

VOLUME 57 NUMBER 195

JULY 1991

# 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  
James W. Demmel  
Walter Gautschi, *Managing Editor*  
Eugene Isaacson  
Heinz-Otto Kreiss  
James N. Lyness  
Harald Niederreiter  
Jorge J. Nocedal  
Syvert P. Nørsett  
Andrew M. Odlyzko  
Frank W. J. Olver  
John E. Osborn  
Stanley Osher  
Carl Pomerance  
René Schoof  
Larry L. Schumaker  
Ridgway Scott  
Daniel Shanks  
Frank Stenger  
Hans J. Stetter  
G. W. Stewart  
Nico M. Temme  
Vidar Thomée  
Lars B. Wahlbin  
Hugh C. Williams  
John W. Wrench, Jr.

PROVIDENCE, RHODE ISLAND USA

ISSN 0025-5718

## Editorial Committee

WALTER GAUTSCHI, Chairman. Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907  
ANDREW M. ODLYZKO, AT&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07974  
FRANK W. J. OLVER, Inst. for Physical Science and Technology, Univ. of Maryland, College Park, MD 20742  
LARS B. WAHLBIN, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853

### Technical Editor

ERIKA GAUTSCHI, Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907

### Board of Associate Editors

JAMES H. BRAMBLE, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853  
JAMES W. DEMMEL, Courant Institute of Mathematical Sciences, New York Univ., 251 Mercer Street, New York, NY 10012  
EUGENE ISAACSON, Courant Institute of Mathematical Sciences, New York Univ., 251 Mercer Street, New York, NY 10012  
HEINZ-OTTO KREISS, Dept. of Applied Mathematics, California Institute of Technology, Pasadena, CA 91125  
JAMES N. LYNNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439  
HARALD NIEDERREITER, Institute for Information Processing, Austrian Academy of Sciences, Sonnenfelsgasse 19, A-1010 Vienna, Austria  
JORGE J. NOCEDAL, Dept. of Electrical Engineering and Computer Science, Northwestern Univ., Evanston, IL 60208-3118  
SYVERT P. NØRSETT, Div. of Numerical Mathematics, The University of Trondheim and The Norwegian Institute of Technology, Alfred Getz vei 1, N-7034 Trondheim-NTH, Norway  
JOHN E. OSBORN, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742  
STANLEY OSHER, Dept. of Mathematics, Univ. of California, Los Angeles, CA 90024  
CARL POMERANCE, Dept. of Mathematics, The Univ. of Georgia, Athens, GA 30602  
RENÉ SCHOOF, Dipartimento di Matematica, Università degli Studi di Trento, I-38050 Povo (Trento), Italy  
LARRY L. SCHUMAKER, Dept. of Mathematics, Vanderbilt Univ., Nashville, TN 37235  
RIDGWAY SCOTT, Dept. of Mathematics, Univ. of Houston, Houston, TX 77204-3476  
DANIEL SHANKS, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742  
FRANK STENGER, Dept. of Mathematics, Univ. of Utah, Salt Lake City, UT 84112  
HANS J. STETTER, Institut für Numerische Mathematik, Technische Universität Wien, Wiedner Hauptstrasse 6-10, A-1040, Wien, Austria  
G. W. STEWART, Dept. of Computer Science, Univ. of Maryland, College Park, MD 20742  
NICO M. TEMME, Stichting Mathematisch Centrum, Centrum voor Wiskunde en Informatica, Kruislaan 413, 1098 SJ Amsterdam, The Netherlands  
VIDAR THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, S-412 96 Göteborg, Sweden  
HUGH C. WILLIAMS, Dept. of Computer Science, Univ. of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2  
JOHN W. WRENCH, JR., 102 Mt. Olivet Blvd., Frederick, MD 21701

**SUBSCRIPTION INFORMATION: MATHEMATICS OF COMPUTATION** is published quarterly, with issues numbered serially since Volume 1, Number 1. Subscription prices for Volumes 56 and 57 (1991) are \$205 list; \$164 institutional member; \$133 member of CBMS organizations; \$123 individual AMS member. A late charge of 10% of the subscription price will be imposed upon orders received from nonmember institutions and organizations after January 1 of the subscription year. Subscribers outside the United States and India must pay a postage surcharge of \$9; subscribers in India must pay a postage surcharge of \$18. Expedited delivery to destinations in North America \$12; elsewhere \$40. Combination paper and microfiche subscription prices are \$273 list; \$219 institutional member. Microfiche of each issue will be mailed the fastest way before the issue is mailed by the printer.

**BACK NUMBER INFORMATION:** Back number prices *per volume* are for Volumes 1–21, \$90 list, \$72 member; for Volumes 22–33, \$136 list, \$109 institutional member; for Volumes 34–43, \$90 list, \$72 institutional member; Volumes 44–45, \$127 list, \$102 institutional member; Volumes 46–47, \$139 list, \$111 institutional member; Volumes 48–49, \$148 list, \$118 institutional member; Volumes 50–51, \$149 list, \$119 institutional member; for Volumes 52–53, \$152 list, \$122 institutional member; for Volumes 54–55, \$144 list, \$115 institutional member. Back volumes may be purchased on microfilm or microfiche from University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

**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 Walter Gautschi, Chairman, Editorial Committee, Mathematics of Computation, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907.

Orders for subscriptions and publications of the American Mathematical Society should be addressed to the AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-1571. *All orders must be accompanied by payment.* Other correspondence should be addressed to P.O. Box 6248, Providence, RI 02940-6248.

MATHEMATICS OF COMPUTATION is published quarterly by the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213. Second-class postage is paid at Providence, Rhode Island, and additional mailing offices. Postmaster: Send address changes to Mathematics of Computation, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248.

Copyright © 1991, American Mathematical Society. All rights reserved.  
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. ☹

This publication was typeset using  $\mathcal{A}_{MS}\text{-}\mathcal{T}_{E}\mathcal{X}$ ,  
the American Mathematical Society's  $\mathcal{T}_{E}\mathcal{X}$  macro system.