Ten years of science in *Philosophical Transactions A*: with the University Research Fellows

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In this brief paper, I review my 10 years as the Editor of the *Philosophical Transactions of the Royal Society A*. I look at the content of the journal over the years, relating it to a full classification of the physical sciences based on the interests of fellows and research fellows of the Royal Society. I show that the journal has performed well in terms of downloads, citations and impact factors. Innovations such as the Millennium and Christmas Issues for young scientists have stimulated a close and enjoyable interaction with the Society’s research fellows. In addition to authoring papers and organizing themes, they have always been keen to help with the refereeing processes. They provided exciting demonstrations for a Summer Science exhibit that I organized to highlight the work of the journal, and five of the research fellows now sit on the Editorial Board. Looking to the future, I describe the new subject clusters that are being introduced as the journal steps up its publication rate from one issue per month to two, starting in January 2008.

Keywords: physical sciences; research frontiers; citation; impact

1. Introduction

Coming to the end of my extended term as Editor of the *Philosophical Transactions of the Royal Society A* (Mathematical, Physical and Engineering Sciences) has prompted me to look back at 10 years working on the journal and with particular pleasure at my close involvement with the Royal Society’s research fellows. Collaborations with these fellows started in earnest when I invited them to contribute to special issues for young scientists designed to celebrate the new Millennium. These links were subsequently strengthened by the Christmas Issues, also called Triennial Issues because their content makes a 3-year cycle through the physical sciences. One happy result is that five (current or former) research fellows are now sitting on the Editorial Board of the journal.

It was a great privilege for me to take over as the Editor of the journal in July 1998. The transition was made particularly smooth by the help and advice of the experienced outgoing editor, Frank Smith, who was a friend and colleague at jmtt2@damtp.cam.ac.uk

One contribution of 20 to a Triennial Issue ‘Chemistry and engineering’.
University College London where he holds the Goldsmid chair in applied mathematics. At that time, it had just been decided to phase out the publication of individual submitted articles, making each issue a collection of papers focused on a single research topic. So, now, each issue is either a Discussion Meeting, publishing the proceedings of one of the Society’s meetings, or a free-standing Theme Issue creating a ‘symposium’ in print.

An early initiative that I promoted was the publication of the proceedings of symposia organized by other organizations outside the Royal Society. These were to be of the highest scientific quality, with each paper being subjected to a rigorous peer review; usually only the keynote lectures could be accommodated. Proposals for such issues are always welcome, and a recent study has shown that these external proceedings perform very well in terms of downloads and citations as seen in Figure 1.

In the top histogram, the topics of some of the very high and very low download figures are indicated. The three highest, in both downloads and citations, are all Discussion Meetings. The fourth for downloads, an external conference on the Big North Sea Flood, has a surprisingly low number of citations. This shows that the two measures are far from synonymous. The best of the normal Themes, under both measures, is the one devoted to Scientific Grid Computation. The 2005 Triennial Issue scores particularly well on citation.

Figure 1. A download and citation study based on the 24 issues published in 2005 and 2006. Note that we expect the numbers for 2006 to be lower than those for 2005 because less time has elapsed since publication. Discussion Meetings are shown in red, normal Themes in blue, Themes based on external conferences in green and Triennial Issues in white.
The impact record of the journal is shown in figure 2. Both of the A-side journals (Proc. R. Soc. A and Phil. Trans. R. Soc. A) are classified on the web under Multidisciplinary Sciences, in which the current top four journals are Science, Nature, Proceedings of the National Academy of Sciences (USA), followed by the present journal, Phil. Trans. R. Soc. A. Of these four leading journals, only Phil. Trans. R. Soc. A has the maximum cited half-life of greater than 10 years: this emphasizes the long-term significance of its material.

2. Involvement of the University Research Fellows

The overall statistics for the Millennium and Triennial Issues, summarized in table 1, show the pivotal role played by the Royal Society’s University Research Fellows (URFs; in which I include Dorothy Hodgkin Fellows, etc.). The total number of authors stands at 203, of which 86 were, at one time or another, URFs. The contributions of the URFs have, however, far exceeded their roles as authors. Many have helped to referee papers and theme proposals, while three (Andrew Coates, Peter Kohl and Allan McRobie) of them responded to invitations to organize Theme Issues. These are tasks that the fellows are well placed to do while they are at the cutting edge of their fields, with no teaching or administrative responsibilities. When I organized a display at one of the Society’s Summer Science Exhibitions to show the work of the journal and highlight the Millennium Issues, two URF authors enthusiastically displayed their latest research using lasers and liquid nitrogen. Finally, five of the URFs are now sitting on the Editorial Board of the journal, two of whom are associate editors in charge of subject clusters. My sincere thanks go out to Andrew Coates, Giles Davies (in charge of the nanocluster), Peter Kohl, Peter Sammonds and Rowan Sutton (in charge of the environment cluster). Similar thanks should also go out to the fellows supported by the various UK Research Councils (EPSRC, PPARC, NERC, etc.) identified in table 1 by RC. These fellows are increasingly participating in the Triennial Issues in response to invitations that we now send directly to the funding agencies.

3. The journal and its coverage

The journal was started, only 5 years after the foundation of the Royal Society itself, on 27 March 1665 when Henry Oldenburg published his correspondence with leading European scientists as the Philosophical Transactions. The journal
Table 1. Millennium and Triennial statistics. (Here, M denotes Millennium and T denotes Triennial. Under issue is given the issue publication number. Pprs signifies the number of contributed papers. The authors’ column gives the number of authors, including co-authors, followed in brackets by the number of female authors. Age denotes the average age of the corresponding authors in years. The job abbreviations, covering all authors, are as follows. URF, holding, or has held, a Royal Society Research Fellowship; RC, holding, or has held, a fellowship funded by a UK Research Council; RF, other research fellows and post-doctoral authors; Lec, lecturers and senior lecturers; R+P, readers and professors; Oth, others.)

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has appeared continuously ever since and can claim to be the world’s longest running scientific journal. It is a measure of its stature that all issues of the journal, from 1665, are archived electronically by JSTOR in the USA (www.jstor.org), accessible via the Royal Society journal webpage (www.journals.royalsoc.ac.uk), and through university libraries.

During my editorial years, I have been concerned to ensure a wide and inclusive coverage of physical science, and I constructed a histogram (see appendix A) based on the declared interests of Fellows of the Royal Society. This clearly has an inevitable historical and backwards-looking bias, and to balance this I have superimposed (to the right) a histogram of the topics of the current holders of Royal Society research awards.

Comparing the two histograms serves to highlight the growing areas of physical science. Four areas of rapid growth have in fact been designated as ‘subject clusters’ for the journal as described in §6. Briefly, these are nanoscience and quantum computing, environmental change and renewable energy, dynamical systems and complexity, and biological mathematics and medical engineering.

To give an overview of the coverage of the journal over the last 10 years (1998–2007 inclusive), I have inserted over the histograms a D for every Discussion and a T for every Theme. Meanwhile, an M signifies an article in one of the three Millennium Issues. Given the highly interdisciplinary nature of today’s research, assessing where to position a topic in the histogram was of course a difficult (and often rather personal and arbitrary) task. An extreme example of this difficulty surrounds the fashionable prefix ‘nano’ which is presumably popular with funding agencies. The prefix appears five times in all, twice in physics, once in chemistry and twice in engineering. Looking, for example, at the departments of the authors, an issue could often be placed quite satisfactorily in any of these five locations. However, despite this difficulty, I do believe the diagrams give a useful, broad-brush overview of the coverage.

As we would expect, the coverage is not entirely uniform, and this can be attributed to a number of factors. The present journal has (like Proc. R. Soc. A) always been strong in applied mathematics and mechanics, so researchers in these areas are more aware of the journal, and more likely to propose themes. Meanwhile, at editorial board meetings, some members state quite categorically that no one in their field would contemplate sending a paper or theme to either of the A-side journals!

The distribution of the Discussion Meetings is of course in the hands of the Society’s Hooke Committee, but again the proposals submitted are influenced by historical factors. Unlike astronomers, engineers rarely send in material.

The details of how the histogram was compiled are given in appendix A. An alternative and more detailed view of recent journal content is given in appendix B, which lists all titles published during the 6-year period, 2001–2006.

4. The Millennium Issues

The approach of the new Millennium presented the opportunity to plan one or more special issues of Phil. Trans. R. Soc. A to celebrate its arrival. The journal, which had in various guises been published for one-third of the outgoing Millennium, was an ideal vehicle for charting research frontiers across the physical sciences. Accordingly, I decided to invite young scientists, worldwide, to

Phil. Trans. R. Soc. A (2007)
write articles reviewing their field of work, presenting some of their recent research and looking forward to new developments. 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. To adequately cover the physical sciences, I decided that three issues would be needed, and as a personal touch, I included photographs and brief CVs of the authors.

A key strategy, which inevitably influenced the make-up and coverage of the issues, was to invite all URFs to submit contributions. These fellows comprise some of the brightest young scientists in the country, and at any one time there are approximately 270, with a nominal one-half working in the physical sciences. This invitation, together with an open, worldwide call, attracted an excellent response and approximately 70 abstracts were received for assessment.

The result of a careful selection was a collection of 46 papers entitled *Science into the Next Millennium: Young Scientists give their Visions of the Future*. The collection was spread over three issues of the journal as follows: Millennium Issue I (December 1999) was devoted to Astronomy and Earth Sciences and contained 13 papers covering cosmology, stars and the Solar System, the Earth’s interior and the Earth’s surface and climate; II (January 2000) was devoted to Mathematics, Physics and Engineering and contained 19 papers covering mathematics, quantum and gravitational physics, electronics, mechanics of solids and fluids, advanced computing and telecommunications; and III (January 2000) was devoted to Chemistry and Biological Physics and contained 14 papers covering reaction dynamics, experiments and calculations, new processes and materials, physical techniques in biology, developmental biology and modelling biological systems. The authors had an average age of approximately 34 years, and over 30 of them were currently URFs.

Sir Roger Penrose, the Emeritus Rouse Ball Professor of Mathematics at Oxford, kindly wrote an introductory article picking out significant common threads in all of the papers and presenting his own views on the probable developments in fundamental physics in the next century. The issues gave a unique snapshot of the state of physical science at the turn of the millennium, of interest to researchers and the public at large. The excitement and enthusiasm of the young scientists was strongly conveyed.

As a measure of their success, popular versions of the three Millennium Issues were subsequently published by Cambridge University Press as three paper-backed books, all carrying the generic title *Visions of the Future* (Thompson 2001). These three books have recently been translated into Chinese editions, giving the material a greatly expanded readership.

5. The Christmas Triennial Issues

The Triennial Series of Christmas Issues was started in 2002 as a natural follow-up to the Millennium Issues. Devoted, again, to visions of the future by young scientists, the series has rolled through the physical sciences in a 3-year cycle as described below. The guidelines for authors followed those of the Millennium Issues, and the URFs have again been targeted as potential authors. The 3-year cycle ensures that the majority of the fellows receive a relevant invitation, and this series acts as a valuable forum for them.

*Phil. Trans. R. Soc. A* (2007)
The first Triennial Issue was devoted to Astronomy and Earth Science. It opened with interviews with key scientists from the two relevant Research Councils, PPARC and NERC. Following these were 18 papers by young scientists covering: cosmology and galaxies; the Sun and its effects on our climate; the Earth’s atmosphere, ionosphere and oceans; volcanoes and earthquakes; and finally pollution and the extinction of species. The second Triennial covered Mathematics, Physics and Engineering. It contained 21 papers in mathematics, statistics, physics, optics, electronics, nanoscience, computers, robots, displays, engineering and materials. The third was devoted to Chemistry and Life Science. In chemistry, topics included spin in magnetic fields, molecular photographs of chemical events, electrifying interfaces and nanotechnology. In biochemistry, they included biosynthesis, and applications of quantum chemistry and powder diffraction to the life sciences. One section, devoted to studies of colour and vision, covered natural animal colours, binocular vision and the design of visual interfaces. In genetics and evolution, papers were devoted to chemical genetics, the use of microscopic movements in the mammalian nucleus and the effect of environmental change on biotic evolution. Finally, three papers in bioengineering and medicine covered bone repair, tracking of intracellular ion migration and the chemistry of the adaptive mind addressing treatments for abnormalities like Parkinson’s disease.

The fourth returned, cyclically, to Astronomy and Earth Science and embraced the following four groups: cosmology and beyond the Solar System; the Solar System; Earth’s interior and oceans; and Earth’s surface, atmosphere and climate. The fifth consisted of 22 papers in Mathematics and Physics. These were organized into two groups as follows. Group 1 focused on mathematics including items from pure mathematics, coding and cryptography, and applied mathematics and mathematical biology. Group 2 was devoted to physics and covered particles and gravity, quantum computing, and general physics and nanoscience. The sixth Triennial Issue devoted to Chemistry and Engineering is the one in which this editorial has been placed. Here, subjects covered include spectroscopy and adaptive optics, nanotechnology and new materials, bioengineering and medicine, soils and structures, computer science, and climate and the environment.

These Triennial Issues have been adapted to form the core content of a new book series published by Imperial College Press in collaboration with the Royal Society. Three books of this series are now in print (Thompson 2005; Davies & Thompson 2007; Sammonds & Thompson 2007).

6. Increased publication and the clusters initiative

Until today’s issues (15 December 2007), the four mainstream journals of the Royal Society have been published once a month. But the two Transactions journals will be changing in January 2008 to publication twice a month. This dramatic expansion will allow Phil. Trans. R. Soc. A to concentrate on four carefully chosen subject clusters, as well as continuing to cover the whole of the physical sciences.

The four specific subject clusters are as follows.

Phil. Trans. R. Soc. A (2007)
(a) **Nanoscience, nano-engineering and quantum computing**

This cluster is designed to include the following: research at the nanoscale in condensed matter physics; bio-nanotechnology, chemistry, materials science and electronics; nanostructures, their fabrication, manufacture and use; nanostructures, their characterization, analysis and assessment; quantum information and quantum computing, drawing on theoretical and experimental physics; and controlling quantum phenomena, quantum time keeping, quantum cryptography systems. The associate editor in charge of this cluster is Giles Davies, Professor of Electronic and Photonic Engineering, University of Leeds (g.davies@leeds.ac.uk).

(b) **Environmental change and renewable energy**

This will cover the following: climate change and its prediction, meteorological and global models; Earth’s long-term climate, geology of the palaeoclimate; carbon emissions, their monitoring and control, Kyoto and international responses; engineering research on clean and renewable power generation; wind, solar, wave and tidal energy; predicting and planning for extreme events, earthquakes, storm surges, flooding; and fluid dynamics of the ocean and atmosphere, transport of pollutants. The associate editor for this cluster is Dr Rowan Sutton, URF, University of Reading (r.sutton@reading.ac.uk).

(c) **Dynamical systems and complexity**

Here we address the following: theory of dynamical systems, applications of nonlinearity and chaos, classical and quantum; time-series analysis, noise reduction, wavelets, synchronization and communication; control and exploitation of chaotic dynamics, spacecraft orbits, lasers, circuits; spontaneous organization and pattern formation, cellular automata, neural and complex networks; fluid instabilities, vortices, turbulence, nonlinear waves, transitions and defects in liquid crystals; transport, mixing, biological and chemical activity in flows, biochemical reactions; dynamics of surface vehicles, aircraft and spacecraft, oscillations of slender bridges; spatial complexity, elastic buckling; shells, space tethers, packing of filaments, DNA, proteins; discontinuous and multi-scale systems, drill strings, impacts, friction, wear, granular materials; applications in biology, neuroscience, medicine and genetics; and cellular dynamics, motor control, neurobrain dynamics, metabolic networks. The associate editor is Celso Grebogi, Professor of Nonlinear and Complex Systems, University of Aberdeen (grebogi@abdn.ac.uk).

(d) **Biophysics, biological mathematics and medical engineering**

This includes the following: biophysics, membrane biology, protein structure and function, sensing and signalling; nanotechnology, novel devices and techniques; biological models that are data-based, experimentally validated and hypotheses testable; modelling of biological function at any level of structural and functional integration; novel tools, algorithms and techniques, emerging standards; medical engineering, medical imaging and image analysis, computer-aided interventions; and remote diagnosis and treatment, new materials and tools, robotics. The associate editor is Dr Blanca Rodriguez, Computing Lab, University of Oxford (blanca@comlab.ox.ac.uk).
7. The future

In terms of downloads, citations and impact, the journal today is seen to be in good shape. The increased rate of publication and the development of subject clusters augur well for the future. In facing the many challenges and opportunities that will undoubtedly emerge, I am sure the new Editor will find the job to be as pleasant and as rewarding as I have over my 10 years.

I would like to thank all the members of the in-house publications staff at the Royal Society for their great help and support over the years. Special thanks go to Phil Hurst and to his staff, with whom I have been closely involved. All were towers of strength and worked on the journal with enthusiasm and good humour; thanks to them, my term as Editor has been a very happy experience indeed.

Appendix A. Histogram of the physical sciences

To get some feel for the levels of activity across the physical sciences I have produced the classification of figure 3. Rectangular blocks in this diagram show roughly the weight of activity in each topic, in arbitrary units. The left-hand histograms were based on the numbers of FRs expressing an interest in a topic. Meanwhile, the contrasting right-hand histograms highlight current research areas being compiled from the list of Royal Society Awards. This list includes the current URFs, the Dorothy Hodgkin Fellows, the James Ellis Research Fellows, the Industry Fellows, the International Incoming Fellows, the UK Relocation Fellows, the Wolfson Research Merit Award Holders, the Leverhulme Trust Senior Research Fellows and the Royal Society’s Research Professors.

As with any classification scheme, the production of this table has involved a lot of arbitrary decisions and boundaries, and even some illogicality, when a very small item does not really fit in any of the larger headings! In particular, to achieve a rough parity within each layer, it has been necessary to distort the more natural layout. Perhaps the grossest of these distortions was to put statistical physics with statistics, rather than physics!

My aim was to define five roughly equal groups, each containing five roughly equal subjects. Finally, each subject contains eight topics, making a total of 200 topics as displayed in the table. The groups and their approximate weightings are: (i) Mathematics (230), (ii) Physics (220), (iii) Chemistry (210), (iv) Engineering (230), and (v) Astronomy and Earth (230). More information and an index to the topics relating to an earlier edition of the histogram are given in Thompson (2002).

Appendix B. Six years of journal content 2001–2006

(a) Contents 2001

— Experimental modal analysis.
— Quark structure of matter.
— Semiconductor light sources for mid-infrared applications.
— Nonlinear dynamics in metal cutting.
— Interactions, structure and phase behaviour of colloidal dispersions.

Phil. Trans. R. Soc. A (2007)
### 1. Mathematics

#### 1.1 Pure mathematics
1. Analysis
2. Algebra
3. Geometry: pure, differential
4. Geometry: algebraic
5. Topology
6. Number theory
7. Groups, sets, combinatorics, logic
8. Asymptotics, special functions, singularities

#### 1.2 Applied mathematics
1. Fluid dynamics: theoretical
2. Solid mechanics: theoretical
3. Dynamical systems, nonlinearity, chaos
4. Pattern formation, self-organization, complexity
5. Differential equations, bifurcation theory
6. Industrial mathematics
7. Modelling: social, financial, evolutionary
8. Biological mathematics and modelling

#### 1.3 Theoretical physics
1. Quantum mechanics, foundations, metrology
2. Quantum information, computers (incl exp )
3. Quantum field theory
4. String theory
5. Gauge theories, elementary particles
6. Conformal field theory
7. Quantum gravity theories, general relativity
8. Mathematical physics, operator methods

#### 1.4 Statistics and statistical physics
1. Statistical theory
2. Stochastic, ergodic theory, Bayesian computation
3. Probability: pure
4. Probability: applied
5. Operational research
6. Statistical inference
7. Risks, hazards, extreme events
8. Statistical physics, equations of state

#### 1.5 Computer science and IT
1. Software, analysis, logic, algebra, complexity
2. Algorithms, protocols, languages, cryptography
3. Human interface, natural language, comp vision
4. High performance computing
5. Information theory, knowledge management
6. Communication networks: computer aspects
7. Artificial intelligence: intelligent, expert systems
8. Neural nets, cognitive science

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**Figure 3.** Histogram of activity in the physical sciences: (1) Mathematics, (2) Physics, (3) Chemistry, (4) Engineering and (5) Astronomy and Earth.

*Phil. Trans. R. Soc. A* (2007)
### 2. Physics

#### 2.1 Particles, nuclear, atomic, molecular
1. Accelerators
2. Collision and cluster physics, sputtering
3. Elementary particle physics
4. Plasma physics
5. Nuclear: structure, reactions, fission, fusion
6. Atomic physics, atom/photon interaction
7. Molecular physics
8. Radioactivity, radiation

#### 2.2 Condensed matter: general
1. Solids, surface physics
2. Liquids, granular materials
3. Polymers, glasses
4. Correlated quantum matter, superfluids, BECs
5. Soft matter, slow dynamics
6. Phase transitions
7. Low-temperature physics
8. Nanostructures, semiconductors: growth, etc.

#### 2.3 Condensed matter: electronic, magnetic
1. Nanoscience: physics, quantum dots
2. Semiconductors, basic, organic, polymer
3. Thin films
4. Low-dimensional electronics, 2D transport
5. Magnetism, magnetic mats, spin electronica
6. Magnetic resonance, NMR
7. Correlated systems: superconductor, FQHE
8. Josephson effects

#### 2.4 Photonics, spectroscopy
1. Lasers: basic
2. Optoelectronics: basic
3. Electroluminescent displays
4. Photonics: basic
5. Spectroscopy: physics
6. Spectra
7. Optics, quantum optics, optical fibres
8. Liquid crystals

#### 2.5 Crystallography, X-rays, scattering
1. Crystallography
2. Crystal structure, polymorphism
3. Structure of macromolecules and proteins
4. Dislocations, defects
5. Fracture
6. Scattering: X-rays
7. Scattering: theory, techniques
8. Scattering: neutrons, electrons, light

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Figure 3. (Continued.)
### 3. Chemistry

#### 3.1 Theoretical chemistry

1. Quantum chemistry
2. Electronic structure, computation, simulation
3. Interatomic, intermolecular forces
4. Condensed matter simulations
5. Macromolecules, including biological
6. Reaction dynamics
7. Gases, fluids, electrolytes
8. Optical, electrical, magnetic properties

#### 3.2 Inorganic chemistry

1. Metals, organo-metallic chemistry
2. Synthesis, catalysis: inorganic chemistry
3. Bonding, structure, reaction mechanisms
4. Coordination chemistry
5. Cluster chemistry
6. Bioinorganics
7. Materials: chemistry
8. Nanoscience: chemistry

#### 3.3 Organic chemistry

1. Synthesis, natural products: organic chemistry
2. Catalysis: organic chemistry
3. Analysis, structure: organic chemistry
4. Combinatorial chemistry
5. Reaction mechanisms: organic chemistry
6. Green chemistry
7. Supramolecular chemistry
8. Polymers, polymerization, organofluorines

#### 3.4 Physical chemistry

1. Spectroscopy: physical chemistry
2. Electrochemistry, magnetism
3. Photochemistry
4. Reaction mechanisms, atmospheric chemistry
5. Polymers, colloids, semiconductors
6. Surface chemistry, thin films, interfaces
7. Molecular physical chem, energy landscapes
8. Astrochemistry, astrophysical chemistry

#### 3.5 Biological chemistry

1. Natural materials, carbohydrates, biocolloids
2. Biological catalysis, transforms, enzymes
3. Biomimetic techniques
4. Biophysical and biochemical techniques
5. Metallo-enzymes, metallo-proteins
6. Proteins, nucleic acids, DNA, structure, folding
7. Lipids, biomembranes, biocompatibility
8. Medical: drug design, implants, tissue engng

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Figure 3. (Continued.)
### 4. Engineering

#### 4.1 Civil, mechanical, aerospace

1. Structures, building operations, management
2. Geotechnics, soils, construction
3. Off-shore, coastal, waterway engineering
4. Solid mechanics, engineering dynamics
5. Control theory, robotics, prosthetic devices
6. Transportation, rail, road, air, space vehicles
7. Manufacturing: operations, machinery, business
8. Materials (civil, etc.) design, testing

#### 4.2 Power, chemical, instrumentation

1. Nuclear reactors, radiation hazards
2. Power/energy generation, renewable, clean
3. Oil and gas extraction
4. Chemical, biochemical processes, biomimetics
5. Combustion, heat and mass transfer
6. Engines, propulsion
7. Electron and optical microscopy, X-ray devices
8. Instruments, microsystems, biological devices

#### 4.3 Electronic, electrical

1. Lasers: applied
2. Optoelectronics: devices and circuits
3. Communication networks: electronic, optical
4. Microwaves and R-frequency, radar, ultrasonics
5. Devices, displays, detectors: electronic, optical
6. Semiconductors: applied
7. Nanotechnology
8. Photonics: applied

#### 4.4 Materials science

1. Solid mechanics: materials, biomaterials
2. Metallurgy, alloys, welding, processing
3. Microstructure, phase change, nucleation
4. Polymers, ceramics, organics, inorganics
5. Corrosion, fatigue, fracture, tribology
6. Composites, foams, porous materials
7. Semiconductors: materials
8. Nanostructures and devices

#### 4.5 Engineering fluid dynamics

1. Aerodynamics, gas dynamics
2. Multiphase flows, suspensions
3.Granular flows
4. Turbulence, mixing
5. Computational fluid dynamics
6. Compressors, turbines, acoustics, cavitation
7. Rheology: viscous, non-Newtonian flow
8. Water, waves, wave energy, ice deposits

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Figure 3. (Continued.)
## 5. Astronomy, Earth

### 5.1 Cosmology, galaxies

1. Big bang, early universe
2. Cosmology
3. Cosmic radiation, X-ray astronomy
4. Cosmic chemistry
5. Galaxies: formation and evolution
6. Galaxies: structure and distribution
7. Black holes, gravity, relativity
8. Interstellar medium, dust, dark matter/energy

### 5.2 Astrophysics, stars, planets

1. Stars: spectra, evolution, gamma ray bursts
2. Pulsars, quasars, masers
3. Solar system
4. Astrophysics of the sun
5. Comets, meteorites, impacts
6. Planets, satellites, extra-solar planets
7. Astrophysics, magnetic fields
8. Telescopes, radio, X-ray, instruments

### 5.3 Geology

1. Evolution of the Earth, its space environment
2. Evolution of Earth’s environment, paleoclimatic
3. Evolution of life, paleontology
4. Structural geology, tectonics
5. Earth’s oceans, surface, crust, lithosphere
6. Volcanology, igneous petrology
7. Seismology, seismic imaging
8. Petroleum geology, resources

### 5.4 Geophysics, geochemistry

1. Glaciology, ice surfaces, polar ice caps
2. Crustal and marine geophysics
3. Crustal and marine geochemistry
4. Earth’s interior: geophysics, magnetism
5. Earth’s interior: geochemistry
6. Geophysical fluids, granular flows, avalanches
7. Geological isotope dating
8. Geochronology, stratigraphy, instruments

### 5.5 Climate, ocean, atmosphere

1. Atmosphere, stratosphere
2. Meteorology
3. Climate: change, prediction
4. Oceanography: physics
5. Oceanography: chemistry, biochemistry, ecology
6. Limnology
7. Pollution, contamination, waste management
8. Tides, waves, hydrology, surges, floods, sea level

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— Extreme natural hazards.
— Exploiting chaotic properties of dynamical systems for their control.
— New directions in liquid crystals.
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References


AUTHOR PROFILE

J. Michael T. Thompson

Michael Thompson was born in Cottingham, Yorkshire in 1937, and attended the Hull Grammar School. He graduated from Cambridge University with first class honours in mechanical sciences in 1958, winning the three top prizes of the Engineering Department. One of these was the prestigious Rex Moir Prize. He was later awarded two Cambridge doctorates, the PhD in 1962 and the ScD in 1977. Recently, in 2004, he received an honorary DSc from the University of Aberdeen.

While a post-doctoral research fellow at Peterhouse, he spent a year as a Fulbright visitor in the Department of Aeronautics and Astronautics at Stanford University in California. Joining University College London (UCL) in 1964, he was appointed a Professor in 1977, and subsequently Director of the Centre for Nonlinear Dynamics in 1991.

Based on his research into elastic buckling phenomena, he published three books on instabilities, bifurcations and catastrophes. A fourth book published in 1986 is now in its second edition as *Nonlinear Dynamics and Chaos* (Wiley, 2002). Over 14 000 copies of this seminal work have been sold worldwide, and it has been translated into Japanese and Italian.

Michael was elected a Fellow of the Royal Society in 1985 and served on the Council of the Society. He won the OMAE Award of the American Society of Mechanical Engineers in 1985 in recognition of his outstanding originality and significance. Seven years later, in 1992, he was awarded the James Alfred Ewing Medal on the joint nomination of the Presidents of the Institution of Civil Engineers and the Royal Society. The award, founded in memory of Sir Alfred Ewing, is made for special meritorious contributions to the science of engineering in the field of research. He was a Senior Fellow of the Science and Engineering Research Council from 1988 to 1993.

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Since 1998, Michael has been the Editor of the *Philosophical Transactions of the Royal Society A* (Mathematical, Physical and Engineering Sciences), the world’s longest running scientific journal. His special Millennium Issues of the journal, in which young scientists were invited to give their visions of the future, were republished as three popular paper-backed books by Cambridge University Press in 2001. As a follow-up to this successful venture, Michael has created a running programme of Christmas Issues which he is using as the basis of his new Royal Society Series on Advances in Science. The first book in the series is *Advances in Astronomy: from the Big Bang to the Solar System* (ed. JMT Thompson, ICP, 2005).

Michael is now Emeritus Professor of Nonlinear Dynamics at UCL, and an Honorary Fellow at the Department of Applied Mathematics and Theoretical Physics (DAMTP) of Cambridge University. He is active in promoting a greater understanding of science and mathematics among the general public. Two popular lectures in the Millennium Mathematics Project, delivered at DAMTP, are now streamed from the web, and also available on DVD. In 2004, Michael was awarded a Gold Medal by the Institute of Mathematics and its Applications (IMA) at their 40th Anniversary Meeting for his lifetime contributions to mathematics.

In April 2006, Michael was appointed, part-time, as a distinguished Sixth Century Professor in Theoretical and Applied Dynamics at the University of Aberdeen.

Married with two children and ten grandchildren, his recreations include astronomy with his grandchildren, wild-life photography, badminton and tennis.