

Inspiring Brilliance: Celebrating Maxwell's Genius and Legacy

Monday 9 November 2015



Being held at
The Royal Society of Edinburgh (RSE)
22–26 George Street,
Edinburgh, EH2 2PQ

Supported by
The James Clerk Maxwell Foundation
The University of Edinburgh
The Institute of Physics
IEEE

James Clerk Maxwell ranks alongside Newton and Einstein as one of the world's great physicists. In designating this year as the International Year of Light, UNESCO explicitly highlight the importance of 2015 as marking the 150th anniversary of the publication of Maxwell's Equations.

Maxwell's impact extends well beyond this outstanding contribution; to enabling developments in colour theory, colour photography, statistical physics, information theory, Saturn's rings, structural mechanics and control theory.

In this meeting, we bring together many eminent speakers to explore the legacy of Maxwell's genius today, which continues to impact on many scientific and technological aspects of our modern society, from mobile phones and cybernetics to the discovery of the Higgs boson. The talks will be accessible to a wide audience.

For more information contact
the RSE Events Team:

Phone: 0131 240 2780

Email: events@royalsoced.org.uk

Conference Programme

Monday 9 November

09.00 **Registration**

09.30 **Welcome and Introductions**

Professor Dame Jocelyn Bell Burnell DBE FRS PRSE MRIA
President, Royal Society of Edinburgh

09.35 David Forfar FFA FRSE

Chairman, James Clerk Maxwell Foundation

Session 1

Chairperson: Dame Jocelyn Bell Burnell

9.40 **Maxwell's Equations: the Tip of an Iceberg**

Professor Peter Higgs CH FRS FRSE

Nobel Laureate; Emeritus Professor of Theoretical Physics, University of Edinburgh

10.10 **Maxwell, Field Theory and the Road to Relativity and Quantum Theory**

Sir Peter Knight FRS

Senior Research Investigator at Imperial College London; Senior Fellow in Residence at Chicheley Hall and Past-President of the Institute of Physics

10.40 **Tea/Coffee break**

Viewing of Maxwell-Higgs Exhibition

11.00 **Clerk Maxwell's Influence on Mathematics**

Sir Michael Atiyah OM FRS HonFRSE HonFREng

Former President of the Royal Society and the Royal Society of Edinburgh

11.30 **The Impact of Maxwell's Work on Colour and Statistical Physics**

Professor Malcolm Longair CBE FRS FRSE

Jacksonian Professor Emeritus of Natural Philosophy and Director of Development of the Cavendish Laboratory, University of Cambridge

12.00 **The Impact on Astronomy of Maxwell's Adams Prize Essay**

Professor Carl Murray

Professor of Mathematics and Astronomy, Queen Mary University of London

12.30 **Launch of the Maxwell-Higgs Booklet**

Dame Jocelyn Bell Burnell

12.40 **Lunch**

Session 2

Chairperson: Dr James Rautio

CEO, President, and Founder of Sonnet Software

- 14.00** **Demonstration: Maxwell, Colour Vision and the Future of Digital Communication**
Peter Reid
Planning & Communications Project Manager, University of Edinburgh
- Professor Harald Haas
Chair of Mobile Communications, School of Engineering, University of Edinburgh
- 14.30** **The Impact on Engineering of Maxwell's Articles on Structural Mechanics**
Professor Iain McLeod
Former Professor of Structural Engineering, University of Strathclyde
- 15.00** **The Impact on Control Theory and Cybernetics of Maxwell's Paper On Governors**
Professor Rodolphe Sepulchre
Professor of Engineering, University of Cambridge
- 15.30** **The Impact of Maxwell's Demon on Information Theory and Computing**
Professor Jim Al-Khalili OBE FRAS HonFBAASc
Professor of Physics, University of Surrey
- 16.00** **Short extract from BBC Scotland James Clerk Maxwell film**
- 16.10** **Short announcement of BBC Radio 4 programme**
- 16.15** **Closing Remarks/Vote of Thanks**
David Forfar
- 16.25** **Close**
- 16.45** **Coaches outside the George Hotel to transport attendees to UoE**
- 17.00** **Unveiling of Maxwell Plaque at the University of Edinburgh**
Old College Quadrangle, South Bridge, University of Edinburgh, EH8 9YL
- Drinks Reception**
Playfair Library Hall, Old College, University of Edinburgh
- 18.00** **Close**

Tour of James Clerk Maxwell House

Tuesday 10 November

09.30–10.30 Tour 1

10.45–11.45 Tour 2

James Clerk Maxwell was born at 14 India Street, a house in Edinburgh's elegant Georgian New Town. Today the home of the James Clerk Maxwell Foundation, it houses a small museum related to his work.

The house is a substantial terrace house, built for Maxwell's father in 1820. James was born there in 1831. He was only a few months old when the family left Edinburgh to return to Glenlair, their country estate in the south of Scotland; but he came back to Edinburgh to attend school and university. He inherited the house on his father's death and retained it throughout his life, finally bequeathing it to his wife on his death in 1879.

The Foundation has retained to a large extent the original character of the house. Restorations were made with the assistance of the Architectural Heritage Fund and the National Heritage Fund. The former dining room now displays memorabilia in the form of portraits, manuscripts and books associated with Clerk Maxwell, his family and his scientific contemporaries. Descendants on both the paternal and maternal sides of the family have donated portraits and watercolours.

Talk Abstracts

Maxwell's Equations: the Tip of an Iceberg

Professor Peter Higgs CH FRS FRSE

Nobel Laureate; Emeritus Professor of Theoretical Physics, University of Edinburgh

Professor Higgs will describe how generalisations of Maxwell's equations have become the basis for our understanding of the interactions among elementary particles.

Maxwell, Field Theory and the Road to Relativity and Quantum Theory

Sir Peter Knight FRS

Senior Research Investigator at Imperial College London; Senior Fellow in Residence at Chicheley Hall and Past-President of the Institute of Physics

James Clerk Maxwell was responsible for a transformation in the way we regarded the electrical and magnetic forces, building on the experimental (and intuitive) notions of Michael Faraday to unite these in a single field-theoretic construct. In doing so, he began the search for the unification of the fundamental forces that continues to dominate modern physics. I will describe how his work presaged special relativity (and, indeed, survived it) and how his field theoretic notions persisted in the new world of quantum theory.

Clerk Maxwell's Influence on Mathematics

Sir Michael Atiyah OM FRS HonFRSE HonFREng

Former President of the Royal Society and the Royal Society of Edinburgh

Maxwell's Equations describe the behaviour of electro-magnetic waves in a way that combines geometry and analysis in perfect harmony. This led William Hodge, from the same Edinburgh–Cambridge stable as Maxwell, to extend the mathematical formalism to higher dimensions, with profound consequences. In due course, this fed into physical theories of the late 20th Century, which in turn, but unexpectedly, stimulated whole new and exciting developments in mathematics, now studied at the Hodge Institute in Edinburgh. For both physics and mathematics, Maxwell is the pioneering hero.

The Impact of Maxwell's Work on Colour and Statistical Physics

Professor Malcolm Longair CBE FRS FRSE

Jacksonian Professor Emeritus of Natural Philosophy and Director of Development of the Cavendish Laboratory, University of Cambridge

Maxwell's genius spanned the whole of experimental and theoretical physics. He lavished on the sciences of colour and statistical physics, the same care and originality of approach, which he displayed in his discovery of the equations of the electromagnetic field. In the field of colour, he established the quantitative three-colour theory of colour vision which is the basis of all forms of colour display used in digital displays. In statistical physics, his derivation of the Maxwell distribution and his understanding of the fundamentals of statistical thermodynamics, were intuitive responses which proved to be the basis of the future development of these subjects. The lecture will explain the originality of Maxwell's work in these areas and its extraordinary future impact.

The Impact on Astronomy of Maxwell's Adams Prize Essay

Professor Carl Murray

Professor of Mathematics and Astronomy, Queen Mary University of London

Maxwell won the 1857 Adams Prize for his essay, *On the Stability of the Motion of Saturn's Rings*. He was able to show that the rings could be neither solid nor fluid, but had to be composed of individual particles orbiting the planet. The wealth of *in-situ* observations of the rings from spacecraft such as *Voyager* and *Cassini* has revealed incredibly intricate structures, many of them reminiscent of those discussed by Maxwell. The talk will summarise our current knowledge of the rings and show the continuing influence of Maxwell's results.

Demonstration: Maxwell, Colour Vision and the Future of Digital Communication

Peter Reid

Planning & Communications Project Manager, University of Edinburgh

Professor Harald Haas

Chair of Mobile Communications, School of Engineering, University of Edinburgh

As part of a brief description of Maxwell's exploration of the nature of colour vision, and using the original monochrome plates and prepared chemical filters, Peter Reid will reconstruct the projection of the first true colour photograph, presented by Maxwell at an 1861 meeting of the Royal Institution. A different form of information conveyance by three colours is demonstrated by Professor Haas, who uses modern LED technology to encode independent digital information in the different colours of light. The lights also become a wireless data source, transmitting visible and invisible information.

The Impact on Engineering of Maxwell's Articles on Structural Mechanics

Professor Iain McLeod

Former Professor of Structural Engineering, University of Strathclyde

The presentation will discuss the contributions that Maxwell made to methods for predicting internal force actions and displacements of triangulated frames, and for calculation of stresses in loaded continua, and will speculate on why he turned the spotlight of his genius on to these matters. Unlike in the theory of electromagnetism, for which he was the runaway leader, Maxwell's contributions in structural mechanics were mostly mirrored by others. His enduring legacy in this field will be discussed.

The Impact on Control Theory and Cybernetics of Maxwell's Paper *On Governors*

Professor Rodolphe Sepulchre

Professor of Engineering, University of Cambridge

"I propose at present, without entering into any details of mechanism, to direct the attention of engineers and mathematicians to the dynamical theory of such governors". This sole quote from the 1868 Maxwell paper *On Governors* could serve as a definition of control theory, a science still in its infancy in 2015. After reviewing the motivation and history of Maxwell's paper, my talk will focus on how control theory has developed in the 20th Century and why Maxwell's 1868 paper is symbolic in many ways of what modern control is about.

The Impact of Maxwell's Demon on Information Theory and Computing

Professor Jim Al-Khalili FRAS HonFBAASc

Professor of Physics, University of Surrey

The paradox of Maxwell's Demon is a simple idea, and yet it has consumed many of the greatest names in science, and has even spawned whole new disciplines of research – and all because it challenges the second law of thermodynamics, a simple yet profound statement about the transfer of heat and energy and how they can be used. But despite dealing with profound issues such as order and randomness, and the link between energy and information, it remains a delightful thought experiment, and only further serves to highlight the remarkable genius of James Clerk Maxwell.

Speaker Biographies

Sir Michael Atiyah OM FRS HonFRSE HonFREng
Former President of the Royal Society and the Royal Society of Edinburgh



Sir Michael Atiyah has contributed to a wide range of topics in mathematics, centring round the interaction of geometry and analysis. Over the past thirty years, he has also been influential in developing cooperation between mathematicians and physicists. He was educated at Cambridge University and held positions in Cambridge, Oxford and Princeton, ending his career as the Master of Trinity College Cambridge. He is now an Honorary Professor at the University of Edinburgh. While President of the Royal Society of Edinburgh, he was responsible for the erection of the statue of Maxwell on George Street. He is a member of around twenty national academies and has been awarded more than thirty honorary degrees. He has been awarded many medals and prizes, including the Fields Medal (1966), the Feltrinelli Prize (1981) and the Abel Prize (2004). He is also a Member of the Order of Merit and a Grand Officier of the Legion d'Honneur.

Professor Dame Jocelyn Bell Burnell DBE FRS PRSE MRIA
President, Royal Society of Edinburgh



Jocelyn Bell Burnell inadvertently discovered pulsars as a graduate student in radio astronomy in Cambridge, opening up a new branch of astrophysics - work recognised by the award of a Nobel Prize to her supervisor. She has subsequently worked in many roles in many branches of astronomy, working part-time while raising a family. She is much in demand as a speaker and broadcaster and is now a Visiting Professor in Oxford and Pro-Chancellor of Trinity College Dublin. She has been President of the Royal Astronomical Society and of the Institute of Physics and is now the (first female) President of the Royal Society of Edinburgh – Scotland's National Academy of the Arts and Sciences. In her spare time she gardens, listens to choral music and is active in the Quakers. She has co-edited an anthology of poetry with an astronomical theme – *Dark Matter; Poems of Space*.

David Forfar FFA FRSE
Chairman, James Clerk Maxwell Foundation



David Forfar is an actuary and was the Appointed Actuary of Scottish Widows. He has served on the Council of the Faculty of Actuaries on several occasions and on the Association of European Actuaries. He is now a Consulting Actuary. He has published extensively in actuarial journals. He has also been associated with Heriot-Watt and Edinburgh Universities. His original interest in Maxwell arose from being educated at the same school and university (Trinity College, Cambridge) as Clerk Maxwell. He has been a Trustee of the Clerk Maxwell Foundation since 1992 and was appointed Chairman in 2014. He was the editor of (and contributor to) the RSE's booklet celebrating the achievements and legacy of James Clerk Maxwell produced for the unveiling of the James Clerk Maxwell statue on George Street in 2008. He has also published articles about Clerk Maxwell in the bulletin of the Institute of Mathematics and its Applications.

Professor Harald Haas

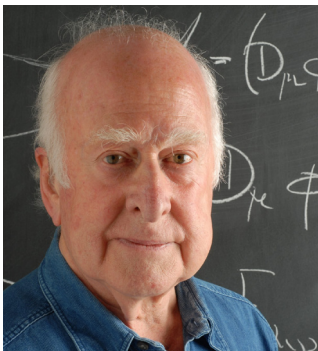
Chair of Mobile Communications, School of Engineering, University of Edinburgh



Professor Harald Haas holds the Chair for Mobile Communications at the University of Edinburgh, and is co-founder and chief scientific officer of pureLiFi Limited. In his 2011 TED Talk, he demonstrated that it is possible to turn LED light bulbs into broadband wireless transmission systems. He has pioneered 'Li-Fi', listed among the 50 best inventions in TIME Magazine, 2011. In 2013, the new Li-Fi Research and Development Centre was established, led by Professor Haas. This internationally-leading UK centre will accelerate the adoption of Li-Fi and the emerging wireless Li-Fi technology. Professor Haas was selected as one of ten UK EPSRC RISE Leaders in 2014, in recognition of their engagement, influence and impact in scientific research.

Professor Peter Higgs CH FRS FRSE

Nobel Laureate; Emeritus Professor of Theoretical Physics, University of Edinburgh



Peter Higgs was born on 29 May 1929 in Newcastle, United Kingdom. He was awarded a BSc in 1950, an MSc in 1951 and a PhD in 1954 by King's College London. He held postdoctoral positions between 1954 and 1960 at the University of Edinburgh, University College London and Imperial College London. In October 1960, he was appointed to a Lectureship at the University of Edinburgh and retired in 1996 as Professor Emeritus in Theoretical Physics. He has received numerous prestigious awards and honorary degrees. He was made a Companion of Honour by Queen Elizabeth II in 2012, and has received the Freedom of the Cities of Bristol, Edinburgh and Newcastle. He has shared several prizes with François Englert, in addition to the 2013 Nobel Prize in Physics. Image © University of Edinburgh.

Professor Jim Al-Khalili OBE FRAS HonFBAASc

Professor of Physics, University of Surrey



Professor Jim Al-Khalili OBE is a physicist, author and broadcaster based at the University of Surrey, where he also holds both a personal Chair in Physics and the first university Chair in the Public Engagement in Science. He received his PhD in theoretical nuclear physics in 1989 and has published over 100 research papers, mainly in nuclear reaction theory.

Jim has written many popular science books, between them translated into 26 languages. His book *Pathfinders: the golden age of Arabic science* was shortlisted for the Warwick Prize in 2013 and his latest, published last year is *Life on the Edge: the coming of age of quantum biology*. Over the past decade, he has been a regular presenter of TV science documentaries, including the Bafta-nominated *Chemistry: A Volatile History*, but is probably best known as presenter of the weekly BBC Radio 4 programme, *The Life Scientific*. He is a recipient of the Royal Society Michael Faraday Medal and the Institute of Physics Kelvin Medal and received an OBE in 2007 for services to science. He is currently President of the British Humanist Association.

Sir Peter Knight FRS

Senior Research Investigator at Imperial College London; Senior Fellow in Residence at Chicheley Hall and Past-President of the Institute of Physics Edinburgh



Knight is Senior Research Investigator at Imperial College and Senior Fellow in Residence at Chicheley Hall and Past-President of the Institute of Physics. He retired in 2010 as Deputy Rector (Research) at Imperial. He was knighted in 2005 for his work in optical physics. Peter Knight was the 2004 President of the Optical Society of America. He is Editor of *Contemporary Physics*; a member of the UK Quantum Technology Initiative Strategy Advisory Board; chairs the new Quantum Metrology Institute at the National Physical Laboratory; was until 2010 Chair of the Defence Scientific Advisory Council; and remains a Government science advisor. His research centres on quantum optics. He has won the Thomas Young Medal and the Glazebrook Medal of the Institute of Physics, the Ives Medal of the OSA and the Royal Medal of the Royal Society. He is a Trustee of the Royal Institution and Council Member at Sussex University.

Professor Malcolm Longair CBE FRS FRSE

Jacksonian Professor Emeritus of Natural Philosophy and Director of Development of the Cavendish Laboratory, University of Cambridge



Malcolm Longair CBE FRS FRSE is Jacksonian Professor Emeritus of Natural Philosophy and Director of Development of the Cavendish Laboratory, Cambridge. He was appointed the ninth Astronomer Royal of Scotland in 1980; as well as the Regius Professor of Astronomy, University of Edinburgh; and the Director of the Royal Observatory, Edinburgh. He was head of the Cavendish Laboratory from 1997 to 2005. He has served on and chaired many international committees, boards and panels, working with both NASA and the European Space Agency. He is currently Chair of the Scottish Universities Physics Alliance (SUPA) International Advisory Committee.

His main research interests are in high energy astrophysics and astrophysical cosmology. He has chaired numerous committees for specific science projects, including the *Planck* and *Euclid* mission of the European Space Agency. He has just completed a *Scientific History of the Cavendish Laboratory*, to be published early in 2016 by Cambridge University Press.

Professor Iain McLeod

Former Professor of Structural Engineering, University of Strathclyde



Prior to his appointment as Professor of Structural Engineering at the University of Strathclyde in 1981, from which he is now retired, Iain MacLeod held a number of posts in structural engineering practice and at universities.

Relevant publications by him include:

- A paper titled *James Clerk Maxwell and the Democratic Intellect* (2003) in which he discusses the possible relevance of Maxwell's upbringing and education to his success.
- A textbook titled *Modern Structural Analysis* (2005) which promotes the principle that structural mechanics should now be viewed as a modelling activity as well as an exercise in doing calculations.

Professor Carl Murray

Professor of Mathematics and Astronomy, Queen Mary University of London



After obtaining his BSc and PhD from Queen Mary College, University of London, Carl worked as a postdoc at Cornell University until 1982, when he returned to Queen Mary to take up a research post. He is a planetary scientist interested in the motion of all Solar System objects, from dust to planets. In 1990, he was selected as a member of the camera team for the NASA/ESA *Cassini* mission to Saturn. The spacecraft has been orbiting the planet and sending back data since 2004. Carl's particular interest is the dynamics of Saturn's rings and their gravitational interaction with small moons. In his career, he has held a Royal Society University Research Fellowship, a SERC Advanced Fellowship and a PPARC Senior Research Fellowship.

Dr James Rautio

CEO, President, and Founder of Sonnet Software



James C. Rautio is CEO, President, and Founder of Sonnet Software. After working in the aerospace industry from 1978 to 1983, he founded Sonnet Software to develop solutions to Maxwell's equations for analysis of planar microwave circuits. He was appointed the MTT (The IEEE Microwave Theory and Techniques Society) Distinguished Microwave Lecturer from 2005 to 2007, lecturing on the life of James Clerk Maxwell. He has published many papers about Maxwell and has given over 130 lectures about Maxwell worldwide. He played a key role in the recent restoration of Glenlair, Maxwell's home.

Peter Reid

Planning & Communications Project Manager, University of Edinburgh



Peter Reid is the Public Engagement Project Manager for the College of Science and Engineering at the University of Edinburgh. With degrees in both Physics and Computing, commercial experience in Internet software design, and qualifications in teaching, science communication, graphic design, sculpture and theatre, Peter has for the last twelve years promoted a wide variety of research activities within the College, including developments in carbon capture and storage, particle physics and Li-Fi communications. He has a particular interest in the history of science, and in connecting a modern public with the magic of discoveries from the past.

Professor Rodolphe Sepulchre

Professor of Engineering, University of Cambridge



Rodolphe Sepulchre is Professor of Engineering at Cambridge University and a Fellow of Sidney Sussex College. His research interests are in nonlinear feedback principles for control and optimization of natural and artificial systems. He is currently Editor-in-Chief of *Systems and Control Letters* and an Associate Editor for *IEEE Transactions on Network Science and Engineering*, *Annual Reviews on Control, Robotics, and autonomous systems*, and *Mathematics of Control, Signals, and Systems*. In 2008, he was awarded the IEEE Control Systems Society Antonio Ruberti Young Researcher Prize. He is a fellow of IEEE and SIAM and an IEEE CSS Distinguished Lecturer since 2010.

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