

---

VOLUME 66 NUMBER 218



APRIL 1997

---

# MATHEMATICS OF COMPUTATION

---

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**

James H. Bramble  
Susanne C. Brenner  
Howard Elman  
Richard S. Falk  
Walter Gautschi  
Daniel W. Lozier  
James N. Lyness  
Harald Niederreiter  
Syvert P. Nørsett  
Andrew M. Odlyzko  
John E. Osborn  
Stanley Osher  
Carl Pomerance  
René Schoof  
L. Ridgway Scott  
Chi-Wang Shu  
Frank Stenger  
Hans J. Stetter  
G. W. Stewart  
Nico M. Temme  
Vidar Thomée  
Lars B. Wahlbin, *Managing Editor*  
Joseph D. Ward  
Hugh C. Williams  
John W. Wrench, Jr.  
Stephen J. Wright

---

PROVIDENCE, RHODE ISLAND USA

ISSN 0025-5718

---

## Mathematics of Computation

This journal publishes research articles in computational mathematics. Areas covered include numerical analysis, with emphasis on the mathematical analysis and development of methods, computational number theory and algebra, and related fields. Table errata and reviews of books in areas related to computational mathematics are also included.

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

**Subscription information.** *Mathematics of Computation* is published quarterly. Beginning in January 1996 *Mathematics of Computation* is accessible from e-MATH via the World Wide Web at the URL <http://www.ams.org/publications/>. Subscription prices for Volume 66 (1997) are as follows: for paper delivery, \$307 list, \$246 institutional member, \$276 corporate member, \$200 MAA & SIAM members; \$184 individual member; for electronic delivery, \$276 list, \$221 institutional member, \$248 corporate member, \$179 MAA & SIAM members, \$166 individual member; for combination paper and electronic delivery, \$353 list, \$282 insitutional member, \$318 corporate member, \$229 MAA & SIAM members, \$212 individual member. If ordering the paper version, add \$12 for surface delivery outside the United States and India; \$18 to India. Expedited delivery to destinations in North America is \$17; elsewhere \$49.

**Back number information.** For back issues see the *AMS Catalog of Publications*.

Subscriptions and orders should be addressed to the American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904. *All orders must be accompanied by payment.* Other correspondence should be addressed to P.O. Box 6248, Providence, RI 02940-6248.

**Unpublished Mathematical Tables.** The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT). When a table is deposited in the UMT repository a brief summary of its contents is published in the section *Reviews and Descriptions of Tables and Books*. Upon request, the chairman of the editorial committee will supply copies of any table for a nominal cost per page. All tables and correspondence concerning the UMT should be sent to Lars B. Wahlbin, Chairman, Editorial Committee, Mathematics of Computation, Center for Applied Mathematics, 657 Frank H. T. Rhodes Hall, Cornell University, Ithaca, NY 14853.

**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 Assistant to the Publisher, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. Requests can also be made by e-mail to [reprint-permission@ams.org](mailto:reprint-permission@ams.org).

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.)

---

*Mathematics of Computation* is published quarterly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213. Periodicals postage is paid at Providence, Rhode Island. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, P. O. Box 6248, Providence, RI 02940-6248.

© 1997 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Science Citation Index*®, *SciSearch*®, *Research Alert*®, *CompuMath Citation Index*®, and *Current Contents*®/Physical, Chemical & Earth Sciences.

⊗ 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 02 01 00 99 98 97

## Editorial Information

As of December 31, 1996, the backlog for this journal was approximately 0 issues. This estimate is the result of dividing the number of manuscripts for this journal in the Providence office that have not yet gone to the printer on the above date by the average number of articles per issue over the previous twelve months, reduced by the number of issues published in six months (the time necessary for editing and composing a typical issue).

A Consent to Publish and Copyright Agreement is required before a paper will be published in this journal. 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.** An author should submit three paper copies of the manuscript. Initial submission by e-mail is not allowed. The author may suggest an appropriate editor for his paper. All contributions intended for publication and all books for review should be addressed to Lars B. Wahlbin, Managing Editor, Mathematics of Computation, Center for Applied Mathematics, 657 Frank H. T. Rhodes Hall, Cornell University, Ithaca, NY 14853-3801. The date received, which is published with the final version of an accepted paper, is the date received in the office of the Managing Editor, and it is the responsibility of the author to submit manuscripts directly to this office.

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 and reasonably self-contained. Included with the footnotes to the paper, there should be the 1991 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. This may be followed by a list of *key words and phrases* describing the subject matter of the article and taken from it. A list of classifications may be found in the annual index of *Mathematical Reviews*, published with the December issue starting in 1990. Journal abbreviations used in bibliographies are also listed in the latest *Mathematical Reviews* annual index. The classifications and the journal abbreviations are accessible from e-MATH via the World Wide Web through the URL <http://www.ams.org/committee/publications/mr-info.html> or via FTP to [e-math.ams.org](http://e-math.ams.org) (login as `anonymous` and enter username as password). The classifications are available as a browsable list and the journal abbreviations are available through a search tool. When the manuscript is submitted, authors should supply the editor with electronic addresses if available. These will be printed after the postal address at the end of each article.

**Electronically prepared manuscripts.** For the final submission of accepted papers, the AMS encourages use of electronically prepared manuscripts, with a strong preference for  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$  submissions. 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, the *AMS Author Handbook*, 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 automatically provide hypertext linking to the bibliography and other elements of the article for searching electronically on the World Wide Web. Because linking must often be added manually to submissions in other forms of  $\mathcal{T}\mathcal{E}\mathcal{X}$ , using  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$  also reduces the amount of technical intervention once the files are received by the AMS. This results in fewer errors in processing and saves the author proofreading time.  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$  papers also move more efficiently through the production stream, helping to minimize publishing costs.

$\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$  is the highly preferred format of  $\mathcal{T}\mathcal{E}\mathcal{X}$ , but author packages are also available in  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$ . Those authors who make use of these style files from the beginning of the writing process will further reduce their own efforts. Electronically submitted manuscripts

prepared in  $\LaTeX$  or plain  $\TeX$  are normally not acceptable due to the high amount of technical time required to insure that the file will run properly through the AMS in-house production system.  $\LaTeX$  users will find that  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\LaTeX$  is the same as  $\LaTeX$  with additional commands to simplify the typesetting of mathematics, and users of plain  $\TeX$  should have little difficulty learning  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\LaTeX$ .

Authors may retrieve an author package from e-MATH via the World Wide Web through the URL <http://www.ams.org/tex/> or via FTP to [e-math.ams.org](ftp://e-math.ams.org) (login as **anonymous** and enter username as password). The author package can also be obtained free of charge by sending e-mail to [pub@ams.org](mailto:pub@ams.org) (Internet) or from the Publication Division, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When requesting an author package, please specify  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\LaTeX$  or  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\TeX$ , Macintosh or IBM (3.5) format, and the publication in which your paper will appear. Please be sure to include your complete mailing address.

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 send the final version of the paper manuscript to the Managing Editor, who will forward a copy to the Providence office. Editors will require authors to send their electronically prepared manuscripts to the Providence office in a timely fashion. Electronically prepared manuscripts can be sent via e-mail to [pub-submit@ams.org](mailto:pub-submit@ams.org) (Internet) or on diskette to the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. When submitting an electronic manuscript, please be sure to include a message indicating in which publication the paper has been accepted. No corrections will be accepted electronically. Authors must mark their changes on their proof copies and return them to the Providence office. Complete instructions on how to submit files are included in the author package.

**Electronic graphics.** Figures may be submitted to the AMS in an electronic format. The AMS recommends that graphics created electronically be saved in Encapsulated PostScript (EPS) format. This includes graphics originated via a graphics application as well as scanned photographs or other computer-generated images.

If the graphics package used does not support EPS output, the graphics file should be saved in one of the standard graphics formats—such as TIFF, PICT, GIF, etc.—rather than in an application-dependent format. Graphics files submitted in an application-dependent format are not likely to be used. No matter what method was used to produce the graphic, it is necessary to provide a paper copy to the AMS.

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.

**$\TeX$  files available.** Beginning with the January 1992 issue of the *Bulletin* and the January 1996 issues of *Transactions*, *Proceedings*, *Mathematics of Computation*, and the *Journal of the AMS*,  $\TeX$  files can be downloaded from e-MATH, starting from URL <http://www.ams.org/journals/>. Authors without Web access may request their files at the address given below after the article has been published. For *Bulletin* papers published in 1987 through 1991 and for *Transactions*, *Proceedings*, *Mathematics of Computation*, and the *Journal of the AMS* papers published in 1987 through 1995,  $\TeX$  files are available upon request for authors without Web access by sending e-mail to [file-request@ams.org](mailto:file-request@ams.org) or by contacting the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248. The request should include the title of the paper, the name(s) of the author(s), the name of the publication in which the paper has or will appear, and the volume and issue numbers if known. The  $\TeX$  file will be sent to the author making the request after the article goes to the printer. If the requestor can receive Internet e-mail, please include the e-mail address to which the file should

be sent. Otherwise please indicate a diskette format and postal address to which a disk should be mailed. **Note:** Because  $\text{\TeX}$  production at the AMS sometimes requires extra fonts and macros that are not yet publicly available,  $\text{\TeX}$  files cannot be guaranteed to run through the author's version of  $\text{\TeX}$  without errors. The AMS regrets that it cannot provide support to eliminate such errors in the author's  $\text{\TeX}$  environment.

Any inquiries concerning a paper that has been accepted for publication should be sent directly to the Electronic Prepress Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248.

### Editorial Committee

ANDREW M. ODLYZKO, AT&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974; *E-mail:* amo@research.att.com

STANLEY OSHER, Department of Mathematics, University of California, Los Angeles, CA 90024; *E-mail:* sjo@math.ucla.edu

G. W. STEWART, Department of Computer Science, University of Maryland, College Park, MD 20742; *E-mail:* stewart@thales.cs.umd.edu

LARS B. WAHLBIN, Chairman. Center for Applied Mathematics, 657 Frank H. T. Rhodes Hall, Cornell University, Ithaca, NY 14853-3801; *E-mail:* awahlbin@cam.cornell.edu

### Board of Associate Editors

JAMES H. BRAMBLE, Department of Mathematics, Texas A & M University, College Station, TX 77843-3368; *E-mail:* bramble@math.tamu.edu

SUSANNE C. BRENNER, Department of Mathematics, University of South Carolina, Columbia, SC 29208; *E-mail:* brenner@math.sc.edu

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

RICHARD S. FALK, Department of Mathematics, Rutgers University, New Brunswick, NJ 08903-2101; *E-mail:* falk@math.rutgers.edu

WALTER GAUTSCHI, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907; *E-mail:* wxg@cs.purdue.edu

DANIEL W. LOZIER, Applied and Computational Mathematics Division, National Institute of Standards and Technology, Gaithersburg, MD 20899-0001; *E-mail:* dlozier@nist.gov

JAMES N. LYNESS, Mathematics and Computer Science Division, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439; *E-mail:* lyness@mcs.anl.gov

HARALD NIEDERREITER, Institute for Information Processing, Austrian Academy of Sciences, Sonnenfelsgasse 19, A-1010 Vienna, Austria; *E-mail:* nied@qiinfo.oeaw.ac.at

SYVERT P. NØRSETT, Division of Numerical Mathematics, The University of Trondheim and The Norwegian Institute of Technology, Alfred Getz vei 1, N-7034 Trondheim-NTH, Norway; *E-mail:* norsett@imf.unit.no

JOHN E. OSBORN, Department of Mathematics, University of Maryland, College Park, MD 20742; *E-mail:* jeo@julia.umd.edu

CARL POMERANCE, Department of Mathematics, The University of Georgia, Athens, GA 30602; *E-mail:* carl@math.uga.edu

RENÉ SCHOOF, Dipartimento di Matematica, 2<sup>a</sup> Università di Roma "Tor Vergata", I-00133 Roma, Italy; *E-mail:* schoof@fwi.uva.nl

L. RIDGWAY SCOTT, Department of Mathematics, University of Houston, Houston, TX 77204-3476; *E-mail:* scott@casc.math.uh.edu

CHI-WANG SHU, Applied Mathematics Division, Brown University, Providence, RI 02912-0001; *E-mail:* shu@cfm.brown.edu

FRANK STENGER, Department of Computer Science, University of Utah, Salt Lake City, UT 84112; *E-mail:* stenger@cs.utah.edu

HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Wiedner Hauptstrasse 6-10, A-1040, Wien, Austria; *E-mail*: [stetter@uranus.tuwien.ac.at](mailto:stetter@uranus.tuwien.ac.at)

NICO M. TEMME, Stichting Mathematisch Centrum, Centrum voor Wiskunde en Informatica, Kruislaan 413, 1098 SJ Amsterdam, The Netherlands; *E-mail*: [nicot@cwi.nl](mailto:nicot@cwi.nl)

VIDAR THOMÉE, Mathematics Department, Chalmers University of Technology, S-412 96 Göteborg, Sweden; *E-mail*: [thomee@math.chalmers.se](mailto:thomee@math.chalmers.se)

JOSEPH D. WARD, Department of Mathematics, Texas A & M University, College Station, TX 77843-3368; *E-mail*: [jward@math.tamu.edu](mailto:jward@math.tamu.edu)

HUGH C. WILLIAMS, Department of Computer Science, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2; *E-mail*: [Hugh.Williams@csmail.cs.umanitoba.ca](mailto:Hugh.Williams@csmail.cs.umanitoba.ca)

JOHN W. WRENCH, JR., 102 Mt. Olivet Boulevard, Frederick, MD 21701

STEPHEN J. WRIGHT, Mathematics and Computer Science Division, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439; *E-mail*: [wright@mcs.anl.gov](mailto:wright@mcs.anl.gov)

(Continued from back cover)

<b>Corey Powell</b> , Bounds for multiplicative cosets over fields of prime order .	807
<b>Thomas Mattman and John McKay</b> , Computation of Galois groups over function fields .....	823
<b>Larry Lehman</b> , Rational eigenvectors in spaces of ternary forms .....	833
<b>Kenji Koyama, Yukio Tsuruoka, and Hiroshi Sekigawa</b> , On searching for solutions of the Diophantine equation $x^3 + y^3 + z^3 = n$ .....	841
<b>Francesco Pappalardi</b> , On the $r$ -rank Artin Conjecture .....	853
<b>F. Arnault</b> , The Rabin-Monier theorem for Lucas pseudoprimes .....	869
<b>G. L. Cohen</b> , Numbers whose positive divisors have small integral harmonic mean .....	883
<b>Chung-Chiang Chou and Yuefan Deng</b> , Decomposing 40 billion integers by four tetrahedral numbers .....	893
<b>David Bailey, Peter Borwein, and Simon Plouffe</b> , On the rapid computation of various polylogarithmic constants .....	903
<b>Reviews and Descriptions of Tables and Books</b> .....	915
Iserles, Managing Editor <b>5</b> , Morton and Mayers <b>6</b> , Überhuber <b>7</b> , Davy and Dew, Editors <b>8</b> , Diaz and Lions, Editors <b>9</b> , Kelley <b>10</b> , Mollin <b>11</b> , Nicely <b>12</b>	
<b>Corrigendum</b> .....	927

No microfiche supplement in this issue



MATHEMATICS OF COMPUTATION

CONTENTS

Vol. 66, No. 218

April 1997

<b>Carsten Carstensen</b> , A posteriori error estimate for the mixed finite element method .....	465
<b>M. G. Andrade and J. B. R. do Val</b> , A numerical scheme based on mean value solutions for the Helmholtz equation on triangular grids .....	477
<b>Tao Tang and Zhen-huan Teng</b> , Viscosity methods for piecewise smooth solutions to scalar conservation laws .....	495
<b>Abdallah Chalabi</b> , On convergence of numerical schemes for hyperbolic conservation laws with stiff source terms .....	527
<b>Bernardo Cockburn and Pierre-Alain Gremaud</b> , A priori error estimates for numerical methods for scalar conservation laws. Part II: flux-splitting monotone schemes on irregular Cartesian grids .....	547
<b>Norbert Hofmann and Peter Mathé</b> , On quasi-Monte Carlo simulation of stochastic differential equations .....	573
<b>Raymond Couture and Pierre L'Ecuyer</b> , Distribution properties of multiply-with-carry random number generators .....	591
<b>M. E. Froes Bunchaft</b> , Some extensions of the Lanczos-Ortiz theory of canonical polynomials in the Tau Method .....	609
<b>Y. Tourigny and M. J. Baines</b> , Analysis of an algorithm for generating locally optimal meshes for $L_2$ approximation by discontinuous piecewise polynomials .....	623
<b>Stefano Serra</b> , Optimal, quasi-optimal and superlinear band-Toeplitz preconditioners for asymptotically ill-conditioned positive definite Toeplitz systems .....	651
<b>Karl Meerbergen and Alastair Spence</b> , Implicitly restarted Arnoldi with purification for the shift-invert transformation .....	667
<b>Reiner Horst</b> , On generalized bisection of $n$ -simplices .....	691
<b>Anne Gelb</b> , The resolution of the Gibbs phenomenon for spherical harmonics .....	699
<b>Heike Fassbender</b> , On numerical methods for discrete least-squares approximation by trigonometric polynomials .....	719
<b>Jürgen Müller</b> , Accelerated polynomial approximation of finite order entire functions by growth reduction .....	743
<b>Laurent Habsieger and Bruno Salvy</b> , On integer Chebyshev polynomials	763
<b>Horst Alzer</b> , On some inequalities for the incomplete gamma function ...	771
<b>A. Omrani and A. Shokrollahi</b> , Computing irreducible representations of supersolvable groups over small finite fields .....	779
<b>Joseph H. Silverman</b> , Computing canonical heights with little (or no) factorization .....	787
<b>Corey Powell</b> , Bounds for multiplicative cosets over fields of prime order .	807

(Continued on inside back cover)



0025-5718(199704)66:218;1-4