members

De Vega H, Gonzalez Ruiz A *Boundary K-matrices for the six vertex and the* $n(2n-1)$ A_{n-1} *vertex models*

De Zoysa A, Mendis C, Gamage-Mendis A *et al* *A mathematical model for plasmodiumvivax malaria transmission: estimation of the impact of transmission-blocking immunity in an endemic area*

De Zoysa A *Mathematical simulation of vaccine trials on transmission blocking vaccines*

Di Francesco P, Itzykson C *A generating function for fat graphs*

Dickey J, Marcus S, Hide R *Global propagation of interannual fluctuations in atmospheric angular momentum*

Diekmann O, Heesterbeek JAP, Metz JAJ *The legacy of Kermack and McKendrick*

Dietz K *Some problems in the theory of infectious diseases: transmission and control*

Dietz K *Back calculations of German AIDS data using information of dates of tests*

Dijkgraaf R, Moore G, Plesser R *The partition function of two-dimensional string theory*

Dorey P *Hidden geometrical structures in integrable models*

Dorey P, Ravanini F *Generalising the staircase models*

Dubrulle B, Knobloch E *On instabilities in magnetized accretion disks*

Dye C, Williams B *Malnutrition, age and the risk of parasitic disease: visceral leishmaniasis revisited*

Dye C *Malnutrition, age and the mix of visceral leishmanniasis*

Dye C *The epidemiological context of vector control*

Dye C *Symmetries and linearities in the dynamics of indirectly-transmitted infections (or, does having a vector make a difference?)*

Eguchi T, Kanno H, Yang S-K W_∞ *algebra in two-dimensional black hole*

Eichner M, Hadeler K, Dietz K *Stochastic models for the eradication of poliomyelitis: minimum population size of polio virus persistence*

Eichner M, Zehnder S, Dietz K *An age-structured model for measles vaccination*

Eichner M, Dietz K, Hadeler KP *Deterministic models on the eradication of poliomyelitis: Vaccination with the inactivated (IPV) or attenuated (OPV) polio virus vaccine*

Eichner M, Dietz K, Hadeler KP *SIR and SIRS models under different assumptions concerning the survivorship function*

Eichner M, Dietz K *Stochastic models on the eradication of polio: Vaccination of newborn children with inactivated (IPV) or attenuated (OPV) polio virus vaccine*

Eichner M, Dietz K *Stochastic models on the eradication of polio- myelitis: Annual vaccination days with attenuated (OPV) polio virus vaccine*

Eichner M, Dietz K *Stochastic models on the eradication of polio- myelitis: Reintroduction of polio virus infection into a virus-free population*

Eichner M, Dietz K *Stochastic models on the eradication of polio- myelitis: Can ring vaccination successfully be applied against poliomyelitis and measles?*

Eichner M, Dietz K *Stochastic models on the eradication of polio- myelitis: How can one be sure whether polio virus has been extinguished?*

Eltayeb IA, Loper D *On the stability of vertical double-diffusive interfaces. Part 2: Two parallel interfaces*

Endquist K, Semikoz V, Shukurov A *et al* *The neutrino mass and the galactic magnetic field*

Evans D, Kawahigashi Y *The* E_7 *commuting squares produce* D_{10} *as principal graph*

Evans D, Kawahigashi Y *Subfactors and conformal field theory*

Evans D, Kawahigashi Y *From subfactors to 3-dimensional topological quantum field theories and back*

Fairlie D, Govaerts J *Linearisation of universal field equations*

Fearn DR *Magnetic instabilities in rapidly rotating systems*

Fearn DR *Nonlinear planetary dynamos*

Felder G *Topological representations of quantum groups and conformal field theory*

Felder G *The elliptic Knizhnik-Zamolodchikov equation*

Felder G, Grandjean O *On combinatorial three-manifold invariants*

5.5 Papers Produced by Visiting Members

Franco D, Reina C *A Borel-Weil-Bott approach to representations of* $sl_q(2, C)$

Franco D, Reina C *The geometry of the quantum corrcetion for topological* σ*-models*

Freeman M, West P W_3 *string scattering*

Frenkel I, Turaev V *Tensor categories*

Friedlander S, Gilbert A, Vishik M *Hydrodynamic instability for certain ABC flows*

Fring A, Mussardo G, Simonetti P *Form factors of the elementary field in the Bullough-Dodd model*

Gailitis A *Experimental aspects of a laboratory scale liquid sodium dynamo model*

Galloway DJ, O'Brian NR *Numerical calculations of dynamos for ABC and related flows*

Galloway DJ, Zheligovsky VA *On a class of non-axisymmetric fluxrope solutions to the electromagnetic induction equation*

Galloway DJ, Jones CA *Alpha-quenching in cylindrical magnetoconvection*

Gama S, Frisch U *Local helicity, a material invariant for the odd-dimensional Euler equations*

Gamage-Mendis A, Carter R, Mendis C *et al* *Clustering of malaria infections within an endemic population: risk of malaria associated with the type of housing construction*

Gemmell MA, Roberts MG *Modelling echinococcus life-cycles*

Gervais J-L, O'Raifeartaigh L, Razumov A *et al* *Gauge conditions for the constrained WZNW-Toda reductions*

Gilbert A *Fast dynamos based on cat maps and pseudo-Anosov maps*

Ginzburg V, Khesin B *Steady fluid flows and symplectic geometry*

Glendinning P *Three lectures on bifurcations and chaos*

Goldstein HF, Knobloch E, Mercader I *Convection in a rotating cylinder II: Linear theory for small Prandtl numbers*

Gordon C, Luecke J *Reducible manifolds and Dehn surgery*

Goto Y *On quotient surfaces in weighted projective spaces over finite fields*

Gouvea F, Yui N *"Brauer numbers" of twisted Fermat motives*

Gouvea F, Yui N *Observations on twisted Fermat motives of* $K3$*-type*

Gouvea F, Yui N *Arithmetic of diagonal hypersurfaces over finite fields*

Green M *The influence of world-sheet boundaries on critical closed string theory*

Greenhalgh D, Dietz K *The effect of different mixing patterns on vaccination programs*

Grenfell B, Dietz K, Roberts M *Modelling the immuno-epidemiology of macroparasites in wildlife host populations*

Grenfell BT, Dietz K, Roberts MG *Host age-structure and infection dynamics in macroparasites*

Heath-Brown DR *Odd perfect numbers*

Heath-Brown DR *The density of rational points on non-singular hypersurfaces*

Heesterbeek JAP, Roberts MG *Mathematical models for microparasites of wildlife*

Heesterbeek JAP, Metz JAJ *The saturating contact rate in epidemic models*

Heesterbeek JAP, Roberts MG *Threshold properties for helminth infections*

Hida H *On* Λ*-adic forms of half integral weight for* $SL(2)_{/\mathbf{Q}}$

Hida H *Geometric modular forms*

Hide R *Planetary magnetism re-visited: the eccentric magnetic fields of Uranus and Neptune*

Hide R, Dickey J *Earth's variable rotation*

Hide R *Fluctuations in the earth's rotation and the topography of the core-mantle interface*

Hide R, Clayton R, Hager B *et al* *Topographic core-mantle coupling and fluctuations in the earth's rotation*

Hollerbach R *Magnetohydrodynamic Ekman and Stewartson layers in a rotating spherical shell*

Hudson P, Dobson A *Transmission dynamics of Trichostrongylus tenuis*

Hull C *Geometry and W-gravity*

Hull C *W-geometry*

5.5 Papers Produced by Visiting Members

Ihara Y *Horizontal divisors on arithmetic surfaces associated with Belyi uniformizations*

Isham V, Medley G (eds) *Models for Infectious Human Diseases*

Ishikawa H, Kato M *$c = 1$ string as a topological model*

Jacquez JA *Core groups and the R_0's for subgroups in heterogeneous SIS and SI models*

Jacquez JA *Modelling progression of HIV infection: Staging and the Chicago MACS cohort*

Jacquez JA *Primary infection, behavior change and core group saturation in epidemics of HIV infection in gay cohorts*

Jeffrey L, Weitsman J *Symplectic geometry of the moduli space of flat connections: the higher rank case*

Jeffrey L, Weitsman J *Toric structures on the moduli space of flat connections II: decomposition theory and explicit computations (in preparation)*

Jeffrey L, Weitsman J *A perfect Morse function on the moduli space of flat connections (in preparation)*

Jimbo M, Miwa T, Nakayashiki A *Difference equations for the correlation functions of the eight-vertex model*

Kaufmann LH, Lins S *Temperley Lieb recoupling theory and invariants of 3-manifolds*

Khesin B, Lyubashenko V *Q-analog of the algebra of pseudo-differential operators*

Khesin B, Ginzburg V *Steady fluid flows and symplectic geometry*

Kimura Y *Probability distribution of passive scalars with nonlinear mean gradient*

Kirillov A *Fusion algebra and Verlinde's formula*

Kirillov A *Dilogarithm identities, partitions and spectra in conformal field theory, I*

Kirillov AN *Dialogarithm identities and spectra in conformal field theory*

Knobloch E *Bifurcations in rotating systems*

Koubek A, Mussardo G *On the operator content of the Sinh-Gordon model*

Kurihara M *Iwasawa theory and fitting ideals*

Liao H, Olive D, Turok N *Topological solitons in A_r affine Toda theory*

Lickorish W *The skein method for three-manifold invariants*

Longini I, Halloran M, Haber M *Some current trends in estimating vaccince efficacy*

Longini I, Clark W, Satten G *et al* *Staged Markov models based on CD4+ T-lymphocytes for the natural history of HIV infection*

Loper D *On the motion of a rigid cylinder in a rotating electrically conducting fluid*

Lu H, Nilsson B, Pope C *et al* *The low-level spectrum of the W_3 string*

Mac Lane S *Coherence theorems and conformal field theory*

Masbaum G, Blanchet C *Topological quantum field theories for spin manifolds*

Masbaum G, Blanchet C, Habegger N *et al* *Topological quantum field theories derived from the Kaufman bracket*

Massad E, Struchiner CJ, Azevedo Neto RS *The impact of heterogeneity in individual frailty on the dynamics of infection and related control strategies*

Massad E, Azevedo-Neto RS, Yang HM *et al* *Modelling age-dependent transmission rates for childhood infections*

Massad E, Azevedo-Neto RS, Yang HM *et al* *Designing and assessing a pulse vaccination campaign against rubella*

Mazur B *Arithmetic Algebraic Geometry*

Mazur B, Fontaine JM *Geometric Galois representations*

McGhee, Mackay *The solitons of affine Toda theory*

Melvin P, Morton H *The coloured Jones function (in preparation)*

Moffatt K *Three lectures on topological aspects of turbulence*

Moffatt K, Kida S, Ohkitani K *Stretched votices - the sinews of turbulence; High Reynolds number asymptotics*

Moffatt K *Cosmic dynamos from alpha to omega*

Moffatt K, Loper D *The magnetostrophic rise of a buoyant parcel in the Earth's core*

5.5 Papers Produced by Visiting Members

Mollison D, Isham V, Grenfell B *Epidemics: Models and data*

Mollison D, Daniels H *The simple deterministic epidemic unmasked*

Mollison D, Ud Din S *Deterministic and stochastic models for the seasonal variability of measles transmission*

Mollison D, Levin S *Spatial dynamics of parasitism*

Mollison D *Newton opportunity*

Mollison D (ed) *Wilderness with people: The management of wild land*

Mollison D (ed) *Epidemic Models: Their Structure and Relation to Data*

Moore G *Spacetime diffeomorphisms in closed string field theory*

Moore G *Finite in all directions*

Morava J, Ando M, Sadofsky H *On conjectures of Mahowald and Waldhausen*

Morava J *Homotopical field theories*

Mori A *An expansion principle for elliptic automorphic forms of quaternionic type*

Morris M *Telling tails explain the discrepancy in sexual partner reports*

Morris M *Data driven network models for the spread of infectious disease*

Morris M *Behavior change and non-homogeneous mixing*

Moss D, Brandenburg A *The excitation of nonaxisymmetric magnetic fields in galaxies*

Moss D, Brandenburg A, Donner K *et al* *Towards the magnetic field of M 81*

Murakami H *Quantum $SU(2)$-invariants dominate Casson's $SU(2)$-invariant (incomplete)*

Mussardo G, Simonetti P *Stress-energy tensor and ultraviolet behaviour in massive integrable quantum field theories*

Nahm W, Recknagel A, Terhoeven *Dilogarithm identities in conformal field theory*

Nasell I *The quasi-stationary distribution of the closed endemic SIS model*

Nasell I *The threshold concepts in stochastic epidemic and endemic models*

Nasell I *Discussion of the paper "Epidemics: Models and Data" by Mollison D; Isham V and Grenfell B*

Olive D, Saveliev M, Underwood J *On a solitonic specialisation for the general solutions of some two-dimensional completely integrable systems*

Olive D, Turok N, Underwood J *Solitons and the energy-momentum tensor for affine Toda theory*

Ooguri H *Schwinger-Dyson equation in three-dimensional simplicial quantum gravity*

Pegoraro F, Bulanov S *Conformal magnetosonic waves*

Pegoraro F, Bulanov S *On the use of conformal transformations for the description of MHD waves (in Russian)*

Pilipenko O, Zinchenko B, Sokoloff D *Turbulent dynamo and the geomagnetic secular variation*

Poezd A, Shukurov A, Sokoloff D *Magnetic patterns in Milky Way and Andromeda Nebula*

Poezd A, Shukurov A, Sokoloff D *Nonlinear dynamo in a disk galaxy*

Priest ER, Titov V *Dynamic collapse of an X-point*

Ribet K *Fields of definition of abelian varieties with real multiplication*

Richardson S, Gilks W *Conditional independence models for epidemiological studies with covariate measurement error*

Roberts MG, Heesterbeek JAP *Bluff your way into epidemiological models*

Roberts MG, Smith G, Grenfell BT *Mathematical models for macroparasites of wildlife*

Roberts MG *Hydatid disease*

Roberts MG, Dobson AP *The population dynamics of communities of parasitic helminths*

Ruan K, Loper D *On a small-scale hydromagnetic flow in the Earth's core: motion of a rigid cylinder parallel to its axis*

Sandberg S, Awerbuch T, Spielman A *A comprehensive multiple matrix model representing the life cycle of the tick that transmits the agent of Lyme disease*

Satten GA, Longini IM *Markov chains with measurement error: Estimating the "true" course of a marker of HIV disease progression*

5.5 Papers Produced by Visiting Members

Sattenspiel L *How does a disease get from here to there? The geographical spread of AIDS and other diseases*

Sattenspiel L, Morris M *Report on family survey of childrens social activities - St Laurence primary school outbreak of stomach illness, March 1993*

Sattenspiel L, Dietz K, Hasibeder G *A structured epidemic model incorporating geographic mobility among regions*

Sattenspiel L *Spatial heterogeneity and the spread of infectious diseases*

Sattenspiel L *Comment on "Epidemics: Models and data" by Mollison D; Isham V and Grenfell B*

Sattenspiel L *Review of "Statistical 1st Aid" by RP Hirsch and RK Riegelman and "Basic and Clinical Biostatistics " by B Dawson-Sanders and G Trapp*

Saveliev M, Gervais J-L, Matsuo Y *On the Plucker embeddings associated with the Toda systems*

Saveliev M, Savelieva S *W–geometry and associated continuous Toda system*

Schep T, Pegoraro F, Kuvshinov B *Two fluid theory of propagating nonlinear magnetic structure*

Schneider P, Stuhler U *Smooth representations and sheaves on the Bruhat- Tits building*

Shukurov A, Sokoloff D *Evolution of magnetic field in a swirling jet*

Shukurov A, Sokoloff D *Hydromagnetic dynamo in astrophysical jets*

Sklyanin E *Separation of variables in the quantum integrable models related to the* $Y[sl(3)]$

Smirnov F *Form factors, deformed Knizhnik-Zamolodchikov equations and finite-gap integration*

Smith G *Models for macroparasitic infections: future directions*

Soward A *An asymptotic solution of a fast dynamo in a two-dimensional pulsed flow*

Soward A *Analytic fast dynamo solution for a two-dimensional pulsed flow*

Soward A *Fast dynamos*

Stilianakis N, Schenzle D, Dietz K *On the antigenic diversity threshold model for AIDS*

Struchiner CJ, Brunet R, Halloran ME *et al* *On the use of nonlinear nonnormal state-space models for vaccine evaluation*

Swinnerton-Dyer P *The Brauer group of cubic surfaces*

Swinnerton-Dyer P *Rational points on pencils of conics and on pencils of quadrics*

Swinnerton-Dyer P *Rational points on rational surfaces*

Swinnerton-Dyer P *The number of rational points on cubic surfaces*

Swinnerton-Dyer P, Sparrow C *The Faulkner-Skan equation I: the creation of strange invariant sets*

Swinnerton-Dyer P, Colliot-Thelene J-L *Hasse principle and weak approximation for pencils of Severi-Brauer and similar varieties*

Swinnerton-Dyer P *Rational points on certain intersections of two quadrics*

Tao L, Cattaneo F, Vainshtein S *Evidence for the suppression of the Alpha-effect by weak magnetic fields*

Tavakol R, Tworski A, Brandenburg A *et al* *Structural stability of two-dimensional dynamo models*

Taylor R, Diamond F *Lifting modular mod* l *representations*

Traczyk P *A new proof of Markov's braid theorem*

Turaev VG *Quantum invariants of 3-manifolds*

Vainshtein S, Tao L, Cattaneo F *et al* *Turbulent magnetic transport effects and their relation to magnetic field intermittency*

Vaughan R, Wooley T *Further improvements in Waring's problem, III: Eighth powers*

Vaughan RC, Wooley TD *Further improvements in Waring's problem, IV: higher powers*

Vergassola M, Gama S, Frisch U *Proving the existence of negative isotropic eddy viscosity*

Vergassola M *Chiral nonlinearities in forced 2-D Navier-Stokes flows*

West P *On the spectrum, no ghost theorem and modular invariance of* W_3 *strings*

Wooley TD *On a new method and its applications to certain local solubility problems*

Wooley TD, Vaughan RC *Non-diagonal solutions of certain symmetric diagonal equations*

Wooley TD, Granville AJ *The maximal discrepancy in Weil's estimates for the number of solutions of equations*

in finite fields
Yang HM, Coutinho FAB, Massad E *Modelling the role of immunity in macroparasite infections*
Yui N *The norms of algebraic numbers associated to Jacobi sums*
Yui N, Chen I *Singular values of Thompson series*
Yui N, Gouvea FQ *Brauer numbers of twisted Fermat motives*
Yui N, Zagier D *Observation on singular values of Weber modular functions*
Yui N, Gouvea FQ *The arithmetic of diagonal hypersurfaces over finite fields*
Yui N, Gouvea FQ *Fermat motives of K3-type*
Yui N, Gouvea FQ (ed) *Advances in Number Theory*
Yui N *Arithmetic of K3 surfaces over finite fields*
Zheligovsky O, Pouquet A *Hydrodynamic stability of the ABC flow*
Zheligovsky O *On the non-linear stability of the 1:1:1 ABC flow*
Zheligovsky VA *A kinematic magnetic dynamo sustained by a Beltrami flow in a sphere*

5.6 Seminars and Lectures July 1992 to June 1993

Witten E	*Floer theory and Chern-Simons theory I*	6 Jul	LDT*
Kauffman LH	*Temperley-Lieb recoupling and three-manifold invariants*	6 Jul	LDT*
Gabai D	*Convergence groups and the geometrisation conjecture*	7 Jul	LDT*
Viro O	*Coloured graphs and invariants of three- manifolds*	7 Jul	LDT*
Thomas C	*Free actions by cyclic groups on* S^3 *(revisited)*	8 Jul	LDT*
Bleiler S	*Composite two-generator links*	8 Jul	LDT*
Witten E	*Floer theory and Chern-Simons theory II*	9 Jul	LDT*
Kirby R	*The signature cocycle and Dedekind sums*	9 Jul	LDT*
Kamada S	*Knotted surfaces in* R^4 *described by braids*	10 Jul	LDT*
Turaev VG	*Foundations of the theory of quantum invariants*	13 Jul	LDT*
Eudave-Munoz M	*Essential tori obtained by surgery*	13 Jul	LDT*
Masbaum G	*TQFT's from the Kauffman bracket*	14 Jul	LDT*
Kanenobu T	*Peripheral subgroups and knots of* T^2 *in* S^4	14 Jul	LDT*
Gordon C	*Dehn surgery*	15 Jul	LDT*
Nakanishi Y	*Generalised unknotting operators*	15 Jul	LDT*
Donaldson SK	*Developments of Floer theory*	16 Jul	LDT*
Yamada S	*The absolute value of Witten's invariant for lens spaces*	16 Jul	LDT*
Thistlethwaite M	*Menasco's work on Bennequin's conjecture*	17 Jul	LDT*
Marumoto Y	*Ribbon concordance and prime knots*	17 Jul	LDT*
Jones V	*von Neumann algebras in mathematics and physics - introductory survey*	22 Jul	LDT*
Voiculescu D	*Random matrices and free probability theory*	22 Jul	LDT*
Wenzl H	*Subfactors, braid groups and invariants of three-manifolds*	23 Jul	LDT*
MacLane S	*Coherence, 2 categories and Zamolodchikov's tetrahedral equations*	23 Jul	LDT
Wassermann AJ	*Operator algebras and conformal field theory*	23 Jul	LDT*
Popa S	*Subfactors and classification problems*	24 Jul	LDT*
Ocneanu A	*Subfactors, TQFT's and invariants of three- manifolds*	24 Jul	LDT*
Turaev VG	*State sum models on shadows*	28 Jul	LDT
Verlinde H	*Conformal field theory and black hole radiation*	29 Jul	LDT
Hide R	*Planetary magnetism*	31 Jul	DYN*
Loper DE	*Compositional convection and the geodynamo*	31 Jul	DYN*
Jackson A	*Uncertainty estimates of the core magnetic field*	31 Jul	DYN*
Braginsky S	*Observational constraints on the geodynamos*	31 Jul	DYN*
Hollerbach R, Jones C	*Towards a self-consistent geodynamo model*	31 Jul	DYN*
Fearn DR	*MHD instability in rotating spherical shells*	31 Jul	DYN*
Zhang KK	*Nonlinear aspects of core-mantle interaction*	31 Jul	DYN*
Ruzmaikin AA	*Magnetic fields of Uranus, Neptune and Mars*	31 Jul	DYN*
Moffatt HK	*The geodynamo - a child's guide*	3 Aug	DYN
Baxter RJ	*Solvable models in statistical mechanics*	4 Aug	LDT
Vainshtein S	*On the generation of "strong" magnetic fields*	4 Aug	DYN
McCoy BM	*Solvable models in statistical mechanics*	5 Aug	LDT
Priest E	*MHD theories of solar coronal theory*	5 Aug	DYN
McCoy BM	*Solvable models in statistical mechanics*	5 Aug	LDT
Vishik M	*Aspects of fast dynamo theory*	6 Aug	DYN
Thaddeus M	*Algebraic geometry and the Verlinde formula*	6 Aug	LDT
Soward AM	*The fast dynamo: asymptotic solution in a two dimensional pulsed flow*	7 Aug	DYN
Garoufalidis S	*Combinatorial versus analytic invariants in three dimensions*	10 Aug	LDT
Friedlander S	*Instabilities in fluid flow*	10 Aug	DYN
Cardy JL	*Boundary conditions in conformal field theories*	11 Aug	LDT

5.6 Seminars and Lectures July 1992 to June 1993

Eltayeb I	*Plume dynamics in the core*	11 Aug	DYN
Cardy JL	*Boundary conditions in conformal field theories*	11 Aug	LDT
Itzykson C	*Kontsevich matrix integrals*	12 Aug	LDT
Proctor MRE	*Compressible magnetoconvection*	13 Aug	DYN
Knobloch E	*Convection in rotating cylinders*	13 Aug	DYN
Cherednik I	*Quantum many-body problem on a lattice via Knizhnik-Zamolodchikov equations*	13 Aug	LDT
Cooper D	*A contractible three-manifold with a hyperbolic orbifold structure*	14 Aug	LDT
Braginsky S	*The geodynamo: model Z and its ramifications*	14 Aug	DYN
Pegoraro F	*Magnetic reconnexion in laboratory plasmas*	17 Aug	DYN
Segal GB	*Aspects of conformal field theory*	18 Aug	LDT
Bayly BJ	*Parametric PDF closures for dynamical systems, turbulence and MHD*	18 Aug	DYN
Hull C	*The geometry of higher-spin gravity in two dimensions: W-gravity, W-algebras and W-strings*	19 Aug	LDT*
Eguchi T	*Discrete states in two dimensional black holes*	19 Aug	LDT*
Morris T	*Random surfaces, matrix models and the KP hierarchy*	20 Aug	LDT*
Moore G	*Two-dimensional gravity and two- dimensional string theory*	20 Aug	LDT*
Hollowood T	*τ -functions and integrable gravity*	21 Aug	LDT*
Gibbons G	*Two-dimensional black holes*	21 Aug	LDT*
Smirnov FA	*Dynamical symmetries of quantum integrable models*	25 Aug	LDT
Frenkel I	*Representation theory, analysis and geometry related to quantum Knizhnik- Zamolodchikov equation*	1 Sep	LDT
Arnold VI	*Poly-integrable systems*	4 Sep	DYN*
Bayly BJ	*Recent work on the SFS dynamo*	4 Sep	DYN*
Proctor MRE	*A numerical fast dynamo in a two- dimensional stirred flow*	4 Sep	DYN*
Soward AM	*An asymptotic solution of a fast dynamo in a pulsed flow*	4 Sep	DYN*
Zheligovsky V	*Spherical dynamo sustained by a Beltrami flow*	4 Sep	DYN*
Collet P	*Dynamo effects for suspensions of Anosov maps*	4 Sep	DYN*
Gilbert AD	*Fast dynamos based on cat maps with shear*	4 Sep	DYN*
Kauffman LH	*Three-manifold invariants, spin networks and the Temperly-Lieb algebras*	7 Sep	LDT*
Weitsman J	*Torus actions, moment maps and symplectic volumes for the moduli space of flat connections on a Riemann surface*	7 Sep	LDT*
Lee R	*Casson's invariant in spectral flow*	7 Sep	LDT*
Turbiner A	*Lie algebras and polynomials*	7 Sep	LDT*
Ganchev A	*Reduction of the Kniznik-Zamolodchikov equation*	7 Sep	LDT*
Baxter RJ	*Yang-Baxter equations and Z-invariant lattice models*	7 Sep	LDT*
Felder G	*On the Turaev-Viro invariants of three-manifolds*	8 Sep	LDT*
Bais S	*Anyons and discrete gauge theories*	8 Sep	LDT*
Ardalan F	*Black holes and two dimensional gravity*	8 Sep	LDT*
Temperley HNV	*New representations of the Temperley-Lieb algebras with applications*	8 Sep	LDT*
Nash C	*Ray-Singer torsion and formulae for $\zeta(3)$*	8 Sep	LDT*
Jimbo M	*Quantum group symmetries and lattice correlation functions*	8 Sep	LDT*
Lyubashenko V	*Invariants of closed three-manifolds arising from non-simple representations of quantum groups*	8 Sep	LDT*
Backofen O	*Quantum field theory and knot invariants*	8 Sep	LDT*
Di Francesco P	*Observables in the Kontsevich model*	9 Sep	LDT*
Tracy CA	*Asymptotics of level spacing distributions of random matrices*	9 Sep	LDT*
Tuite MP	*Monstrous moonshine and the uniqueness of the moonshine module*	9 Sep	LDT*

5.6 Seminars and Lectures July 1992 to June 1993

Joerss M	*On the existence of fields in conformal invariant physics*	9 Sep	LDT*
Pasquier V	*Quantising the periodic Toda chain*	9 Sep	LDT*
Eguchi T	*W_∞ algebra in two-dimensional black holes*	9 Sep	LDT*
Da Costa G	*BW type relations from lattice models*	9 Sep	LDT*
Nahm W	*Operator algebras in conformal QFT*	10 Sep	LDT*
Schimmrigk R	*Non-critical dimensions in critical string theory, a novel framework for string compactification*	10 Sep	LDT*
Shirrmacher A	*Quantum groups, R-matrices and quantised space time*	10 Sep	LDT*
Giavarini G	*Regularisation and renormalisation of Chern-Simons theory*	10 Sep	LDT*
Kimura Y	*Statistics of an advected passive scalar with nonlinear mean gradient*	10 Sep	DYN
Papadopoulos G	*The global phase space structure of the WZW model*	10 Sep	LDT*
Ooguri H	*On simplicial quantum gravity in three-dimensions*	10 Sep	LDT*
Ahn C	*Onsager algebra and integrable lattice models*	10 Sep	LDT*
Sonnenschein J	*Coset model approach to topological conformal field theories*	11 Sep	LDT*
Levy D	*Realisation and structure of affine Hecke algebra quotients in two-dimensional lattice models*	11 Sep	LDT*
Dick R	*Graded Lie derivatives and short distance expansions in two-dimensions*	11 Sep	LDT*
Westbury BW	*Renormalisation in lattice models*	11 Sep	LDT*
Szlachanyi K	*Order-disorder quantum symmetries in two-dimensional lattice models*	11 Sep	LDT*
Cicuta G	*Matrix models in statistical mechanics and quantum field theory: recent examples and problems*	11 Sep	LDT*
Arnold VI	*Vasiliev theory of discriminants and knots*	11 Sep	LDT*
Recknagel A	*K theory for quantum field theory*	11 Sep	LDT*
Kellendonk J	*Algebraic characterisation of aperiodic tilings*	11 Sep	LDT*
Jeffrey L	*Symplectic geometry and the stationary phase approximation to the Witten- Reshetikhin-Turaev invariant*	12 Sep	LDT*
Tjin T	*A geometric construction of W-algebras*	12 Sep	LDT*
Evans D	*Orbifold subfactors from soluble lattice models*	12 Sep	LDT*
Ginzburg V	*Resolution of diagonals and moduli spaces*	14 Sep	LDT
de Vega H	*Bethe Ansatz and quantum groups: the light-cone lattice approach*	17 Sep	LDT
Roberts PH	*Fundamentals of dynamo theory*	21 Sep	DYN*
Weiss NO	*Stellar magnetic fields*	21 Sep	DYN*
Hughes DW	*Testing for numerical dynamo action*	21 Sep	DYN*
Jones CA	*Cylindrical convection in a twisted magnetic field*	21 Sep	DYN*
Roberts PH	*Fundamentals of dynamo theory*	22 Sep	DYN*
Weiss NO	*Solar and stellar dynamos II*	22 Sep	DYN*
Proctor MRE	*Convection and magnetic fields I*	22 Sep	DYN*
Murakami H	*Derivatives of the Jones polynomical and Vasiliev invariants*	22 Sep	LDT
Jones CA	*Cylindrical convection in a twisted magnetic field*	22 Sep	DYN*
Cupal I	*The role of balance equation in explaining the solution of model Z*	22 Sep	DYN*
Rucklidge A	*Shearing instabilities in magnetoconvection*	22 Sep	DYN*
Ferriz-Mas A	*Stability of magnetic flux tubes in stellar convection zones*	22 Sep	DYN*
Shen H	*Minimum dissipation, non-axisymmetry and MHD alignment*	22 Sep	DYN*
Cardin P	*Is convection in the earth's outer core thermal or chemical?*	22 Sep	DYN*
Chui AYK	*Thermally driven disc dynamos*	22 Sep	DYN*
Vainshtein S	*Nonlinear restrictions on dynamo action*	22 Sep	DYN*
Soward AM	*Fast dynamos*	23 Sep	DYN*
Proctor MRE	*Convection and magnetic fields II*	23 Sep	DYN*

5.6 Seminars and Lectures July 1992 to June 1993

Brandenburg A	*Nonlinear dynamos: computational aspects I*	23 Sep	DYN*
Malkus WVR	*Energy sources for planetary dynamos I*	23 Sep	DYN*
Kearton C	*Knots in higher dimensions-a survey*	23 Sep	LDT
Kerswell RR	*Elliptical instabilities of stratified, hydromagnetic waves and the earth's outer core*	23 Sep	DYN*
St.Pierre MG	*The strong field branch of the Childress-Soward dynamos*	23 Sep	DYN*
Shukurov A	*Evolution of magnetic fields in a swirling jet*	23 Sep	DYN*
Barenghi CF	*Nonlinear dynamos in a spherical shell*	23 Sep	DYN*
Soward AM	*An asymptotic solution of a fast dynamo in a two-dimensional pulsed flow*	24 Sep	DYN*
Sulem P-L	*Dynamos and Hamiltonian chaos*	24 Sep	DYN*
Linardatos D	*Magnetostatic equilibria: determination using a variational principle and numerical relaxation*	24 Sep	DYN*
Klapper I	*Current sheet formation in two-dimensional incompressible MHD turbulence from a Lagrangian viewpoint*	24 Sep	DYN*
Soward AM	*Fast dynamos II*	25 Sep	DYN*
Brandenburg A	*Nonlinear dynamos: computational aspects II*	25 Sep	DYN*
Malkus WVR	*Energy sources for planetary dynamos II*	25 Sep	DYN*
Hollerbach R	*Towards a self-consistent convective geodynamic model*	25 Sep	DYN*
Ruzmaikin AA	*Internal core as a source of motions*	25 Sep	DYN*
Kulsrud RM	*Magnetic fluctuations in fast dynamos*	25 Sep	DYN*
Sokoloff DD	*Turbulent dynamo and 60-year geomagnetic secular variations*	25 Sep	DYN*
Stepinski TF	*Special problems of dynamo magnetic field generation in thin accretion discs*	25 Sep	DYN*
Barker DM	*Numerical simulations of three-dimensional* $\alpha - \Omega$ *dynamos*	25 Sep	DYN*
Childress S	*A model of fast action dynamo action in near integrable flows*	25 Sep	DYN*
Kichatinov LL	*The dynamo with turbulent transport of magnetic fields*	26 Sep	DYN*
Zhang K	*Hydrodynamic and magnetohydrodynamic inertial oscillations in planetary fluid cores*	26 Sep	DYN*
Nunez M	*On the essential spectrum of Faraday's equation with zero resistivity*	26 Sep	DYN*
Zheligovsky V	*Kinematic dynamo sustained by a Beltrami flow in a sphere*	26 Sep	DYN*
Kambe T	*On the stretching of line elements in fluid with or without conductivity: an approach from differential geometry*	26 Sep	DYN*
Platt N	*On-off intermittency: general description and feedback models*	26 Sep	DYN*
Fearn DR	*Nonlinear planetary dynamos*	28 Sep	DYN*
Frisch U	*Turbulence*	28 Sep	DYN*
Spiegel EA	*Chaos and order in the solar dynamo*	28 Sep	DYN*
Moss D	*Non-axisymmetric magnetic fields during the growth phase of a mean field dynamo*	28 Sep	DYN*
Prautzsch T	*Advantage of a dynamo in the deep convective zone of the sun*	28 Sep	DYN*
Anderson SW	*Random magnetic fields and the galactic dynamo: numerical results*	28 Sep	DYN*
DeLuca EE	*Fibril dynamics and fibril dynamos*	28 Sep	DYN*
Kuang W	*Topographic core-mantle coupling*	28 Sep	DYN*
Loper DE	*On small-scale bouyant hydromagnetic rotating flow on the earth's core*	28 Sep	DYN*
Rosner R	*On the role of field topology in turbulent magnetic field diffusion*	28 Sep	DYN*
Tao L	*Suppression of turbulent transport by large scale magnetic fields*	28 Sep	DYN*
Anufriev AA	*On the Hartmann flow between conducting walls*	28 Sep	DYN*

5.6 Seminars and Lectures July 1992 to June 1993

Gailitis A	*Experimental aspects of a laboratory scale liquid sodium dynamo model*	28 Sep	DYN*
Fearn DR	*Nonlinear planetary dynamos*	29 Sep	DYN*
Frisch U	*Turbulence*	29 Sep	DYN*
Spiegel EA	*Chaos and order in the solar dynamo*	29 Sep	DYN*
Cattanes F	*Turbulent transport and weak magnetic fields*	29 Sep	DYN*
Galloway DJ	*Numerical calculations of dynamos for ABC and related flows*	29 Sep	DYN*
Braginsky S	*The geodynamo and model-Z*	30 Sep	DYN*
Bayly BJ	*Maps and dynamos*	30 Sep	DYN*
Knobloch E	*Bifurcations and symmetry in dynamo models*	30 Sep	DYN*
Trazcyk P	*Simple proof of Markov's braid theorem*	30 Sep	LDT
Jennings RL	*A nonlinear model of the solar dynamo*	30 Sep	DYN*
Matthews PC	*Compressible magnetoconvection in three dimensions*	30 Sep	DYN*
Shukorov A	*Evolution of magnetic fields in a swirling jet*	30 Sep	DYN*
Pouquet A	*Dynamos and Hamiltonian chaos*	30 Sep	DYN*
Braginsky S	*The geodynamo and model-Z*	1 Oct	DYN*
Bayly BJ	*Maps and dynamos*	1 Oct	DYN*
Knobloch E	*Bifurcations and symmetry in dynamo models*	1 Oct	DYN*
Rosso M	*Representations of quantum groups*	1 Oct	LDT
Zheligovsky V	*Kinematic dynamo sustained by a Beltrami flow in a sphere*	1 Oct	DYN*
Galanti B	*Hydromagnetic dynamos in flows stirred by deterministic body forces: the example of ABC flows*	1 Oct	DYN*
Wicht J	*Dynamo action induced by lateral variations of electrical conductivity*	1 Oct	DYN*
Foth M	*A non-axisymmetric dynamo in torus geometry*	2 Oct	DYN*
Gilbert AD	*Simple dynamical fast dynamos*	2 Oct	DYN*
Kirby R	*Topological invariants for low-dimensional manifolds - a survey*	6 Oct	LDT
Zuber J-B	*Fusion and confusion!!*	8 Oct	LDT
Donaldson SK	*Yang-Mills instantons and holomorphic curves*	9 Oct	LDT*
Miwa T	*Quantum affine symmetry in solvable lattice models*	9 Oct	LDT*
Olive D	*Conformal to integrable quantum field theory*	9 Oct	LDT*
Moffatt HK	*Rising blobs and the geodynamo*	13 Oct	DYN
Connes A	*Standard model of particle physics and the fine structure of space-time*	14 Oct	LDT
Lickorish WBR	*Whyever knot theory?*	19 Oct	INS
Simon GW	*Observations of magnetoconvection at the solar surface*	20 Oct	DYN
Arnold VI	*Applications of singularity theory to invariants of knots and immersions*	20 Oct	LDT
West PC	*W-String*	21 Oct	LDT
Fairlie DB	*Euler iterates and universal field equations*	21 Oct	LDT
Vergassola M	*Negative isotropic eddy viscosity associated with two-dimensional flow*	22 Oct	DYN
Khesin B	*Group of pseudo-differential operators and the KP-KdV hierarchy*	22 Oct	LDT
Ockendon J	*The mathematical stimulus of working with industry*	26 Oct	INS
Ravanini F	*Testing RG flows in two-dimensional QFT by thermodynamic Bethe Ansatz: a relation with ADE classification*	27 Oct	LDT*
Sklyanin E	*Separation of variables and Bethe Ansatz*	27 Oct	LDT*
Lythe GD	*Noise-sensitive equations*	27 Oct	DYN
Mansfield P	*Topological expansions in field theory*	27 Oct	LDT*
Sasaki R	*Reflection equations*	27 Oct	LDT*
Braden HW	*Affine Toda quantum field theory*	28 Oct	LDT*
Cardy JL	*The chiral Potts model from CFT*	28 Oct	LDT*

5.6 Seminars and Lectures July 1992 to June 1993

Kirillov A	*Fusion rules for $Sl(n)$*	28 Oct	LDT*
Borcherds R	*Orbifolds and GKO constructions*	28 Oct	LDT*
Saveliev M	*New class of dimensional Lie algebras and associated multidimensional nonlinear systems*	29 Oct	LDT*
Freeman M	*Quantum KP hierarchy and NLS equation*	29 Oct	LDT*
Smirnov F	*Form factors, $k = O$ Knizhnik-Zamolodchikov equations and finite-gap integration*	29 Oct	LDT*
Chu M	*Exchange algebras*	29 Oct	LDT*
Linden N	*Fundamental particles and forces*	31 Oct	
Isham C	*The importance of quantum gravity*	31 Oct	
Shellard P	*The early universe*	31 Oct	
Goddard P	*String theory*	31 Oct	
Fairlie DB	*Euler iterates and universal field equations*	2 Nov	LDT
Moffatt HK	*Whyever dynamo theory?*	2 Nov	INS
Galloway DJ	*Twisted magnetoconvection*	3 Nov	DYN
Cates M	*Random surfaces*	3 Nov	LDT
Morava J	*Two-dimensional topological gravity as algebraic topology*	4 Nov	LDT
Masbaum G	*Verlinde formulae for surfaces with spin structure*	4 Nov	LDT
Date E	*Crystal base and q-vertex operators*	5 Nov	LDT
Hollerbach R	*A geodynamo model incorporating a finitely conducting inner core*	10 Nov	DYN
Olive D	*Affine Toda solitons*	10 Nov	LDT
Schnitzer H	*Topological field theories and fusion rings*	11 Nov	LDT
Taubes C	*Kontsevich's interpretation of perturbative Chern-Simons invariants*	11 Nov	DYN
Taubes C	*Kontsevich's interpretation of perturbative Chern-Simons invariants - continuation*	12 Nov	DYN
Taubes C	*Kontsevich's interpretation of perturbative Chern-Simons invariants - continuation*	13 Nov	DYN
Fenn R	*Some new (?) knot invariants obtained from the rack space*	16 Nov	LDT*
Przytycki J	*Vassiliev-Gusarov invariants and polynomially computable parts of Jones-type polynomials*	16 Nov	LDT*
Corrigan E	*Whyever string theory?*	16 Nov	INS
Lickorish WBR	*The skein method for three-manifold invariants*	17 Nov	LDT*
Melvin P	*Low-level quantum invariants*	17 Nov	LDT*
Pringle J	*Magnetic fields in accretion disks*	17 Nov	DYN
Morton HR	*Extracting information from knot invariants*	18 Nov	LDT*
Murakami J	*Invariants of tangles, links in a solid torus and satellite links*	18 Nov	LDT*
Barrett J	*Three-manifold invariants from triangulations*	18 Nov	LDT*
Stix M	*The Sun I*	19 Nov	DYN*
Gough D	*The Sun II*	19 Nov	DYN*
Hughes DW	*The Sun III*	19 Nov	DYN*
Zahn J-P	*$\alpha - \Omega$ dynamos I*	19 Nov	DYN*
Galloway DJ, Jones C	*$\alpha - \Omega$ dynamos II*	19 Nov	DYN*
Moffatt HK	*$\alpha - \Omega$ dynamos III*	19 Nov	DYN*
Goldhaber F	*Topological solitons with fractional charge- inevitable, impossible, or invisible?*	19 Nov	LDT
Weiss N	*Main sequence stars I*	20 Nov	DYN*
Brandenburg A	*Main sequence stars II*	20 Nov	DYN*
Tavakol R	*Main sequence stars III*	20 Nov	DYN*
Pringle J	*Accretion discs I*	20 Nov	DYN*
Torkelsson U	*Accretion discs II*	20 Nov	DYN*
Campbell C	*Accretion discs III*	20 Nov	DYN*

5.6 Seminars and Lectures July 1992 to June 1993

Soward AM	*Accretion discs IV*	20 Nov	DYN*
Obers N	*Ward identities for affine-Virasoro correlators*	20 Nov	LDT
Tuominen I	*Giant stars I*	21 Nov	DYN*
Moss D	*Giant stars II*	21 Nov	DYN*
Elstner D	*Giant stars III*	21 Nov	DYN*
Cameron A	*Giant stars IV*	21 Nov	DYN*
Brenner S	*What theories are we looking for in biology?*	23 Nov	INS
Zahn J-P	*Rotation and mixing in the solar interior*	24 Nov	DYN
Dotsenko V	*The discrete state operators and their correlation functions in two-dimensional gravity coupled to $c < 1$ matter*	24 Nov	LDT
Bar-Natan D	*On the Vassiliev knot invariants I*	25 Nov	LDT
Drummond I	*Stretching and bending in random flows*	26 Nov	DYN
Bar-Natan D	*On the Vassiliev knot invariants II*	26 Nov	LDT
Arnold VI	*Topological and ergodic properties of poly-integrable systems*	27 Nov	LDT*
Ricca RL	*The helicity and the elastic energy of a knotted flux tube via the Călugăreanu invariant*	27 Nov	LDT*
Berger MA	*Energy crossing number relations for braided magnetic fields*	27 Nov	LDT*
Moffatt HK	*Relaxation under topological constraints: implications for knots and links*	27 Nov	LDT*
Khesin B	*Impossible steady flows*	27 Nov	LDT*
Priest E	*Does fast magnetic reconnection exist?*	27 Nov	LDT*
Bar-Natan D	*On the Vassiliev knot invariants III*	27 Nov	LDT
Vekstein G	*Separatrix current sheets*	27 Nov	LDT*
Berry M	*Classical gauge forces of reaction: a simple example*	27 Nov	LDT*
Arnold VI	*Newton's Principia read 300 years later*	27 Nov	INS
Arnold VI	*Topological problems in hydrodynamics*	30 Nov	DYN
Uchida Y	*On the Δ-unknotting operation*	1 Dec	LDT
Sokoloff DD	*Global magnetic patterns in the Milky Way and Andromeda nebula*	1 Dec	DYN
Hawking SW	*Two-dimensional black holes*	1 Dec	LDT
Jeffrey L, Weitsman J	*Symplectic geometry of the moduli space of flat connections on a two-manifold*	2 Dec	LDT
Jeffrey L, Weitsman J	*Symplectic geometry of the moduli space of flat connections on a two-manifold*	2 Dec	LDT
Broda B	*Path integral approach to link invariants*	2 Dec	LDT
Cupal I, Anufriev AA	*On the nearly symmetric hydromagnetic geodynamo*	3 Dec	DYN
Lassig M	*Critical roughening of interfaces - a new class of renormalized field theories*	3 Dec	LDT
Roberts J	*Skeins and mapping class groups*	7 Dec	LDT
Figueroa-O'Farrill J	*W-algebras in the KP hierarchy*	7 Dec	LDT
Reina C	*Geometrical meaning of the quantum corrections in topological sigma models*	7 Dec	LDT
Dijkgraaf R	*Mirror symmetry, moduli space and singularity theory*	8 Dec	LDT*
Fateev V	*The sausage model (Integrable deformations of the 0(3) sigma model)*	8 Dec	LDT*
Fradkin L	*Chaotic advection of electrons in quiet discharges in Tokamacs*	8 Dec	DYN
Mussardo G	*Correlation functions in two-dimensional integrable quantum field theory*	8 Dec	LDT*
Dorey P	*Spiral staircases*	8 Dec	LDT*
Dubrovin B	*Integrable hierarchies, τ-functions and two-dimensional topological field theory*	9 Dec	LDT*
Kausch H	*New series of rational conformal field theories*	9 Dec	LDT*

5.6 Seminars and Lectures July 1992 to June 1993

Gervais J-L	*The W-geometry of holomorphic surfaces and conformal Toda field theories*	9 Dec	LDT*
O'Raifeartaigh L	*On the exhaustivity of the canonical KM-W algebra reductions*	9 Dec	LDT*
Watts G	*W-symmetry in conformal field theory*	9 Dec	LDT*
Feigin B	*Some approaches to Rogers-Ramanujan identities*	10 Dec	LDT*
Kent A	*Non-unitary field theories*	10 Dec	LDT*
Kambe T	*Reconnection*	10 Dec	DYN
Gillespie TA	*Transference techniques in analysis*	11 Dec	
Bursill-Hall P	*An early theory of the transfinite*	11 Dec	
West TT	*Groups, semi-groups, semi-algebras and spectral theory*	12 Dec	
Dixon PG	*Varieties of Banach algebras and von Neumann's inequality*	12 Dec	
Zheligovsky O	*A numerical study of bifurcations of time- dependent solutions of the ABC-forced Navier- Stokes equation*	15 Dec	DYN
Gailitis A	*Magnetic field generation by an axisymmetric meridional circulation*	17 Dec	DYN
Dietz K	*Mathematical problems in disease dynamics*	4 Jan	EPI*
Mollison D	*The structure of epidemic models*	4 Jan	EPI*
Nasell I	*The threshold concept in deterministic and stochastic models*	4 Jan	EPI*
Ball F	*Coupling methods in epidemic theory*	4 Jan	EPI*
Lefevre C	*Collective Reed-Frost epidemic processes*	4 Jan	EPI*
Kurtz T	*Relationship between stochastic and deterministic epidemic models*	4 Jan	EPI*
de Jong MCM	*How does transmission depend on population size?*	4 Jan	EPI*
Diekmann O	*The legacy of Kermack and McKendrick*	4 Jan	EPI*
Daniels H	*A perturbation approach to nonlinear deterministic epidemic waves*	5 Jan	EPI*
Billard L	*A bivariate death process in plants*	5 Jan	EPI*
Anderson R	*Simple models of the spatial dynamics of plant pathogens*	5 Jan	EPI*
Metz H	*Velocities of epidemic spread*	5 Jan	EPI*
Durrett R	*Epidemics and evolutionary games in spatially distributed populations*	5 Jan	EPI*
Levin S	*Models for collective movements of organisms*	5 Jan	EPI*
Dobson A	*Population dynamics of a parasitic nematode and its host*	6 Jan	EPI*
Rand D	*Attracting and repelling chaos in noisy systems*	6 Jan	EPI*
Ellner S	*Detecting nonlinearity and chaos in epidemiological time series*	6 Jan	EPI*
Grenfell B	*Chaos and biological realism in measles dynamics*	6 Jan	EPI*
May R	*Nonlinear aspects of epidemiological data in space and time*	6 Jan	EPI*
Cliff A	*Space-time models for human diseases*	6 Jan	EPI*
Hadeler KP	*Models for pair formation*	7 Jan	EPI*
Jacquez JA	*Core groups and* R_0*'s for subgroups in heterogeneous SIS and SI models*	7 Jan	EPI*
Castillo-Chavez C	*Stochastic and deterministic models for social dynamics*	7 Jan	EPI*
Morris M	*Data driven network models for the spread of disease*	7 Jan	EPI*
Hasibeder G	*Heterogeneous disease transmission: estimating the basic reproduction number from prevalences*	7 Jan	EPI*
Gupta S	*What do age-exposure profiles tell us about the transmissibility of malaria?*	7 Jan	EPI*
Becker N	*The challenges of estimation and prediction from epidemic data*	8 Jan	EPI*
Cairns A	*A practical approach to model fitting and projection*	8 Jan	EPI*
Keiding N	*Modern survival analysis methods in infectious disease epidemiology*	8 Jan	EPI*

5.6 Seminars and Lectures July 1992 to June 1993

Remme H, Alley E, Plaisier A	*Estimation and prediction in tropical control*	8 Jan	EPI*
Fine P	*Simple, vaccine-related, problem-specific models*	8 Jan	EPI*
Longini I	*Estimating vaccine efficacy for endemic infectious diseases*	8 Jan	EPI*
Bailey N	*Operational modelling of HIV/AIDS to assist public health control*	8 Jan	EPI*
Yui N	*Brauer numbers and motives from twisted Fermat surfaces*	12 Jan	LFN
Granville A	*Carmichael numbers*	14 Jan	LFN
Longini I	*Testing AIDS vaccines: feasibility and statistics*	18 Jan	INS
Mollison D	*Introduction: the structure of epidemic models*	19 Jan	EPI
Antoniadis J	*Artin L-functions for tetrahedral representations*	19 Jan	LFN
Ellner S	*Overlapping generations and the maintenance of genetic variability by fluctuating selection*	20 Jan	EPI
Boston N	*A refinement of the Faltings-Serre method*	21 Jan	LFN
Wassermann AJ	*Connes fusion in conformal field theory*	22 Jan	
Becker N	*Epidemic models: an essential tool or mathematical gymnastics?*	25 Jan	INS
Becker N	*Inference for basic epidemic models*	26 Jan	EPI
McKee J	*Division polynomials for elliptic curves*	26 Jan	LFN
Birch BJ	*Coverings of the projective line*	28 Jan	LFN
Kelly F	*Modelling communication networks*	1 Feb	INS
Pinch R	*Carmichael numbers and pseudo primes*	2 Feb	LFN
Sattenspiel L	*Population mobility and the spread of infectious disease on the island of Dominica, West Indies*	3 Feb	EPI
Altmann M	*Graph theoretic measures of risk in disease transmission networks*	3 Feb	EPI
Buzzard K	*On reducible mod 2 representations*	4 Feb	LFN
Longini I	*Estimating vaccine efficacy with applications including AIDS*	4 Feb	EPI
Taylor R	*What is the Langlands programme?*	8 Feb	INS
Shepherd-Barron N	*Effective version of Mordell's theorem in characteristic p*	9 Feb	LFN
Heesterbeek JAP	*An algorithm to calculate R_0 for discrete-time epidemic models*	10 Feb	EPI
de Jong M	*R_0 in the real world: Aujeszky's disease virus in pigs*	10 Feb	EPI
Roberts M	*The population dynamics of nematode infections of sheep*	10 Feb	EPI
Swinnerton-Dyer P	*Rational points on conic bundles*	11 Feb	LFN
Dietz K	*Epidemic models for AIDS*	11 Feb	EPI
Taylor R	*Introduction to the course on automorphic forms*	15 Feb	LFN*
Taylor M	*Background and GL_1*	15 Feb	LFN*
Scholl T	*GL_2 over a local field*	15 Feb	LFN*
Taylor R	*Background and GL_1*	15 Feb	LFN*
Scholl T	*GL_2 over a local field*	15 Feb	LFN*
Penrose R	*Computability and the mind*	15 Feb	INS
Coates J	*GL_2 over a number field*	16 Feb	LFN*
Taylor R	*Quaternion algebras*	16 Feb	LFN*
Taylor R	*Introduction*	16 Feb	LFN*
Taylor R	*Background and GL_1*	16 Feb	LFN*
Coates J	*GL_2 over a number field*	17 Feb	LFN*
Taylor R	*Quarternion algebras*	17 Feb	LFN*
Taylor R	*Introduction*	17 Feb	LFN*
Diggle P	*Point process methods in environmental epidemiology*	17 Feb	EPI
Taylor M	*Background and GL_1*	17 Feb	LFN*
Coates J	*GL_2 over a number field*	18 Feb	LFN*
Taylor R	*Quarternion algebras*	18 Feb	LFN*
Ball F	*Stochastic coupling methods in epidemiology*	18 Feb	EPI
Taylor M	*Background and GL_1*	18 Feb	LFN*

5.6 Seminars and Lectures July 1992 to June 1993

Scholl T	*GL_2 over a local field*	18 Feb	LFN*
Coates J	*GL_2 over a number field*	19 Feb	LFN*
Taylor R	*Quarternion algebras*	19 Feb	LFN*
Taylor M	*Background and GL_1*	19 Feb	LFN*
Scholl T	*GL_2 over a local field*	19 Feb	LFN*
Taylor M	*Background and GL_1*	20 Feb	LFN*
Scholl T	*GL_2 over a local field*	20 Feb	LFN*
Taylor R	*Quarternion algebras*	20 Feb	LFN*
Scholl T	*GL_2 over a local field*	20 Feb	LFN*
Coates J	*GL_2 over a number field*	22 Feb	LFN*
Taylor R	*Quarternion algebras*	22 Feb	LFN*
Coates J	*GL_2 over a number field*	22 Feb	LFN*
Taylor R	*Quarternion algebras*	22 Feb	LFN*
Peto R	*How to live forever by avoiding both cancer and heart disease*	22 Feb	INS
Coates J	*GL_2 over a number field*	23 Feb	LFN*
Taylor R	*Quarternion algebras*	23 Feb	LFN*
Coates J	*GL_2 over a number field*	23 Feb	LFN*
Taylor R	*Orbital integrals*	23 Feb	LFN*
Taylor R	*Orbital integrals*	24 Feb	LFN*
Scholl T	*Base change*	24 Feb	LFN*
Scholl T	*Base change*	24 Feb	LFN*
Schneider P	*Fundamental Lemma-1*	24 Feb	LFN*
Taylor R	*Orbital integrals*	25 Feb	LFN*
Scholl T	*Base change*	25 Feb	LFN*
Mollison D	*Spatial epidemic models*	25 Feb	EPI
Schneider P	*Fundamental Lemma-1*	25 Feb	LFN*
Scholl T	*Base change*	25 Feb	LFN*
Schneider P	*Fundamental Lemma-1*	26 Feb	LFN*
Scholl T	*Base change*	26 Feb	LFN*
Labesse J-P	*Fundamental Lemma-2*	26 Feb	LFN*
Harrison M	*Artin's conjecture*	26 Feb	LFN*
Labesse J-B	*Fundamental Lemma-2*	27 Feb	LFN*
Harrison M	*Artin's conjecture*	27 Feb	LFN*
Labesse J-P	*Fundamental Lemma-2*	27 Feb	LFN*
Harrison M	*Artin's conjecture*	27 Feb	LFN*
Dasgupta P	*Individual choices and collective situations*	1 Mar	INS
Vaughan R	*Use of smooth numbers in additive number theory*	2 Mar	LFN
Jannsen V	*A Hasse principle for function fields over Q: proof of a conjecture of Kato*	4 Mar	LFN
Cliff A, Grenfell B	*Case studies 1 : Measles*	4 Mar	EPI
Mori A	*Expanding modular forms at CM points*	5 Mar	LFN
Coates J	*Whyever L-functions in arithmetic?*	8 Mar	INS
Deninger C	*Evidence for a cohomological approach to analytic number theory*	11 Mar	LFN
Harwood J	*Case studies 2: the 1988 North Sea seal epidemic*	11 Mar	EPI
Schneider P	*The character theory of smooth representations*	11 Mar	LFN
Gulland F	*Parasite impact and control*	15 Mar	EPI*
Dobson A	*Microparasites, observed patterns*	15 Mar	EPI*
Barlow N	*Microparasites, models*	15 Mar	EPI*
Hudson P	*Macroparasites, observed patterns*	15 Mar	EPI*
Roberts M, Smith G	*Macroparasites, models*	15 Mar	EPI*
Dye C	*Consequences of indirect transmission*	15 Mar	EPI*
Swinton J, Anderson R	*Dynamics of plant pathogens*	15 Mar	EPI*

5.6 Seminars and Lectures July 1992 to June 1993

Mollison D	*Spatial dynamics of parasitism*	15 Mar	EPI*
Lloyd S	*Environmental influences on host immunity*	16 Mar	EPI*
Grenfell B, Godfray C	*Host age structure and infection dynamics*	16 Mar	EPI*
Begon M, Bowers R	*Multispecies aspects of parasitism*	16 Mar	EPI*
Apanius V, Lively C	*Population genetics and coevolution*	16 Mar	EPI*
Flynn EV	*Descent via isogeny on Jacobians of curves of genus 2*	16 Mar	LFN
Wooley T	*On a new method and its application to the local solubility of certain equations*	18 Mar	LFN
Wingberg K	*On unramified extensions of algebraic number fields*	18 Mar	LFN
Mollison D	*Random graph models for epidemics*	23 Mar	EPI*
Wasserman S	*Statistical models for social networks*	23 Mar	EPI*
Haran S	*Symbolic calculus over the p-adics*	23 Mar	LFN
Hethcote HW	*Mathematical models of population regulation by infectious diseases*	24 Mar	EPI*
Metz H	*How to deal with a finite number of potential contacts in yet homogeneously mixing populations*	24 Mar	EPI*
Kato K	K_2 *and rational points of elliptic curves I*	25 Mar	LFN
Mollison D, Sattenspiel L	*What is space and how do we model it?*	25 Mar	EPI*
Murty R	*Selberg conjectures and Artin L-functions*	25 Mar	LFN
Bolz G	*Modelling epidemics on random graphs*	25 Mar	EPI*
Wasserman S	*Demonstration of UCINET network analysis software*	25 Mar	EPI*
Sattenspiel L	*School social structures and epidemic spread*	26 Mar	EPI*
Koopman J	*Analysing interaction data to assess risk factor effects on transmission*	26 Mar	EPI*
Joyce C	*Sexual networks among gay men in England and Wales*	26 Mar	EPI*
Longini I	*The feasibility of prophylactic HIV vaccine trials: statistical issues*	28 Mar	EPI*
Gore S	*Overview of data analysis: Diseases with long development times*	29 Mar	EPI*
Peto J	*Human papilloma virus - the cause of cervical cancer*	29 Mar	EPI*
Dietz K, Eichner M	*The relative risks of vaccinated and non-vaccinated individuals for different vaccination strategies*	29 Mar	EPI*
De Angelis D, Gilks WR	*New methodology for AIDS back-calculation*	29 Mar	EPI*
Ades A, Nokes DJ	*Simultaneous modelling of age and time effects on toxoplasmosis incidence, from age- and time- specific seroprevalence data*	29 Mar	EPI*
Blower SM, McLean AR	*Imperfect HIV vaccines, the consequences for epidemic control and clinical trials*	29 Mar	EPI*
Halloran E	*Counting process models and vaccination efficiency*	29 Mar	EPI*
Hadeler KP	*Optimal vaccination patterns in age-structured populations with age-dependent costs*	29 Mar	EPI*
Mueller J	*Optimal vaccination patterns in age-structured populations with loss of immunity*	29 Mar	EPI*
Edmonds WJ, Medley GF, Nokes DJ	*The design of immunisation programmes against hepatitus B virus in developing countries*	29 Mar	EPI*
Greenhalgh D	*The effect of different mixing patterns on vaccination programmes*	29 Mar	EPI*
Nowak M	*Evolutionary dynamics of HIV infections*	30 Mar	EPI*
Taylor JMG, Cumberland WG, Sy JP	*Statistical models for analysis of longitudinal CD4 data*	30 Mar	EPI*

5.6 Seminars and Lectures July 1992 to June 1993

Fulford AJC, Butterworth AE, Dunne DW	*Some mathematical and statistical issues in assessing the evidence for acquired immunity to schistosomiasis*	30 Mar	EPI*
Day K, Gupta S	*Virulence and transmissability*	30 Mar	EPI*
McLean AR, Michie CA	*Lifespan of human T lymphocytes*	30 Mar	EPI*
McNeil A, Gore S	*Statistical analysis of the effect of treatment on CD4 cell counts in HIV disease*	30 Mar	EPI*
de Boer RJ, Boerlijst MC	*Diversity and virulence thresholds in AIDS*	30 Mar	EPI*
Jacquez JA, Koopman JS, Simon CP	*Modelling disease progression and staging: HIV and the Chicago MACS cohort*	30 Mar	EPI*
Lichtenbaum S	*Motives and motivic cohomology*	30 Mar	LFN
Woolhouse M	*The interpretation of immunoepidemiological data for helminth infections*	30 Mar	EPI*
Medley GF, Billingsley P, Sinden RE	*The distribution of malaria parasites in the mosquito vector: consequences for assessing infection intensity in the field*	30 Mar	EPI*
Hasibeder G	*When susceptible and infective human hosts are not equally attractive to mosquitos: a generalisaton of the Ross malaria model*	30 Mar	EPI*
Gupta S, Day K	*Antigenic diversity and the transmissability of malaria*	30 Mar	EPI*
Swinton J	*The dynamics of blood stage malaria: modelling strain specific and strain transcending immunity*	30 Mar	EPI*
Hethcote HW	*Modelling heterogeneous mixing in infectious disease dynamics*	31 Mar	EPI*
Morris M	*Behavior change and non-homogeneous mixing*	31 Mar	EPI*
Johnson AM	*Sources and use of empirical observations to characterise networks of sexual behavior*	31 Mar	EPI*
Downs AM, de Vincenzi I	*Per-contact rates of heterosexual transmission of HIV, estimated from partner study data*	31 Mar	EPI*
Garnett GP, Swinton J	*Dynamic simulation of sexual partner networks: which properties are important in sexually transmitted disease epidemiology?*	31 Mar	EPI*
Kretzchmar M	*The spread of a STD on a dynamic network of sexual contacts*	31 Mar	EPI*
Altmann M	*Network measures for epidemiology*	31 Mar	EPI*
Sattenspiel L	*Spatial heterogeneity and the spread of infectious diseases*	31 Mar	EPI*
van Griensven G, Koopman JS	*Data analysis for estimating risk factor effects using transmission models*	31 Mar	EPI*
van Druten H	*Homosexual role behavior and the spread of HIV*	31 Mar	EPI*
Billard L, Smith D	*Homogeneity tests for groupings of AIDS patient classifications*	31 Mar	EPI*
Fielding KL	*Risk factors for heterosexual transmission of HIV*	31 Mar	EPI*
Medley GF	*The conflicts between the interests of the individual and the community in disease treatment and control*	1 Apr	EPI*
Peto J	*The design and analysis of HIV clinical trials*	1 Apr	EPI*
Agur Z	*A theory of population dynamics used for improving control of viral diseases: AZT chemotherapy and measles vaccination policy*	1 Apr	EPI*
Wildeshaus J	*Polylogarithms in the context of Shimura varieties*	1 Apr	LFN
Habbema D	*Models at work: the use of ONCHOSIM in the control of onchocerca*	1 Apr	EPI*
van Oortmarssen G	*Demonstration of ONCHOSIM computer model for control of onchocerciasis*	1 Apr	EPI*

Gove D	*Demonstration of computer model for control of trachoma (a major cause of preventable blindness)*	1 Apr	EPI*
Kato K	*K_2 and rational points on elliptic curves II*	1 Apr	LFN
Roberts M	*Hydatid disease*	1 Apr	EPI*
de Jong MCM	*Vaccines and herd immunity: consequences for vaccine evolution*	1 Apr	EPI*
Chan MS, Medley GF, Bundy DAP	*A quantitative framework for the design of chemotherapy programmes to reduce morbidity due to helminth infections of humans*	1 Apr	EPI*
Nokes DJ	*The control of directly transmitted infections by pulse vaccination: concepts and preliminary studies*	1 Apr	EPI*
Heesterbeek JAP, Metz JAJ	*The saturating contact rate in epidemic models*	1 Apr	EPI*
Tudor D	*The behavioral differences between susceptibles and infectives with respect to HIV transmission and their influence on R_0*	1 Apr	EPI*
Simon C, Jacquez J, Koopman J	*The Liapunov function approach to stability and thresholds in disease models*	1 Apr	EPI*
Eichner M, Hadeler KP, Dietz K	*Minimum population size for persistence of polio virus infection*	1 Apr	EPI*
Solomon PJ	*AIDS: modelling and predicting*	2 Apr	EPI*
Longini I, Satten G	*Staged Markov models based on CD4+ T-lymphocytes for the natural history of HIV infection*	2 Apr	EPI*
Heisterkamp SH, Downs AM	*Short term projections by dynamic modelling in large populations: a case study in France and The Netherlands*	2 Apr	EPI*
Raab G	*Bayesian prediction of AIDS cases and CD200 cases in Scotland*	2 Apr	EPI*
Rossi C, Abundo M	*Some scenario analyses for the HIV - AIDS epidemic in Italy*	2 Apr	EPI*
Dangerfield B, Roberts C	*Relating a transmission model of AIDS spread to data: some international comparisons*	2 Apr	EPI*
Shahani A	*Demonstration of a computer model of HIV/AIDS for planning and clinical uses*	2 Apr	EPI*
Lang S	*Analytic numbers theory and spectral theory*	2 Apr	LFN
Farewell VT, Aalen OO, de Angelis D	*Estimation of the rate of first positive tests in HIV+ individuals*	2 Apr	EPI*
Fan DP	*Effects of AIDS public education on HIV infections among gay men*	2 Apr	EPI*
Uche C, Anderson RM	*Changes in sexual behavior and HIV control*	2 Apr	EPI*
Satten G, Longini I	*Markov chains with measurement error: estimating the true course of a marker of HIV disease progression*	2 Apr	EPI*
Hendriks J, Medley G, van Druten H	*Time to AIDS estimated from a cohort of homosexual men*	2 Apr	EPI*
Bushnell C	*Smooth representations of p-adic groups I*	5 Apr	LFN*
Bushnell C	*Smooth representations of p-adic groups II*	5 Apr	LFN*
Henniart G	*Automorphic induction for GL_n over local fields*	5 Apr	LFN*
Harder G	*Comparison of trace formulae I*	6 Apr	LFN*
Harder G	*Comparison of trace formulae II*	6 Apr	LFN*
Ramakrishnan D	*On the cohomology of quarternionic quotients*	6 Apr	LFN*
Schmidt C	*Kummer congruences for Siegel modular L-functions*	6 Apr	LFN*
Rapoport M	*Local Shimura varieties I*	7 Apr	LFN*
Rapoport M	*Local Shimura varieties II*	7 Apr	LFN*
Laumon G	*Cohomology with compact support of Drinfeld modular varieties*	7 Apr	LFN*
Carayol H	*Pseudo-representations and representations of Galois groups*	7 Apr	LFN*
Kudla S	*The Siegel formula and values of L-functions I*	8 Apr	LFN*
Kudla S	*The Siegel formula and values of L-functions II*	8 Apr	LFN*

5.6 Seminars and Lectures July 1992 to June 1993

Harris M	*Periods of automorphic forms on unitary groups*	8 Apr	LFN*
Murty R	*The supersolvable reciprocity law*	8 Apr	LFN*
Hida M	*On critical values of the GL_2 L-functions I*	9 Apr	LFN*
Hida M	*On critical values of the GL_2 L-functions II*	9 Apr	LFN*
Taylor R	*Lifting modular mod L representations*	9 Apr	LFN*
Murty R	*How big is Sha?*	13 Apr	LFN*
Heath-Brown R	*The average rank of elliptic curves*	13 Apr	LFN*
Granville A	*Carmichael numbers*	13 Apr	LFN*
Cohen H	*Computing regulators and classgroups*	14 Apr	LFN*
Cremona J	*Computing the degree of a modular parametrisation*	14 Apr	LFN*
Smart N	*Finding integer points on elliptic curves*	14 Apr	LFN*
Wooley T	*Equations over finite fields*	15 Apr	LFN*
Odoni R	*Hasse-Weil L-functions of linear algebraic groups*	15 Apr	LFN*
Vaughan R	*A matrix related to the Riemann hypothesis*	15 Apr	LFN*
Rose H	*A class of elliptic curves with rank at most 2*	15 Apr	LFN*
Huxley M	*Modular L-functions (or) rational points close to curves*	16 Apr	LFN*
Granville A	*Why primes are not distributed quite as people expect*	16 Apr	LFN*
Zuang Do N	*K_2 and the p-adic Gross conjecture*	20 Apr	LFN
Clozel L	*Congruences between automorphic representations for higher groups and the Selberg trace formula*	22 Apr	LFN
Gore S, Farewell V	*Work in progress: meta-analysis of 5 seroconverter cohorts*	23 Apr	EPI*
Borcherds R	*Fusion of modules over vertex algebras*	23 Apr	
Taylor M	*Arithmetic equivariant Riemann-Roch theorems*	27 Apr	LFN*
Nelson A	*The factorisability defect*	27 Apr	LFN*
Holland D	*Chinburg's third invariant for abelian extensions of quadratic imaginary fields*	27 Apr	LFN*
Chan SP	*Associated orders of Lubin-Tate division fields*	27 Apr	LFN*
Fröhlich A	*Shadows and L-functions*	28 Apr	LFN*
Byott N	*Tame and Galois extensions with respect to a Hopf order*	28 Apr	LFN*
Maculloh L	*Realizeable relative Galois modules classes*	28 Apr	LFN*
Gore S, Farewell V	*Progress report 2: meta analysis of 5 seroconverter cohorts*	29 Apr	EPI*
Wassermann AJ	*Connes fusion and constructive conformal field theory*	30 Apr	
Blasius D	*On multiplicities for $SL(N)$*	4 May	LFN
Bloch S	*Some aspects of the theory of motives*	6 May	LFN
Maynard Smith J	*Game theory and animal communication*	10 May	INS
Blasius D	*Good reduction of shimura varieties*	11 May	LFN
Kolyvagin V	*Some remarks on Kummer's descent*	13 May	LFN
Greenberg R	*Iwasawa theory of Artin representations*	13 May	LFN
Teleman C	*Kodaira vanishing theorems for loop groups*	14 May	
Mazur B	*Turning algebra into geometry*	17 May	INS
Fontaine J-M	*Computing mod p Galois cohomology of local fields*	18 May	LFN
Blasius D	*On the cohomology of S-arithmetic groups*	20 May	LFN
Colmez P	*Adelic heights on curves*	20 May	LFN
Segal G	*Holomorphic induction and fusion*	21 May	
Feit W	*Steinberg characters*	24 May	LFN*
Crick F	*Thinking about the brain*	24 May	INS
Svensson A	*Vaccine efficacy and severity of illness: some (still?) confused ideas*	25 May	EPI
Boston N	*A programme parallel to that of Serre, Mazur, Ribet et al*	25 May	LFN
Richardson S	*Hidden Markov processes: a Gibbs sampling approach*	26 May	EPI
Awerbuch T	*Host abundance and tick dynamics: the case of Lyme disease*	26 May	EPI
Bloch S	*Polylogarithms and motives*	28 May	LFN*
Kolyvagin V	*Euler systems and their applications to arithmetic*	28 May	LFN*

5.6 Seminars and Lectures July 1992 to June 1993

Ribet K	*Points on a curve that are torsion in its Jacobian*	28 May	LFN*
Mazur B	*Torsion points on elliptic curves over number fields*	28 May	LFN*
Batchelor M	*The Kazhdan-Lusztig correspondence and fusion*	28 May	
Kurihara M	*Iwasawa theory and fitting ideals*	1 Jun	LFN
Mollison D	*Space, the next frontier*	2 Jun	EPI*
Altmann M	*High performance techniques for connecting dots*	2 Jun	EPI*
Sattenspiel L	*Where in the world is the epidemic that Carmen Sandiego started?*	2 Jun	EPI*
Morris M	*Telling tails: when data go bad*	2 Jun	EPI*
Ball F	*Groups of groups*	2 Jun	EPI*
Isham V	*Higher moments at the Newton*	2 Jun	EPI*
Nasell I	*Stochastic SIS-models*	2 Jun	EPI*
Billard L	*Stochastic models for plant diseases*	2 Jun	EPI*
Longini I	*Will the frail inherit the earth?*	2 Jun	EPI*
Cairns A	*Sensitive information*	2 Jun	EPI*
Grenfell B	*What I did on my holidays*	2 Jun	EPI*
Castillo-Chavez C	*The T^3 - Theorem or, it takes two to tango*	2 Jun	EPI*
Smith G	*Serendipitous treatments and other flukes*	2 Jun	EPI
Dye C	*No, the frail will not inherit the earth*	2 Jun	EPI*
Dietz K	*Variations on variances and covariances*	2 Jun	EPI*
Dobson A	*Et in Arcadia sumus*	2 Jun	EPI*
Roberts M	*Antipodian fauna: machoparasites*	2 Jun	EPI*
Heesterbeek H	*R_0, a worm-eaten subject?*	2 Jun	EPI*
Conrey B	*A conjecture for the sixth moment of the Riemann zeta function*	3 Jun	LFN
Bott R	*Infinite-dimensional analysis and geometry*	4 Jun	
Perrin-Riou B	*Iwasawa theory of elliptic curves I*	7 Jun	LFN
Rubin K	*Elliptic curves, p-adic heights, and derivatives*	8 Jun	LFN
Ihara Y	*Belyi functions and arithmetic surfaces*	8 Jun	LFN
Bombieri E	*A new approach to effective Diophantine approximation on G_m I*	9 Jun	LFN
Shepherd-Barron N	*Foliations and isogenies*	10 Jun	LFN
Perrin-Riou B	*Iwasawa theory of elliptic curves II*	10 Jun	LFN
Bombieri E	*A new approach to effective Diophantine approximation on G_m II*	11 Jun	LFN
Perrin-Riou B	*Iwasawa theory of elliptic curves III*	15 Jun	LFN
de Shalit U	*Refining Hida's theory*	16 Jun	LFN
Nychka D	*Splines and portents: A survey of non-parametric curve fitting and prediction*	16 Jun	EPI
Berthelot P	*A crystalline construction of rigid cohomology*	17 Jun	LFN
Wiles A	*Galois representations and automorphic forms I*	21 Jun	LFN*
Taylor R	*Galois representations attached to automorphic forms over imaginary quadratic fields*	21 Jun	LFN*
Fontaine J-M	*p-adic mixed Hodge structures*	21 Jun	LFN*
Perrin-Riou B	*Fonctions L p-adiques*	21 Jun	LFN*
Wiles A	*Galois representations and automorphic forms II*	22 Jun	LFN*
Ihara Y	*Galois Lie algebras and higher commutators of Soulé elements*	22 Jun	LFN*
Colmez P	*Values at $s = 0$ of p-adic L-functions*	22 Jun	LFN*
de Shalit U	*p-adic regulators and K_2 of curves*	22 Jun	LFN*
Wiles A	*Galois representations and automorphic forms III*	23 Jun	LFN*
Ribet K	*Torsion points $X_0(p)$*	23 Jun	LFN*
Greenberg R	*Iwasawa theory for p-adic deformations*	23 Jun	LFN*
Jannsen U	*On rigidity of K-cohomology*	23 Jun	LFN*
Rubin K	*Some thoughts on Stark's conjecture*	24 Jun	LFN*

5.6 Seminars and Lectures July 1992 to June 1993

Messing W	*Remark on the f-ness of the image of the Abel-Jacobi map*	24 Jun	LFN*
Berthelot P	*On the Bernstein inequaliy for D^+ - modules*	24 Jun	LFN*
Bloch S	*p-adic Arakelov theory*	24 Jun	LFN*
Harrison M	*On the Block-Kato conjecture for Grossencharacers of $Q(i)$*	24 Jun	LFN*
Schneider P	*Lattices in rational representations and sheaves on the Bruhat-Tits building*	25 Jun	LFN*
Tilouine J	*Deformations of Galois representations*	25 Jun	LFN*
Mazur B	*Global representations which are locally potentially crystalline*	25 Jun	LFN*

'DYN','LDT','EPI' or 'LFN' indicate that the seminar is within the 'Dynamo Theory', 'Low Dimensional Topology and Quantum Field Theory','Epidemic Models' or 'L-functions and Arithmetic' programmes; 'INS' denotes an Institute seminar. An asterisk indicates that the seminar takes place within a workshop