

QUARTERLY
OF
APPLIED MATHEMATICS

EDITED BY

S. S. ANTMAN
Z. ARTSTEIN
H. T. BANKS
H. COHEN
A. CONSTANTIN
J. D. COWAN

P. J. DAVIS
S. GEMAN
G. IOOSS
J. HUNTER
I. KONTOYIANNIS
D. MUMFORD

W. E. OLMSTEAD
J. R. RICE
B. SANDSTEDE
J. G. SIMMONDS
L. SIROVICH
M. SLEMROD

WALTER FREIBERGER
Managing Editor

CONSTANTINE DAFERMOS
Associate Managing Editor

FOUNDER, AND
MANAGING EDITOR 1943–1965

W. PRAGER

VOLUME LXXI

MARCH • 2013

NUMBER 1

This journal is devoted to original papers in applied mathematics which have an intimate connection with applications. It is expected that each paper will be of a high scientific standard; that the presentation will be of such character that the paper can be easily read by those to whom it would be of interest; and that the mathematical argument, judged by the standard of the field of application, will be of an advanced character.

In accordance with their general policy, the Editors welcome particularly contributions which will be of interest both to mathematicians and to scientists or engineers. Authors will receive galley proof, and offprints will be provided in electronic form free of charge. A downloadable and printable PDF of each published article will be available to authors immediately after publication. Detailed instructions will be sent with galley proofs.

Submission information. Manuscripts submitted for publication should be sent as a PDF via email to walter_freiberger@brown.edu, either directly or through any one of the Editors. The final decision on acceptance of a manuscript for publication is made by the Managing Editor. Simultaneous submissions (i.e., concurrent submissions to another journal) are not accepted. See **Suggestions Concerning the Preparation of Manuscripts for the Quarterly of Applied Mathematics** at the end of this issue.

Publisher Item Identifier. The Publisher Item Identifier (PII) appears at the top of the first page of each article published in this journal. This alphanumeric string of characters uniquely identifies each article and can be used for future cataloging, searching, and electronic retrieval.

Postings to the AMS website. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

Copying and reprinting. Material in this journal may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Division of Applied Mathematics, Brown University, 182 George Street, Box F, Providence, RI 02912.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

Subscription information. Beginning March 2005 the *Quarterly of Applied Mathematics* is accessible from www.ams.org/journals/. Subscription prices for Volume 71 (2013) are as follows: for paper delivery, US\$165; for electronic delivery, US\$145. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. For back volume/back issue prices and availability, go to www.ams.org/bookstore/backvols/. For paper delivery, subscribers inside the United States must pay a postage surcharge of US\$5; subscribers outside the United States must pay a postage surcharge of US\$13. Subscriptions and orders for back volumes must be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904, USA. All orders must be accompanied by payment. Other subscription correspondence should be addressed to the American Mathematical Society, 201 Charles St., Providence, RI 02904-2294, USA. Periodicals postage paid at Providence, RI. POSTMASTER: Send address changes to *Quarterly of Applied Mathematics*, Membership and Customer Services Department, American Mathematical Society, 201 Charles St., Providence, RI 02904-2294, USA.

© 2013 Brown University

This journal is indexed in *Mathematical Reviews*, *Zentralblatt MATH*, *Science Citation Index*[®], *Science Citation Index*TM-Expanded, *ISI Alerting Services*SM, *CompuMath Citation Index*[®], *Current Contents*[®]/*Engineering, Computing & Technology*. It is also indexed by *Applied Science & Technology Index* and abstracted by *Applied Science & Technology Abstracts*. Periodicals postage paid at Providence, Rhode Island.

Publication number 808680. *Quarterly of Applied Mathematics* (ISSN 0033-569X (print); ISSN 1552-4485 (online)) is published four times per year (March, June, September, and December) by Brown University, Division of Applied Mathematics, 182 George St., Providence, RI 02912, USA.

Printed in the United States of America.

The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability.

SUGGESTIONS CONCERNING THE PREPARATION OF MANUSCRIPTS FOR THE QUARTERLY OF APPLIED MATHEMATICS

The editors will appreciate the authors' cooperation in taking note of the following directions for the preparation of manuscripts. These directions have been drawn up with a view toward eliminating unnecessary correspondence, avoiding the return of papers for changes, and reducing the charges made for "author's corrections."

Submission of Accepted Manuscripts:

Submission of electronically-prepared manuscripts is required, with a strong preference for $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$. To assist authors in preparing electronic manuscripts, the AMS has prepared author packages. The author package includes instructions for preparing electronic manuscripts, the *AMS Author Handbook*, samples, graphic creation instructions, and a style file. Though $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ is the highly preferred format of $\mathcal{T}\mathcal{E}\mathcal{X}$, an author package is also available in $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{T}\mathcal{E}\mathcal{X}$. When choosing a style file for the *Quarterly of Applied Mathematics*, choose the QAM-specific journal package, made available by the American Mathematical Society at www.ams.org/distribution/qam/qamauthorpac.html. For more technical information, please visit www.ams.org/authors/author-faq.html.

Contributions to the *Quarterly of Applied Mathematics* should be submitted in final form. Only typographical errors should be corrected in proof; composition charges for any major deviations from the manuscript will be passed on to the *Quarterly of Applied Mathematics*. An abstract is required for all QAM manuscripts.

After the contribution has been accepted for publication, electronic files (.tex files along with .eps (or .tiff) files for figures) should be submitted via the web at www.ams.org/submit-book-journal, or sent via email to pub-submit@ams.org, or sent on CD to the Electronic Prepress Department, American Mathematical Society, 201 Charles St., Providence, RI 02904-2294 USA. When submitting electronic manuscripts via email or CD, please include a message indicating that the paper has been accepted for publication in the *Quarterly of Applied Mathematics*.

Electronic Graphics:

Comprehensive instructions on preparing graphics are included in PDF format in the author package. Submit files for graphics as EPS (Encapsulated PostScript) files. This includes graphics originating via a graphics application as well as scanned photographs or other computer-generated images. If this is not possible, TIFF files are acceptable as long as they can be opened in Adobe Photoshop or Illustrator.

Authors using graphics packages for the creation of electronic art should avoid the use of any lines thinner than 0.5 points in width at 100%. Many graphics packages allow the user to specify a "hairline" for a very thin line. Hairlines often look acceptable when proofed on a typical laser printer. However, when produced on a high-resolution laser imagesetter, hairlines become nearly invisible and will be lost entirely in the final printing process.

Screens should be set to values between 15% and 85%. Screens that fall outside of this range are too light or too dark to print correctly. Variations of screens within a graphic should be no less than 10%.

Any graphics created in color will be rendered in grayscale for the printed QAM issue unless color printing is authorized by the Managing Editor and paid for by the authors. In general, color graphics will appear in color in the online QAM issue.

CONTENTS

Vol. LXXI, No. 1	March 2013
REMCO DUIJS, BART JANSSEN, ALESSANDRO BECCIU, AND HANS VAN ASSEN, A variational approach to cardiac motion estimation based on covariant derivatives and multi-scale Helmholtz decomposition	1
YOUNG-SAM KWON AND KONSTANTINA TRIVISA, On the incompressible limit problems for multicomponent reactive flows	37
THOMAS BERGER AND ACHIM ILCHMANN, On the standard canonical form of time-varying linear DAEs	69
ERIC BONNETIER, DAVID MANCEAU, AND FAOUZI TRIKI, Asymptotic of the velocity of a dilute suspension of droplets with interfacial tension	89
BARBARA LEE KEYFITZ, ALLEN M. TESDALL, KEVIN R. PAYNE, AND NEDYU I. POPIVANOV, The sonic line as a free boundary	119
FUMIOKI ASAKURA AND ANDREA CORLI, Global existence of solutions by path decomposition for a model of multiphase flow	135
GISÈLE RUIZ GOLDSTEIN, JEROME A. GOLDSTEIN, AND GUSTAVO PERLA MENZALA, On the overdamping phenomenon: A general result and applications	183



0033-569X(201303)71:1;1-0