

**Editorial Board**

**C. David Garner, Editor**  
School of Chemistry, University of Nottingham

**Russel Cafflich**  
Department of Mathematics, University of California, Los Angeles

**Gu-Qiang Chen**  
Mathematical Institute, University of Oxford

**Peter Coveney**  
Centre for Computational Science, University College London

**Walter Craig**  
Department of Mathematics and Statistics, McMaster University

**John Dainton**  
Cockcroft Institute For Accelerator Science and Technology

**Daniel Feltham**  
Centre for Polar Observation & Modelling,  
University College London

**Ben Feringa**  
Stratingh Institute for Chemistry, University of Groningen

**Nigel Goldenfeld**  
Department of Physics, University of Illinois

**Godfrey Gumbs**  
Department of Physics, Hunter College

**Yasuhiro Iwasawa**  
Catalysis and Surface Science Laboratory, University of Tokyo

**Bruce Joyce**  
Department of Physics, Imperial College, London

**Holger Kantz**  
Max Plank Institute for the Physics of Complex Systems

**Christopher Kilburn**  
Department of Earth Sciences, University College London

**Jürgen Kurths**  
Institute of Physics, University of Potsdam

**Marta Kwiatkowska**  
Computing Laboratory, University of Oxford

**Ying-Cheng Lai**  
Arizona State University

**Frank Larkins**  
University of Melbourne

**Brian Launder**  
School of Mechanical, Aerospace and Civil Engineering,  
University of Manchester

**Joseph T. C. Liu**  
School of Engineering, Brown University

**Malcolm Longair**  
Department of Physics, University of Cambridge

**Alan Martin**  
Department of Physics, Durham University

**Bill McGuire**  
Department of Earth Sciences, University College London

**Nicolas Moussiopoulos**  
Department of Mechanical Engineering,  
Aristotle University, Thessaloniki

**Alfredo Ozorio de Almeida**  
Centro Brasileiro de Pesquisas Físicas (CBPF)

**Richard Pattick**  
School of Earth, Atmospheric and Environmental Sciences,  
University of Manchester

**Michael Pepper**  
Department of Electronic and Electrical Engineering,  
University College London and London Centre for Nanotechnology

**Annie Powell**  
Institute of Inorganic Chemistry, University of Karlsruhe

**Eric Priest**  
Department of Mathematics and Statistics, University of St Andrews

**C.N.R. Rao**  
CSIR Centre of Excellence in Chemistry,  
Jawaharlal Nehru Centre for Advanced Scientific Research

**Ulrich Rist**  
Institut für Aerodynamik und Gasdynamik, Universität Stuttgart

**Howard Stone**  
Princeton University

**Rowan Sutton**  
National Centre for Atmospheric Science, University of Reading

**Bill Unruh**  
Department of Physics and Astronomy, University of British Columbia

**Paul Valdes**  
School of Geographical Sciences, University of Bristol

**Tanja van Mourik**  
School of Chemistry, University of St Andrews

**Bryan Webber**  
Department of Physics, University of Cambridge

**Paul Williams**  
Department of Meteorology, University of Reading

**Vivian Yam**  
Department of Chemistry, University of Hong Kong

**Nan Yao**  
PRISM Imaging and Analysis Centre, Princeton University

**John Zarecki**  
Planetary & Space Sciences Research Institute,  
The Open University

**Commissioning Editor: Suzanne Abbott**

(tel: +44 (0)20 7451 2214; fax: +44 (0)20 7976 1837;  
philtransa@royalsociety.org)

**Editorial Coordinator: Ruth Milne**

(tel: +44 (0)20 7451 2633; philtransa@royalsociety.org)

**Production Editor: Kelly Hutchinson**

6–9 Carlton House Terrace, London SW1Y 5AG, UK  
royalsocietypublishing.org

**AIMS AND SCOPE**

Each issue of *Phil. Trans. R. Soc. A* is devoted to a specific area of the mathematical, physical and engineering sciences. This area will define a research frontier that is advancing rapidly, often bridging traditional disciplines. *Phil. Trans. R. Soc. A* is essential reading for mathematicians, physicists, engineers and other physical scientists. As well as theme issues, the journal publishes papers from the Royal Society's mathematical, physical and engineering discussion meetings. For information on submitting a proposal for a theme issue, please consult the journal's website at [rsta.royalsocietypublishing.org](http://rsta.royalsocietypublishing.org)

ISBN 978-1-78252-000-9

**COPYRIGHT** © 2013 The Royal Society

Except as otherwise permitted under the Copyright, Designs and Patents Act, 1988, this publication may only be reproduced, stored or transmitted, in any form or by any means, with the prior permission in writing of the publisher, or, in the case of reprographic reproduction, in accordance with the terms of a licence issued by the Copyright Licensing Agency. In particular, the Society permits the making of a single photocopy of an article from this issue (under Sections 29 and 38 of the Act) for an individual for the purposes of research or private study.

**SUBSCRIPTIONS**

In 2013 *Phil. Trans. R. Soc. A* (ISSN 1364-503X) will be published twice a month. Full details of subscriptions and single issue sales may be obtained either by contacting our journal fulfilment agent, Portland Customer Services, Commerce Way, Colchester CO2 8HP; Tel: +44 (0)1206 796351; fax: +44 (0)1206 799331; email: [sales@portland-services.com](mailto:sales@portland-services.com) or by visiting our website at [royalsocietypublishing.org/info/subscriptions](http://royalsocietypublishing.org/info/subscriptions). The Royal Society is a Registered Charity No. 207043.

Subscription prices 2013 calendar year	UK, Europe and RoW	Europe	USA, Canada and RoW
Printed version plus electronic access	£3164	€4114	\$5996
Electronic access only	£2260	€2939	\$4283

Typeset in India by Techset Composition Limited, Salisbury, UK. Printed in the UK by Cambrian Printers.

This paper meets the requirements of ISO 9706:1994(E) and ANSI/NISO Z39:48-1992 (Permanence of Paper) effective with volume 338, issue 1649, 1992.

*Phil. Trans. R. Soc. A* (ISSN 1364-503X) is published twice a month for US\$4283 per year by the Royal Society, and is distributed in the USA by Agent named Air Business, C/O Worldnet Shipping USA Inc., 149-35 177th Street, Jamaica, New York, NY11434, USA. US Postmaster: Send address changes to *Phil. Trans. R. Soc. A*, C/O Air Business Ltd, C/O Worldnet Shipping USA Inc., 149-35 177th Street, Jamaica, New York, NY11414.