



Editorial Board

M. V. Berry FRS, Editor, HH Wills Physics Laboratory, University of Bristol

Mike Ashfold FRS, School of Chemistry, University of Bristol

Anthony Barrett FRS, Chemistry Department, Imperial College London

Simon Benjamin, Department of Materials, University of Oxford

L. Botten, Department of Mathematical Sciences, University of Technology, Sydney

O. Bruno, Applied Computational Mathematics, California Institute of Technology

Marc Cahay, School of Electronics and Computing Systems, University of Cincinnati

M. Chai, Department of Chemistry, Central Michigan University

Stan Cowley FRS, Department of Physics & Astronomy, University of Leicester

D. Crowdy, Department of Mathematics, Imperial College London

Anthony Davison, Institute of Mathematics, Ecole Polytechnique Fédérale de Lausanne

M. Destrade, School of Mathematics, Statistics and Applied Mathematics, National University of Ireland, Galway

Brian Foster FRS, University of Hamburg

J.-M. Fourneau, PRISM, Université de Versailles St Quentin

Marc Geers, Mechanical Engineering, Eindhoven University of Technology

M. Green, Department of Physics, King's College London

D. J. Higham, Department of Mathematics and Statistics, University of Strathclyde

Ian Horrocks FRS, Department of Computer Science, University of Oxford

C. J. Howls, School of Mathematics, University of Southampton

Yonggang Huang, Department of Civil and Environmental Engineering and Department of Mechanical Engineering, Northwestern University

Susana Huelga, Institute of Theoretical Physics, Ulm University

Giles Hunt, School of Mechanical Engineering, University of Bath

Graham Hutchings FRS, School of Chemistry, Cardiff University

Anjan Kundu, Theory Group, Saha Institute of Nuclear Physics

Bruce Lennox, Department of Chemistry, McGill University

P. F. Linden FRS, Department of Mechanical and Aerospace Engineering, University of California, San Diego

Juan Lopez, School of Mathematical and Statistical Sciences, Arizona State University

R. MacKay FRS, Mathematics Institute, University of Warwick

D. McKenzie, School of Physics, University of Sydney

K. Nakamura, Department of Applied Physics, Osaka City University

T. Palmer FRS, ECMWF

Alun Preece, School of Computer Science & Informatics, Cardiff University

Geraint Price FRS, Engineering and the Environment, University of Southampton

B. Rustem, Department of Computing, Imperial College London

P. Sammonds, Department of Earth Sciences, University College London

Jerry Shan, Department of Mechanical and Aerospace Engineering, Rutgers University

A. Sousa, Department of Mechanical Engineering, University of New Brunswick

S. Spector, Department of Mathematics, Southern Illinois University

D. M. A. Stuart, Department of Applied Mathematics and Theoretical Physics, University of Cambridge

Z. Suo, School of Engineering and Applied Sciences, Harvard University

Michael Thompson FRS, Department of Applied Mathematics and Theoretical Physics, University of Cambridge

Henry Tye, Institute for Advanced Study, The Hong Kong University of Science and Technology

Matt Visser, School of Mathematics, Statistics, and Computer Science, Victoria University of Wellington

G. Wake FRSNZ, Institute of Information and Mathematical Sciences, Massey University

Zhong-Lin Wang, School of Materials Science and Engineering, Georgia Institute of Technology

Chris Williams, School of Informatics, University of Edinburgh

R. Wong, Department of Mathematics, City University of Hong Kong

J. Woodhouse FRS, Department of Earth Sciences, University of Oxford

Jun Xia, Key Lab. of Water Cycle & Related Surface Processes, Chinese Academy of Sciences

Tao Xiang, Institute of Theoretical Physics and Institute of Physics, Chinese Academy of Sciences

Publishing Editor: Joanna Harries

(tel: +44(0)20 7451 2634; joanna.harries@royalsociety.org)

Editorial Coordinator: Raminder Shergill

(tel: +44(0)20 7451 2694; raminder.shergill@royalsociety.org)

Production Editor: Kelly Hutchinson

6-9 Carlton House Terrace, London SW1Y 5AG, UK

AIMS AND SCOPE

Proc. R. Soc. A publishes research articles across the mathematical, physical and engineering sciences. The emphasis is on high-quality, original, fundamental articles of interest to a wide range of scientists, in emerging and interdisciplinary areas as well as established disciplines.

COPYRIGHT © 2012 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 2012 *Proc. R. Soc. A* (ISSN 1364-5021) will be published monthly. Full details of subscriptions may be obtained either by contacting our journal fulfilment agent, Portland Customer Services, Commerce Way, Colchester CO2 8HP; tel: +44 (0)1206 796351; fax: +(0)1206 799331; email: sales@portland-services.com or by visiting our website at royalsocietypublishing.org/info/subscriptions. The Royal Society is Registered Charity No. 207043.

| Subscription prices 2012 calendar year | Europe | USA & Canada | All other countries |
|--|-------------|--------------|---------------------|
| Online only | £1142/€1483 | US\$2149 | £1222/US\$2193 |
| Combined online and print | £1484/€1927 | US\$2793 | £1588/US\$2850 |

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 436, issue 1896, 1992.

Proc. R. Soc. A (ISSN 1364-5021) is published monthly for \$2048 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 *Proc. R. Soc. A* C/O Air Business Ltd, C/O Worldnet Shipping USA Inc., 149-35 177th Street, Jamaica, New York, NY11414.