PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Philosophical Transactions into the 21st Century: an editorial

J. M. T. Thompson

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THE ROYAL SOCIETY

Philosophical Transactions into the 21st century: an editorial

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It was a great pleasure for me to take over as the Editor of the *Philosophical Transactions of the Royal Society* (Series A: Mathematical, Physical and Engineering Sciences) in July 1998. The transition was made particularly smooth by the help and advice of the experienced outgoing Editor, Frank Smith, who is a friend and colleague at University College London, where he holds the Goldsmid chair in applied mathematics. Frank had been the Editor for nearly a decade in a period of much change and development, and his policy of concentrating on cross-disciplinary research and applications has helped to keep the journal at the leading edge of the physical sciences. I had already served on the Editorial Board for many years, and had organized five interdisciplinary Themes covering nonlinear dynamics, engineering vibrations, electronics, solid mechanics, and flight instabilities of aircraft. So I had been closely involved with the journal for many years, and had seen at first hand Frank's leadership and initiative.

The Royal Society was founded in 1660 to promote the new or experimental philosophy, embodying the principles envisaged by Sir Francis Bacon. Henry Oldenburg was appointed as the first (joint) secretary to the Society, and on 27 March 1665 he published his correspondence with leading European scientists as the *Philosophical Transactions*. This has appeared continuously ever since, and has the prestige of being the world's longest running scientific journal. In its formative years, Isaac Newton published 17 papers in the journal. His first paper, 'New theory about light and colours', effectively served to launch his scientific career in 1672. In the following month, his new reflecting telescope was described, and the original drawing from the journal is reproduced in figure 1.†

Subsequently, the famous brachistochrone problem, posed by Johann Bernoulli, was published anonymously by Newton in the issue of February 1697. In this way, *Phil. Trans.* played a vital role in the new spirit of enquiry that led to the blossoming of mathematical creativity in the latter part of the 17th century. This was crowned by the publication of Newton's *Principia*, which was reviewed anonymously by Halley in the journal in 1687. Under Newton's Presidency, from 1703 to his death in 1727, the reputation of the Society was firmly established among the scholars of Europe, and today it is the UK's academy of science, an independent organization promoting the natural and applied sciences.

The original journal created by Oldenburg has branched and expanded over the years to give the four Royal Society journals of today. The physical sciences are served

† 'An account of a new kind of catadioptrical telescope invented by Mr. Newton, Fellow of the R. Society, and Professor of Mathematiques in the University of Cambridge.' *Phil. Trans. R. Soc. Lond.* **7**, 4004–4010 (1672).

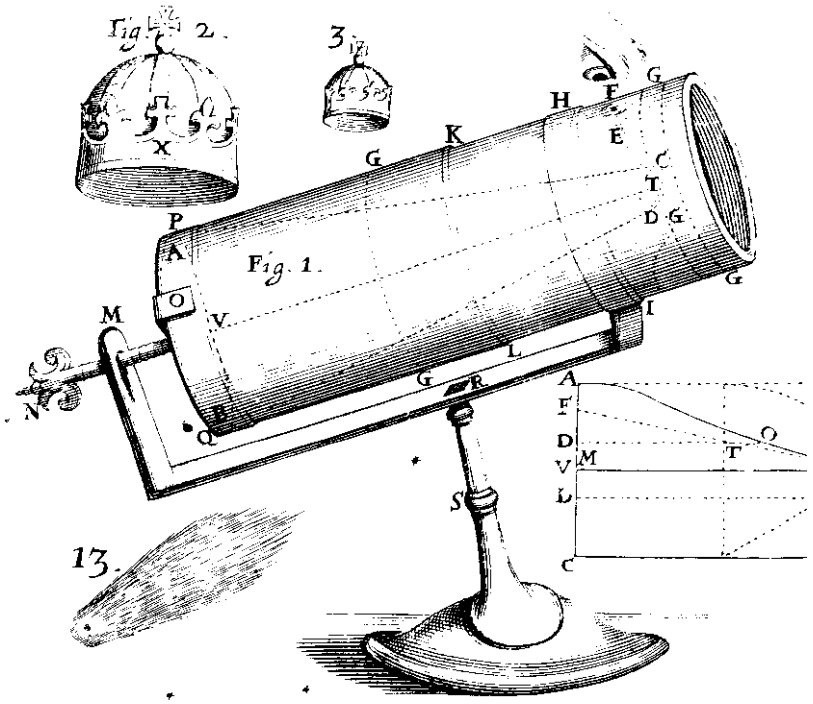

Figure 1. Newton's reflecting telescope. This image appears as figure 1 of tab. 1 at the front of vol. 7 of *Philosophical Transactions of the Royal Society* and is referred to in the letters following on pp. 4004–4010 of that volume.

by the *Proceedings of the Royal Society* (Series A) and the *Philosophical Transactions of the Royal Society* (Series A), while the biological sciences are served by two corresponding Series B journals. Of these four journals, the two *Proceedings* concentrate on publishing individual submitted research papers, while the *Transactions* publish the papers presented at the Society's Discussion Meetings as well as Prize Lectures, invited reviews and Themes. So today, each issue of *Phil. Trans.* A is typically devoted to a single area of the physical sciences. This area will normally define a research frontier that is advancing rapidly, often bridging traditional disciplines. Some idea of the recent subject coverage of *Phil. Trans.* A, is given in table 1.

Here a discussion issue will be dedicated to the proceedings of one of the Society's celebrated Discussion Meetings, which regularly bring together distinguished scientists from around the world. A noteworthy example is issue 1743, devoted to theoretical and experimental work on quantum computers: the paper by Mosca *et al.* in the current Millennium collection is also devoted to this subject. These computers seek to make use of large-scale quantum coherence and quantum entanglement. They have enormous potential, and could offer computational processes of a fundamentally different character from those which have been used to date. Figure 2, taken from the paper by Bouwmeester *et al.* (1998), illustrates the fascinating subject of quantum teleportation.

A Theme issue of *Phil. Trans.* A is typically organized by a small number of leading international scientists. They will often have been invited by the Editor to prepare the Theme, although unsolicited suggestions for themes are always welcome.

Table 1. *Issues devoted to Discussions and Themes, July 1998 to December 1999*
(Gaps in the issue numbers correspond to the (last) issues devoted to contributed papers.)

1742	Discussion (M. Blamire, L. F. Cohen, D. M. Edwards and J. L. Macmanus-Driscoll) Understanding and utilizing colossal magnetoresistance materials
1743	Discussion (A. Ekert, R. Jozsa and R. Penrose) Quantum computation: theory and experiment
1744	Theme (W. Gelletly) Science with beams of radioactive nuclei
1745	Theme (J. M. T. Thompson and F. B. J. Macmillen) Nonlinear flight dynamics of high-performance aircraft
1747	Discussion (D. Muir Wood, G. S. Boulton and J. M. Rotter) Mechanics of granular materials in engineering and Earth sciences
1748	Theme (S. R. Bishop and D. D. Drysdale) Fire dynamics
1750	Discussion (G. P. Efstathiou, R. S. Ellis, J. E. Gunn and D. York) Large-scale structure in the universe
1751	Theme (J. R. Blake) Acoustic cavitation and sonoluminescence
1752	Discussion (C. Windsor, M. Keilhacker, J. D. Lawson, G. J. Pert and D. C. Robinson) The approach to ignited plasma
1753	Discussion (R. S. White, R. F. P. Hardman, A. B. Watts and R. B. Whitmarsh) Response of the Earth's lithosphere to extension
1754	Theme (C. J. Budd and A. Iserles) Geometric integration: numerical solution of differential equations on manifolds
1755	Theme (N. J. Mason and K. Burnett) Atomic, molecular and photon collision physics: new challenges and new opportunities
1756	Discussion (M. F. Ashby, F. J. Humphreys, C. M. Sellars, H. R. Shercliff and M. J. Stowell) Deformation processing of metals
1757	Discussion (N. J. Shackleton, I. N. McCave and G. P. Weedon Astronomical (Milankovitch) calibration of the geological time-scale
1758	Theme (J. N. Dewynne, S. D. Howison and P. Wilmott) Mathematics of finance
1759	Theme (L. H. Townend) Hypersonic aircraft: lifting re-entry and launch
1760	Discussion (B. W. Silverman and J. C. Vassilicos) Wavelets: the key to intermittent information?
1761	Theme (D. K. Bowen and B. K. Tanner) X-ray topography and crystal characterization
1762	Discussion (P. Day and A. E. Underhill) Metal–organic and organic molecular magnets
1763	this issue
1764	Theme (K. N. C. Bray and N. Nikiforakis) Combustion science at the end of the Millennium

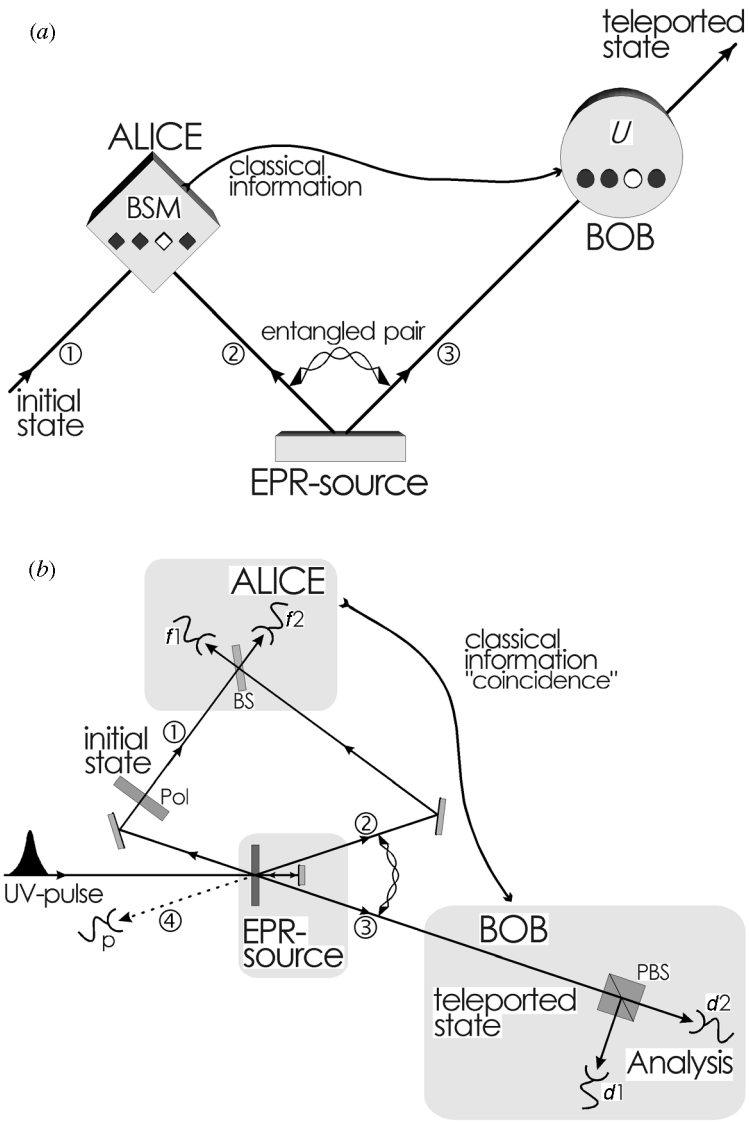

Figure 2. Diagram illustrating the principle of quantum teleportation, showing (*a*) the scheme and (*b*) the experimental set-up. Reproduced from vol. 356 of *Philosophical Transactions of the Royal Society* (see Bouwmeester *et al*. 1998).

Whether solicited or unsolicited, organizers are asked to prepare a brief summary of the proposed theme. This must explain why the topic is innovative and timely, and give a provisional list of the research papers and their authors. Themes should be normally about 200 journal pages in length, and contain perhaps 12 research papers. It is suggested that the first paper should be a tutorial or review, which will serve to introduce the theme to the more general reader. If this summary is approved by the editor, the organizers will be asked to solicit the contributions and subsequently have all papers subjected to a rigorous peer review. A recent Theme,

in issue 1755, is devoted to the collision physics of atoms, molecules and photons. In this, a scheduled experiment on antihydrogen is described by Laricchia & Charlton (1999) in their paper on collisions involving antiparticles: the ATHENA apparatus, taken from Holzscheiter *et al.* (1997) is illustrated in figure 3. Taken from the same theme, figure 4 shows theoretical results for the chaotic dynamics of the hydrogen atom, discussed by Monteiro *et al.* (1999). Aspects of classical chaos are discussed in the second Millennium issue, by Jaroslav Stark in his essay on time-series analysis.

A new initiative that I am keen to promote is the publication of the proceedings of conferences and symposia organized by other organizations outside the Royal Society. These must be of the highest scientific quality, and all papers must be thoroughly peer reviewed. A single issue would normally be devoted to the meeting, so for a large conference only the keynote lectures could be accommodated. Proposals for such an issue are always welcome.

The physical appearance of *Phil. Trans.* A has naturally changed dramatically over the years, and today the use of the latest technologies in processing, printing and disseminating the papers makes the world's oldest scientific journal one of the most modern and forward-looking. High-quality typesetting is generated from authors' electronic files using the TEX system, and the one-column format facilitates the reproduction of complex mathematics. The journal is published monthly in both paper and electronic format. In keeping with its distinguished history, it has a worldwide circulation and a high scholarly reputation. On becoming Editor, I was particularly thrilled to be involved in the design of the first-ever illustrated cover, which has been in use since January 1999: and now a new illustrated cover has been designed for the present publication.

Phil. Trans. has been published continuously for one-third of this millennium, so it seemed natural to plan some special issues to mark the arrival of the 21st century. For the physical sciences, the result is the present special issues of *Phil. Trans.* A: while for the biological sciences there is a corresponding special issue of *Phil. Trans.* B organized by its Editor, Semir Zeki, who is co-head of the Wellcome Department of Cognitive Neurology at UCL. For the special A-side issues, I decided to invite leading young scientists, including in particular past and current holders of Royal Society Research Fellowships, to write articles reviewing their field of work and looking forward to new developments that might emerge in the next millennium. They were encouraged to be more speculative, and perhaps more provocative, than they would normally be in a review article, and to write for a general scientific audience. The papers were subjected to a refereeing process which took account of the above criteria. As far as possible, authors were asked to make the articles well illustrated with diagrams and photographs, while keeping detailed mathematics to a minimum. In the event, we have included over 50 colour pictures in this special publication, and as a personal touch, have included photographs and brief profiles of the authors.

A key strategy, which has inevitably influenced the make-up and coverage of the physical science issues, was to invite all holders of the Royal Society's University Research Fellowships to submit contributions. These prestigious fellowships are held by some of the brightest young scientists in the country, and at the present time there are about 278, with perhaps one-half working in the physical sciences. This invitation, together with an open, worldwide call for papers, attracted an excellent response and about 70 abstracts were received. In assessing these, I was looking for

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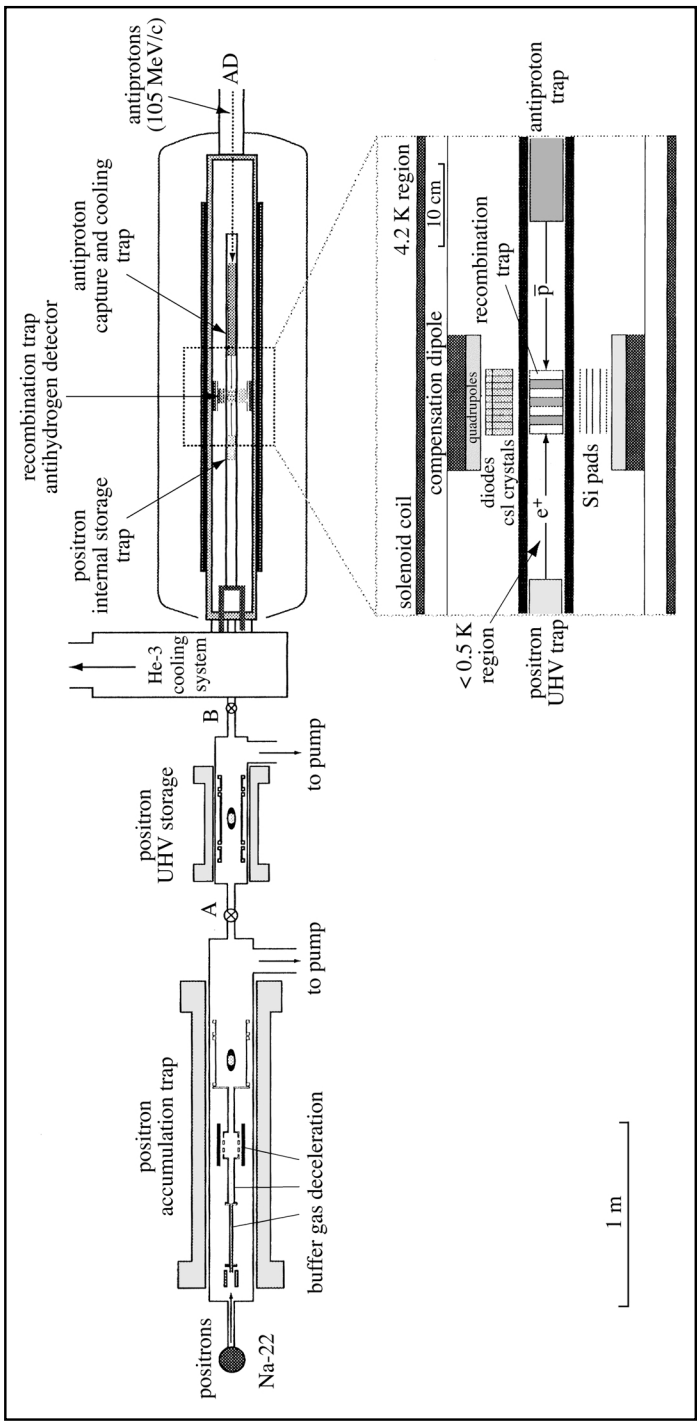

Figure 3. Schematic illustration of the apparatus of a scheduled antihydrogen experiment employing positron and antiproton traps. Reproduced from vol. 357 of *Philosophical Transactions of the Royal Society* (see Laricchia & Charlton 1999) after Holzscheiter *et al.* (1997).

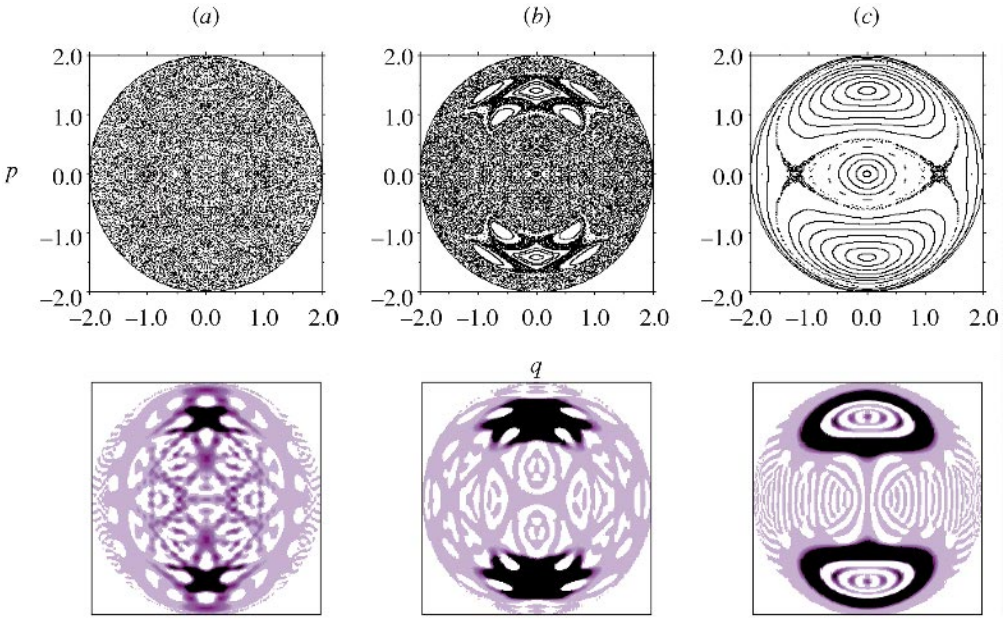

Figure 4. Transition from regular to chaotic dynamics for a hydrogen atom in a magnetic field as the energy is increased, showing three Wigner functions and classical Poincaré sections. Reproduced from vol. 357 of *Philosophical Transactions of the Royal Society* (see Monteiro *et al*. 1999).

contributions that were reasonably broad, covering a subject that is timely, topical, growing rapidly, and likely to be of long term interest and significance. A paper that described some recent cutting edge research, as well as putting it in its wider context, and looking forward to the future was an ideal candidate.

The result of this careful selection is the present *Science into the Next Millennium: Young Scientists give their Visions of the Future*, containing 46 articles. The authors have an average age of about 34 years, and over 30 of them currently hold Royal Society University Research Fellowships. This 'Millennium Issue' is spread over three issues of the journal as follows. Issue I (December 1999) is devoted to Astronomy and Earth Sciences and contains 13 papers covering cosmology, stars and the Solar System, the Earth's interior, the Earth's surface and climate. Issue II (January 2000) is devoted to Mathematics, Physics and Engineering and contains 19 papers covering mathematics, quantum and gravitational physics, electronics, mechanics of solids and fluids, advanced computing, telecommunications. Issue III (January 2000) is devoted to Chemistry and Biological Physics containing 14 papers, covering reaction dynamics, experiments and calculations, new processes and materials, physical techniques in biology, developmental biology, modelling biological systems.

Sir Roger Penrose, the Emeritus Rouse Ball Professor of Mathematics at the University of Oxford, has kindly written an introductory article picking out significant common threads in all the papers, and presenting additionally his own views on likely developments in fundamental physics in the next century. It is hoped that selected papers from these three issues will form the basis for three popular scientific books, to be published by Cambridge University Press.

I hope that this collection will give a unique snapshot of the state of physical

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science at the turn of the millennium, of interest to research scientists and more generally to the public at large. I am sure the obvious excitement and enthusiasm of the young scientists will be strongly conveyed to all our readers. I, myself, look forward to leading *Phil. Trans.* A into the new millennium, and building on its influential 335 years at the cutting edge of scientific progress.

I am pleased to acknowledge the continuing help and support of all members of the Publications Department at the Royal Society. I am particularly grateful to Cathy Brennan for her enthusiasm and good humour during all the hard work of putting this Millennium Issue together.

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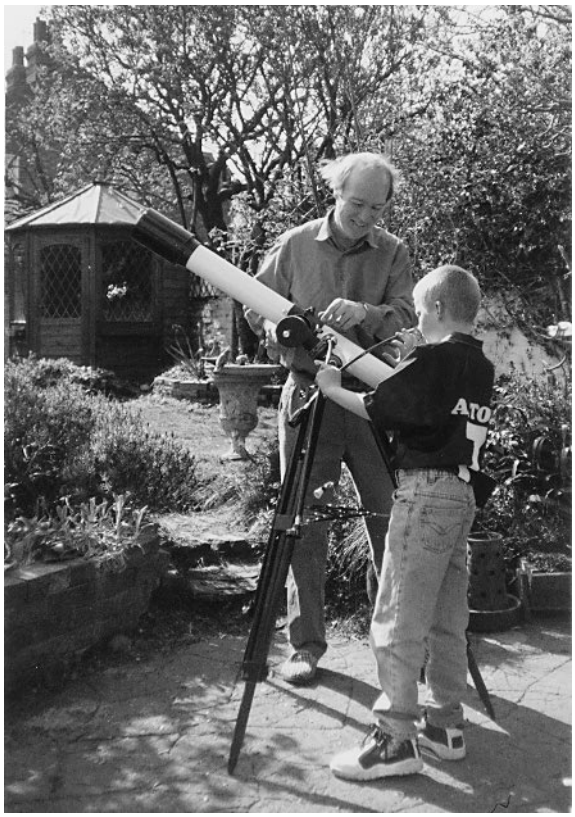
AUTHOR PROFILE

J. M. T. Thompson

Born in Cottingham, Yorkshire, Michael Thompson studied at Cambridge, where he graduated with first class honours in Mechanical Sciences in 1958, and obtained his PhD in 1962. He was a Fulbright researcher in aeronautics at Stanford University, and joined University College London in 1964. He has published four books on bifurcation theory and was appointed Professor at UCL in 1977. Michael was elected a Fellow of the Royal Society in 1985, and was awarded the Ewing Medal of the Institution of Civil Engineers. He was a Senior SERC Fellow and served on the IMA Council. In 1991 he was appointed Director of the Centre for Nonlinear Dynamics. Aged 62, his scientific interests include nonlinear dynamics and their applications: recreations include walking, tennis and astronomy with his grandson Ben, shown below.



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