

QUARTERLY
OF
APPLIED MATHEMATICS

EDITED BY

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

G. DASSIOS
S. GEMAN
G. IOOSS
J. HUNTER
I. KIM
I. KONTOYIANNIS
P. D. MILLER

D. MUMFORD
J. R. RICE
B. SANDSTEDTE
L. SIROVICH
M. SLEMROD
J. WILKENING

CONSTANTINE DAFERMOS
Managing Editor

GOVIND MENON
Associate Managing Editor

MANAGING EDITOR 1965–2014
WALTER FREIBERGER

FOUNDER, AND
MANAGING EDITOR 1943–1965
W. PRAGER

VOLUME LXXVII

MARCH • 2019

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. The Quarterly of Applied Mathematics uses Centralized Manuscript Processing for initial submission. Authors should submit a PDF file using the Initial Manuscript Submission form found at www.ams.org/submit/qam. 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.

Publication on the AMS website. Articles are published on 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 77 (2019) are as follows: for paper delivery, US\$200; for electronic delivery, US\$175. Subscription renewals are subject to late fees. See www.ams.org/journals-faq for more journal subscription information. 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\$5.25; subscribers outside the United States must pay a postage surcharge of US\$15. 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 02904-2213, USA.

© 2019 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, RI and additional mailing offices.

POSTMASTER: Send address changes to *Quarterly of Applied Mathematics*, Membership and Customer Services Department, American Mathematical Society, 201 Charles St., Providence, RI 02904-2213, USA. 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 manuscripts electronically-prepared in L^AT_EX is required, with a strong preference for $\mathcal{A}\mathcal{M}\mathcal{S}$ -L^AT_EX. 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. 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. LXXVII, No. 1	March 2019
THOMAS STOJSAVLJEVIC, GABRIELLA PINTER, ISTVAN LAUKO, AND NICHOLAS MYERS, Parameter identification and sensitivity analysis for a phytoplankton competition model	1
HYUNG JU HWANG, JUHI JANG, AND JUAN J. L. VELÁZQUEZ, On the structure of the singular set for the kinetic Fokker–Planck equations in domains with boundaries	19
EKEOMA R. IJIOMA AND ADRIAN MUNTEAN, Fast drift effects in the averaging of a filtration combustion system: A periodic homogenization approach	71
HABIB AMMARI, WEI WU, AND SANGHYEON YU, Double-negative electromagnetic metamaterials due to chirality	105
SEUNG-YEAL HA, JEONGHO KIM, CHAN HO MIN, TOMMASO RUGGERI, AND XIONGTAO ZHANG, Uniform stability and mean-field limit of a thermodynamic Cucker-Smale model	131
HONGJIE JU, HAIGANG LI, AND LONGJUAN XU, Estimates for elliptic systems in a narrow region arising from composite materials	177



0033-569X(201903)77:1;1-0