Mathematical Sciences Institute

Introduction

The School of Mathematical Sciences was established in 1989 with the aim of unifying activities in the mathematical sciences across the University. It was renamed the Mathematical Sciences Institute in 2002. Its purpose is to promote and develop research, teaching and consulting in the mathematical sciences (including mathematics, statistics, mathematical physics and mathematical computation). As of June 2005, its staff includes three Fellows of the Royal Society, this being all Fellows in the mathematical sciences residing in Australia, ten Fellows of the Australian Academy of Science and nearly half of all the winners of the Medal of the Australian Mathematical Society (in fact four in the last seven years).

Structure

Major Discipline

Mathematics, Physics

Other Disciplines

Information Science

Research Directions

The Mathematical Sciences Institute (MSI) has two Academic Organisational Units. These are the Department of Mathematics (DoM) and the Centre for Mathematics and its Applications (CMA). The DoM is also a Department in the Faculty of Science and its staff is responsible for the teaching of mathematics courses at ANU. The CMA is divided into eight programs with the following main interests:

- **Advanced Computation and Modelling:** From theoretical analysis of numerical algorithms to practical implementation of software on parallel supercomputers; applications include data mining, optimisation and solving pde's;
- **Astronomy and Astrophysics:** Modelling of accretion disks, modelling of stars and stellar atmospheres, and fluid mechanical problems;
- **Algebra and Topology:** Algebraic geometry, algebraic K-theory and homotopy theory, as well as the more traditional areas of finite and discrete groups, and representations of Lie algebras;
- **Mathematical Physics:** Exactly solved models in statistical mechanics, related combinatorics, spin ladders, chiral Potts model, theoretical morphology and stromatolites, algebraic geometry and quantum field theory;
- **Analysis and Geometry:** Several complex variables, Banach algebras, spectral theory of operators, harmonic analysis on Lie groups, manifolds and Lipschitz

surfaces, microlocal analysis on manifolds with corners, non-commutative geometry, and applications to pde's and Maxwell's equations;
- **Statistical Science:** Applied statistics, bioinformatics, statistical genetics, biometrics, medical statistics, epidemiology, survival analysis, bootstrap methods, curve estimation, spatial statistics, data mining and robust statistical inference;
- **Applied and Nonlinear Analysis:** Nonlinear elliptic and parabolic partial differential equations and applications. Geometric evolutions and curvature problems. Variational problems in geometry and physics. Optimal transportation. Fractal geometry and applications;
- **Stochastic Analysis:** Applied probability with interests in general properties of a range of models as well as in particular models; applications include mathematical finance, telecommunication systems and epidemics.

History

The Chair of Mathematics, and effectively the Department of Mathematics was established in the Research School of Physical Sciences (RSPhysS) in 1959 on the initiative of the then Director Sir Mark Oliphant (Ophel and Jenkin 1996). The foundation head was Professor B. H. Neumann who took up his post at the beginning of 1962 and held it until his retirement until in 1975.

The original Department was designed to have nine tenured positions, including three professors and a corresponding number of non-tenured posts (Ophel and Jenkin 1996). The Department was reduced in size in 1970 with the creation of the Department of Applied Mathematics due to the loss of six positions. The Department of Mathematics had a major impact on the international standing of mathematics in Australia both in practical and pure mathematics. In practical mathematics it was originally involved with Group Theory, Number Theory, Fluid Mechanics, Functional and Harmonic Analysis and Differential Equations, and later also in Operator Algebras and partial Differential Equations. The outstanding achievements of the Department in pure mathematics can be seen in the fact that it was “for some time the main producer of doctorates in pure mathematics in the country” (Ophel and Jenkin 1996:102).

The pressure for the foundation of a School of Mathematics finds it impetus in the structure of the RSPhysS. The diverse nature of research in the RSPhysS and the strong departmental identities meant that after Oliphant’s retirement from the Directorship there were difficulties in trying to find someone who could fill the position who would be able to exercise the appropriate level of academic leadership (Foster and Varghese 1996). By the mid 1960’s there was continuing pressure from the geophysicists, astronomers, engineers and mathematicians to break away from Physical Sciences and establish new schools of their own (Foster and Varghese 1996). Sir Ernest Titterton, the Director of RSPhysS in the early seventies and Sir Mark Oliphant were concerned about this fracturing of the RSPhysS, arguing that if these Departments were given independent schools it would threaten the school and structure of the Institute of Advanced Studies as a whole (Foster and Varghese 1996).

In January of 1989 the School of Mathematical Sciences (SMS) was established as a separate entity from the RSPhysS. The Mathematical Sciences Institute was officially created in 2002 with two divisions: The Centre for Mathematics and its Applications and the Department of Mathematics. When it was established the purpose of the School was to conduct and promote research, teaching and consulting in the mathematical sciences (including mathematics, statistics, mathematical and statistical computation, mathematical physics) and to provide a structure for collaboration in these fields between the Institute of Advanced Studies and The Faculties. This places the MSI in a unique position amongst the research schools at ANU. It has links with both the IAS and the Faculties. The Centre for Mathematics and its Applications has the primary function of a research institute in the mathematical sciences, fulfilling both national and international roles in that capacity. The Department of Mathematics has the responsibility for undergraduate and honours teaching in mathematics in the Faculties.

The Research

Centre for Bioinformation Science (CBiS)

The CBiS is a joint venture between the MSI and the JCSMR. The development of biologically relevant statistical foundations for post-genome biology and biotechnology has entered a critical stage, as an exciting era built on continuing progress in high throughput data generation technology has been heralded in modern biology. It is widely anticipated that the information extracted from the massive quantities of data being generated will enable fundamental breakthroughs in mankind's goal of understanding biological systems. Critical to achieving this goal will be the development of fast, accurate, statistical procedures. Today, as experimental techniques are being developed for studying genome wide patterns, such as expression arrays, the need to appropriately deal with the inherent variability has been multiplied astronomically. Not only must methodologies be developed which scale up to handle the enormous data sets generated in the post-genomic era, they need to become more sensitive to the underlying biological knowledge and understanding of the mechanisms that generate the data. Research has reached an exciting and challenging stage at the interface of computational statistics and biology. The need for novel approaches to handle the new genome-wide data (including that generated by microarrays) has coincided with a period of dramatic change in approaches to statistical methods and thinking. This ‘quantum’ change has been brought about, or even has been driven by, the potential of ever more increasing computing power. What was thought to be intractable in the past is now feasible, and so new methodologies need to be developed and applied. Unfortunately too many of the current practices in the biological sciences rely on methods developed when computational resources were very limiting and are often ad-hoc methods (that are commonly referred to as ‘statistical’ or ‘computational’ methods) that make many assumptions for which there is no (biological) justification. The challenge now is to creatively combine the power of the computer with relevant biological and stochastic process knowledge to derive novel approaches and models, using minimal assumptions, and which can be applied at genomic wide scales. Such techniques comprise the foundation of bioinformatic methods in the future.

Centre of Excellence for Mathematics and Statistics of Complex Systems (MASCOS)

MASCOS comprises thirteen Chief Investigators from The University of Melbourne, Australian National University, The University of New South Wales, The University of Queensland and La Trobe University, all of who have international reputations for their research in mathematics and statistics. The Centre's mission is to stimulate research activity in mathematical and statistical modelling of complex systems. In doing so, the Centre will conduct research on criticality and phase change (e.g. in control of traffic queuing, and understanding catastrophic failure), Monte Carlo methods (e.g. in modelling financial systems), statistical modelling (e.g. in understanding telephone and internet traffic), dynamic systems (e.g. in meteorology, oceanography, and the behaviour of polymers and composite materials), risk modelling (e.g. in insurance, national security and health interventions), and advanced computation (e.g. to speed industrial design and to predict large-scale, long-term environmental impacts). The Centre will also reinforce the importance of mathematics and statistics across the spectrum of Australia's scientific and technological development. To achieve this, the Centre will maintain an extensive and vigorous outreach program, encompassing schools, commerce and industry, and the broader research community in Australia.

Today and the Future

The broad long-term goals of the MSI are to:

- Continue Research Excellence;
- Attract high quality staff in cross disciplinary areas and enhance cross campus cooperation in the mathematical sciences;
- Diversify research funding sources;
- Appoint new staff with exceptional research credentials to the Department of Mathematics;
- Improve research led teaching in mathematics and statistics at ANU.

Beyond this the MSI is recognised as a leading international research group in statistical science and fundamental mathematics. MSI has always continued to work towards its goal of achieving similar eminence in selected areas of cross-disciplinary mathematics. Its short term goals relate to this through expanding interaction with NICTA and strengthening the research and cross campus links of CBiS; strengthening research cooperation with RSISE; and developing mathematical physics in cooperation with RSPhysSE.

Deans

- Professor Chris Heyde: 1989-1991
- Professor Neil Trudinger: 1992-2000
- Professor Peter Hall: 2001

- Professor Alan Carey: 2002 – Present

Awards

1981 Neil Trudinger	Medal of the Australian Mathematical Society
1986 Peter Hall	Medal of the Australian Mathematical Society
1987 Rodney Baxter	Danny Heinemann Medal, American Physical Society
1989 Peter Hall	Lyle Medal, Australian Academy of Science
1989 Peter Hall	Committee of Presidents of Statistical Societies Award
1990 Peter Hall	Pitman Medal, Statistical Society of Australia
1991 Sue Wilson	Fellow of the American Statistical Association
1994 Joe Gani	Pitman Medal, Statistical Society of Australia
1994 Rodney Baxter	Massey Medal, British Institute of Physics
1995 Peter Hall	Hannan Medal, Australian Academy of Science
1995 Chris Heyde	Hannan Medal, Australian Academy of Science
1995 Chris Heyde	Lyle Medal, Australian Academy of Science
1995 Alexander Isaev	Humboldt Fellowship, Humboldt Foundation
1995 Eamonn O'Brien	Humboldt Fellowship, Humboldt Foundation
1995 John Urbas	Humboldt Fellowship, Humboldt Foundation
1996 Neil Trudinger	Humboldt Award, Humboldt Foundation
1996 Neil Trudinger	Hannan Medal, Australian Academy of Science
1996 Peter Hall	Fellow of the American Statistical Association
1997 Murray T. Batchelor	Pawsey Medal, Australian Academy of Science
1997 Peter Hall	André-Aisenstadt Chair at the University of Montreal
1997 Peter Hall	Degree Doctor *honoris causa*, Catholique Universite de Louvain
1998 Ben Andrews	J.G. Russell Award, Australian Academy of Science
1998 Murray T. Batchelor	Medal of the Australian Mathematical Society
1999 John Urbas	Medal of the Australian Mathematical Society
1999 John Urbas	ARC Senior Fellowship
1999 Daryl J. Daley	Humboldt Award, Humboldt Foundation
2000 Daryl J. Daley	Humboldt Award, Humboldt Foundation
2000 Daryl J. Daley	Alexander von Humboldt Foundation Prize
2000 Joe Gani	Inaugural Moyal Medal, Macquarie University
2001 M.F. Newman	Listed in 2000 Most Outstanding Intellectuals of the 20th Century
2001 Bernhard Neumann	Doctor of Science, *honoris causa*, ANU
2002 Xu-Jia Wang	Medal of the Australian Mathematical Society

2002 Alan McIntosh	Moyal Medal for contributions to Mathematics
2002 Alan Welsh	Fellow of the American Statistical Association
2003 Ben Andrews	Medal of the Australian Mathematical Society
2003 Andrew Hassell	Medal of the Australian Mathematical Society
2004 Richard Brent	Federation Fellowship

References

Foster, S.G. and Varghese, M.M. (1996): *The Making of the Australian National University, 1946-1996*. Allen and Unwin, Sydney.

MSI Website: http://wwwmaths.anu.edu.au

Ophel, T. and Jenkin, J. (1996): *Fire in the Belly: The First Fifty Years of the Pioneer School at the ANU*. Institute of Advanced Studies, ANU, Canberra.