
VOLUME 92

NUMBER 343

SEPTEMBER 2023

MATHEMATICS OF COMPUTATION

ISSN 0025-5718 (print)
ISSN 1088-6842 (online)

A M E R I C A N M A T H E M A T I C A L S O C I E T Y

EDITED BY

Paola F. Antonietti
Markus Bachmayr
Jennifer Balakrishnan
Ernesto G. Birgin
Susanne C. Brenner, *Managing Editor*
Martin Burger
Coralia Cartis
Ronald F. A. Cools
Alan Demlow
Bruno Despres
Alicia Dickenstein
Jan Draisma
Qiang Du
Bettina Eick
Howard C. Elman
Kevin Hare
Ralf Hiptmair
Frances Kuo
Buyang Li
Christian Lubich
Andrei Martínez-Finkelshtein
Jens Markus Melenk
Michael J. Mossinghoff
Michael J. Neilan
Fabio Nobile
Houman Owhadi
Daniel Peterseim
Robert Scheichl
Igor E. Shparlinski
Chi-Wang Shu
Andrew V. Sutherland
Daniel B. Szyld



AMERICAN
MATHEMATICAL
SOCIETY

Providence, Rhode Island USA

Mathematics of Computation

This journal is devoted to research articles of the highest quality in computational mathematics. Areas covered include numerical analysis, computational discrete mathematics, including number theory, algebra and combinatorics, and related fields such as stochastic numerical methods. Articles must be of significant computational interest and contain original and substantial mathematical analysis or development of computational methodology.

Submission information. See **Information for Authors** 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.

Subscription information. *Mathematics of Computation* is published bimonthly and is also accessible electronically from www.ams.org/journals/.

Individual subscription prices for Volume 92 (2023) are as follows. For electronic only: non-member, US\$766, member, US\$459.60. For paper delivery: non-member, US\$871, member, US\$522.60. Add US\$6 for delivery within the United States; US\$31 for surface delivery outside the United States. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. For information on institutional pricing, please visit <https://www.ams.org/publications/journals/subscriberinfo>. Subscription renewals are subject to late fees. See www.ams.org/journal-faq for more journal subscription information.

Back number information. For back issues see the www.ams.org/backvols.

Subscriptions and orders should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904 USA. *All orders must be accompanied by payment.* Other correspondence should be addressed to 201 Charles Street, Providence, RI 02904-2213 USA.

Copying and reprinting. Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Requests for permission to reuse portions of AMS publication content are handled by the Copyright Clearance Center. For more information, please visit www.ams.org/publications/pubpermissions.

Excluded from these provisions is material for which the author holds copyright. In such cases, requests for permission to reuse or reprint material 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.

Mathematics of Computation (ISSN 0025-5718 (print); ISSN 1088-6842 (online)) is published bimonthly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213 USA. Periodicals postage is paid at Providence, Rhode Island. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA.

© 2023 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Mathematical Reviews*, *Zentralblatt MATH*, *Science Citation Index*®, *Science Citation Index*TM-*Expanded*, *ISI Alerting Services*SM, *CompuMath Citation Index*®, and *Current Contents*®/*Physical, Chemical & Earth Sciences*. This journal is archived in *Portico* and in *CLOCKSS*.

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

10 9 8 7 6 5 4 3 2 1 28 27 26 25 24 23

MATHEMATICS OF COMPUTATION

CONTENTS

Vol. 92, No. 343

September 2023

Benjamin Gess, Rishabh S. Gvalani, Florian Kunick, and Felix Otto, Thermodynamically consistent and positivity-preserving discretization of the thin-film equation with thermal noise	1931
Marién-Lorenzo Hanot, An arbitrary-order fully discrete Stokes complex on general polyhedral meshes	1977
L'ubomír Bañas and Christian Vieth, Robust a posteriori estimates for the stochastic Cahn-Hilliard equation	2025
Yao Cheng, Shan Jiang, and Martin Stynes, Supercloseness of the local discontinuous Galerkin method for a singularly perturbed convection- diffusion problem	2065
Hélène Barucq, Nathan Rouxelin, and Sébastien Tordeux, Construction and analysis of a HDG solution for the total-flux formulation of the convected Helmholtz equation	2097
Juntao Huang, Ruo Li, and Yizhou Zhou, Coupling conditions for linear hyperbolic relaxation systems in two-scale problems	2133
Charles-Edouard Bréhier, David Cohen, and Tobias Jahnke, Splitting integrators for stochastic Lie–Poisson systems	2167
Zhou Sheng, Jianze Li, and Qin Ni, Jacobi-type algorithms for homogeneous polynomial optimization on Stiefel manifolds with applications to tensor approximations	2217
Sören Bartels and Alex Kaltenbach, Explicit and efficient error estimation for convex minimization problems	2247
Pietro Sgobba, Divisibility conditions on the order of the reductions of algebraic numbers	2281
Bernard Mans, Min Sha, Igor E. Shparlinski, and Daniel Sutantyo, Functional graphs of families of quadratic polynomials	2307
M. Burr, F. Sottile, and E. Walker, Numerical homotopies from Khovanskii bases	2333
David A. Cox and Carlos D’Andrea, Subresultants and the Shape Lemma	2355
Ramachandran Balasubramanian, Olivier Ramaré, and Priyamvad Srivastav, Explicit bounds for products of primes in AP	2381

Editorial Information

Information on the backlog for this journal can be found on the AMS website starting from <http://www.ams.org/mcom>.

In an effort to make articles available as quickly as possible, articles are electronically published on the AMS website individually after proof is returned from authors and before appearing in an issue.

A Consent to Publish is required before we can begin processing your paper. After a paper is accepted for publication, the Providence office will send a Consent to Publish and Copyright Agreement to all authors of the paper. By submitting a paper to this journal, authors certify that the results have not been submitted to nor are they under consideration for publication by another journal, conference proceedings, or similar publication.

Information for Authors

Initial submission. All articles submitted to this journal are peer-reviewed. The AMS has a single blind peer-review process in which the reviewers know who the authors of the manuscript are, but the authors do not have access to the information on who the peer reviewers are. The AMS uses Centralized Manuscript Processing for initial submission. Authors should submit a PDF file using the Initial Manuscript Submission form found at www.ams.org/submission/mcom, or send one copy of the manuscript to the following address: Centralized Manuscript Processing, MATHEMATICS OF COMPUTATION, 201 Charles Street, Providence, RI 02904-2213 USA. If a paper copy is being forwarded to the AMS, indicate that it is for *Mathematics of Computation* and include the name of the corresponding author and contact information, such as an email address or mailing address. The author may suggest an appropriate editor for his or her paper.

The first page must consist of a *descriptive title*, followed by an *abstract* that summarizes the article in language suitable for workers in the general field (algebra, analysis, etc.). The *descriptive title* should be short, but informative; useless or vague phrases such as “some remarks about” or “concerning” should be avoided. The *abstract* must be brief, reasonably self-contained, and not exceed 300 words. Included with the footnotes to the paper should be the 2020 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. The classifications are accessible from www.ams.org/msc/. The Mathematics Subject Classification footnote may be followed by a list of *key words and phrases* describing the subject matter of the article and taken from it. Journal abbreviations used in bibliographies are listed in the latest *Mathematical Reviews* annual index. The series abbreviations are also accessible from www.ams.org/mshtml/serials.pdf. To help in preparing and verifying references, the AMS offers MR Lookup, a Reference Tool for Linking, at www.ams.org/mrlookup/.

Electronically prepared manuscripts. Manuscripts should be electronically prepared in $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$. To this end, the Society has prepared $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ author packages for each AMS publication. Author packages include instructions for preparing electronic manuscripts, samples, and a style file that generates the particular design specifications of that publication series. Articles properly prepared using the $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ style file and the `\label` and `\ref` commands automatically enable extensive intra-document linking to the bibliography and other elements of the article for searching electronically on the Web.

Authors may retrieve an author package for *Mathematics of Computation* from www.ams.org/mcom/mcomauthorpac.html. The *AMS Author Handbook* is available in PDF format from the author package link. The author package can also be obtained free of charge by sending email to tech-support@ams.org or from the Publication Division, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA. When requesting an author package, please specify the publication in which your paper will appear. Please be sure to include your complete email address.

After acceptance. The source files for the final version of the electronic manuscript should be sent to the Providence office immediately after the paper has been accepted for publication. The author should also submit a PDF of the final version of the paper to the Managing Editor, who will forward a copy to the Providence office. Accepted electronically prepared manuscripts can be submitted via the web at www.ams.org/submit-book-journal/, sent via email to pub-submit@ams.org, or sent on CD to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA. When sending a manuscript electronically via email or CD, please be sure to include a message indicating in which publication the paper has been accepted. Complete instructions on how to send files are included in the author package.

Electronic graphics. Comprehensive instructions on preparing graphics are available starting from www.ams.org/authors/journals.html. A few of the major requirements are given here.

Submit files for graphics as EPS (Encapsulated PostScript) files. This includes graphics originated 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 also avoid the use of any lines thinner than 0.5 points in width. 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 which 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 version unless color printing is authorized by the Managing Editor and the Publisher. In general, color graphics will appear in color in the online version.

AMS policy on making changes to articles after publication. Articles are published on the AMS website individually after proof is returned from authors and before appearing in an issue. To preserve the integrity of electronically published articles, once an article is individually published to the AMS website, changes cannot be made in place in the paper. The AMS does not keep author-related information, such as affiliation, current address, and email address, up to date after a paper is electronically published.

Corrections of critical errors may be made to the paper by submitting an errata article to the Editor. The errata article will be published electronically, will appear in a future print issue, and will link back and forth on the Web with the original article.

Secure manuscript tracking on the Web. Authors can track their manuscripts through the AMS journal production process using the personal AMS ID and Article ID printed in the upper right-hand corner of the Consent to Publish form sent to each author who publishes in AMS journals. Access to the tracking system is available from www.ams.org/mstrack/. An explanation of each production step is provided on the web through links from the manuscript tracking screen. Questions can be sent to mcom-query@ams.org.

Inquiries. Any inquiries concerning a paper that has been accepted for publication that cannot be answered via the manuscript tracking system mentioned above should be sent to mcom-query@ams.org or directly to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA.

Editorial Committee

SUSANNE C. BRENNER, Chair, Center for Computation & Technology and Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803 USA; *E-mail*: mathcomp@math.lsu.edu

MICHAEL J. MOSSINGHOFF, Center for Communications Research, 805 Bunn Dr., Princeton, NJ 08540 USA; *E-mail*: m.mossinghoff@idaccr.org

MICHAEL J. NEILAN, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260 USA; *E-mail*: neilan@pitt.edu

DANIEL B. SZYLD, Department of Mathematics 038-16, Temple University, 638 Wachman, 1805 N. Broad St. Philadelphia, PA 19122-6094 USA; *E-mail*: szyld@temple.edu

Board of Associate Editors

PAOLA F. ANTONIETTI, Dipartimento di Matematica, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milano, Italy; *E-mail*: paola.antonietti@polimi.it

MARKUS BACHMAYR, Institut für Mathematik, Johannes Gutenberg Universität Mainz, 55128 Mainz, Germany; *E-mail*: bachmayr@uni-mainz.de

JENNIFER BALAKRISHNAN, Department of Mathematics and Statistics, Boston University, 11 Cummington Mall, Boston, MA 02215 USA; *E-mail*: jbala@bu.edu

ERNESTO G. BIRGIN, Department of Computer Science, University of São Paulo, Rua de Matão, São Paulo - SP 05508-090, Brazil; *E-mail*: ebirgin@ime.usp.br

MARTIN BURGER, Department Mathematik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Cauerstrasse 11, 91058 Erlangen, Germany; *E-mail*: martin.burger@fau.de

CORALIA CARTIS, Mathematical Institute, University of Oxford, Andrew Wiles Building, Woodstock Road, Oxford OX2 6GG, England; *E-mail*: Coralia.Cartis@maths.ox.ac.uk

RONALD F. A. COOLS, Department of Computer Science, Katholieke Universiteit Leuven, Celestijnenlaan 200A, B-3001 Heverlee, Belgium; *E-mail*: ronald.cools@cs.kuleuven.ac.be

ALAN DEMLOW, Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843 USA; *E-mail*: demlow@math.tamu.edu

BRUNO DESPRES, University of Paris VI, Laboratory Jacques-Louis Lions, 175 rue du Chevaleret, 75013 Paris, France; *E-mail*: despres@ljl1.math.upmc.fr

ALICIA DICKENSTEIN, Departamento de Matemática, FCEN, University of Buenos Aires, Ciudad Universitaria, Pab. I, C1428EGA Buenos Aires, Argentina; *E-mail*: alidick@dm.uba.ar

JAN DRAISMA, Mathematical Institute, University of Bern, Sidlerstrasse 5, 3012 Bern Switzerland; *E-mail*: jan.draisma@math.unibe.ch

QIANG DU, Columbia University, 500 W 120th Street, APAM, 200 Mudd, MC 4701, New York, NY 10027 USA; *E-mail*: qd2125@columbia.edu

BETTINA EICK, Institut Computational Mathematics, University of Braunschweig, 38106 Braunschweig, Germany; *E-mail*: beick@tu-bs.de

HOWARD C. ELMAN, Department of Computer Science, University of Maryland, College Park, MD 20742 USA; *E-mail*: elman@cs.umd.edu

KEVIN HARE, Department of Pure Mathematics, University of Waterloo, 200 University Ave. W, Waterloo ON N2L 3G1, Canada; *E-mail*: kghare@uwaterloo.ca

RALF HIPTMAIR, Department of Mathematics, Seminar of Applied Mathematics, ETH Zurich, CH-8092 Zurich, Switzerland. *E-mail*: hiptmair@sam.math.ethz.ch

FRANCES KUO, University of New South Wales, School of Mathematics, Sydney NSW 2052, Australia; *E-mail*: f.kuo@unsw.edu.au

BUYANG LI, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong; *E-mail*: buyang.li@polyu.edu.hk

CHRISTIAN LUBICH, Mathematisches Institut, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany; *E-mail*: lubich@na.uni-tuebingen.de

ANDREI MARTÍNEZ-FINKELSHTEIN, Department of Mathematics, Baylor University, Waco, TX 76798 USA; and Department of Mathematics, University of Almeria, 04120 Almeria, Spain; *E-mail*: a.martinez-finkelshtein@baylor.edu

JENS MARKUS MELENK, Institute of Analysis and Scientific Computing, Technische Universität Wien, Wiedner Hauptstrasse 8-10, A-1040 Vienna, Austria; *E-mail*: melenk@tuwien.ac.at

FABIO NOBILE, Mathematics Institute of Computational Science and Engineering, École Polytechnique Fédérale de Lausanne, CH 1015 Lausanne, Switzerland; *E-mail*: fabio.nobile@epfl.ch

HOUMAN OWHADI, Department of Computing and Mathematical Sciences, Division of Engineering, California Institute of Technology, 1200 E. California Blvd., Pasadena, CA 91125, USA; *E-mail*: owhadi@caltech.edu

DANIEL PETERSEIM, Institute of Mathematics, University of Augsburg, Universitätsstrasse 12a, 86159 Augsburg, Germany; *E-mail*: daniel.peterseim@math.uni-augsburg.de

ROBERT SCHEICHL, Institute for Applied Mathematics, University of Heidelberg, Im Neuenheimer Feld 205, 69120 Heidelberg, Germany; *E-mail*: r.scheichl@uni-heidelberg.de

IGOR E. SHPARLINSKI, Department of Pure Mathematics, University of New South Wales, Sydney, NSW 2052, Australia; *E-mail*: igor.shparlinski@unsw.edu.au

CHI-WANG SHU, Applied Mathematics Division, Brown University, P.O. Box F, 182 George St., Providence, RI 02912-0001 USA; *E-mail*: Chi-Wang_Shu@brown.edu

ANDREW V. SUTHERLAND, Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139 USA; *E-mail*: drew@math.mit.edu

MATHEMATICS OF COMPUTATION
CONTENTS

Vol. 92, No. 343

September 2023

Benjamin Gess, Rishabh S. Gvalani, Florian Kunick, and Felix Otto, Thermodynamically consistent and positivity-preserving discretization of the thin-film equation with thermal noise	1931
Marien-Lorenzo Hanot, An arbitrary-order fully discrete Stokes complex on general polyhedral meshes	1977
L'ubomír Bañas and Christian Vieth, Robust a posteriori estimates for the stochastic Cahn-Hilliard equation	2025
Yao Cheng, Shan Jiang, and Martin Stynes, Supercloseness of the local discontinuous Galerkin method for a singularly perturbed convection-diffusion problem	2065
Hélène Barucq, Nathan Rouxelin, and Sébastien Tordeux, Construction and analysis of a HDG solution for the total-flux formulation of the convected Helmholtz equation	2097
Juntao Huang, Ruo Li, and Yizhou Zhou, Coupling conditions for linear hyperbolic relaxation systems in two-scale problems	2133
Charles-Edouard Bréhier, David Cohen, and Tobias Jahnke, Splitting integrators for stochastic Lie–Poisson systems	2167
Zhou Sheng, Jianze Li, and Qin Ni, Jacobi-type algorithms for homogeneous polynomial optimization on Stiefel manifolds with applications to tensor approximations	2217
Sören Bartels and Alex Kaltenbach, Explicit and efficient error estimation for convex minimization problems	2247
Pietro Sgobba, Divisibility conditions on the order of the reductions of algebraic numbers	2281
Bernard Mans, Min Sha, Igor E. Shparlinski, and Daniel Sutantyo, Functional graphs of families of quadratic polynomials	2307
M. Burr, F. Sottile, and E. Walker, Numerical homotopies from Khovanskii bases	2333
David A. Cox and Carlos D'Andrea, Subresultants and the Shape Lemma	2355
Ramachandran Balasubramanian, Olivier Ramaré, and Priyamvad Srivastav, Explicit bounds for products of primes in AP	2381



0025-5718(202309)92:343;1-0