Mathematics of Computation



EDITED BY

lames H. Bramble Bille C. Carlson Walter Gautschi, Managing Editor Donald Goldfarb Eugene Isaacson Heinz-Otto Kreiss lames N. Lyness Morris Newman Syvert P. Nørsett Frank W. J. Olver John E. Osborn Stanley Osher **Beresford Parlett** Philip Rabinowitz **Ridgway Scott Daniel Shanks** Frank Stenger Hans J. Stetter G. W. Stewart Vidar C. Thomée Lars B. Wahlbin Hugh C. Williams John W. Wrench, Jr.

October 1985

Volume 45, Number 172, Pages 279-648

Published by the American Mathematical Society Providence, Rhode Island USA ISSN 0025-5718

Editorial Committee

WALTER GAUTSCHI, Chairman. Dept. of Computer Sciences, Purdue Univ., West Lafayette, IN 47907 DONALD GOLDFARB, Dept. of Industrial Engineering and Operations Research, Seely W. Mudd Building,

Columbia Univ. in the City of New York, New York, NY 10027

JOHN E. OSBORN, Dept. of Mathematics, Univ. of Maryland, College Park, MD 20742

HUGH C. WILLIAMS, Dept. of Computer Science, Univ. of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

Technical Editor

MIRIAM E. PORILE, 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

BILLE C. CARLSON, Dept. of Mathematics, Iowa State Univ., Ames, IA 50011

EUGENE ISAACSON, Courant Institute of Mathematical Sciences, New York Univ., 251 Metcer Street, New York, NY 10012

HEINZ-OTTO KREISS, Dept. of Applied Mathematics, California Institute of Technology, Pasadena, CA 91125

JAMES N. LYNESS, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439

MORRIS NEWMAN, Dept. of Mathematics, Univ. of California, Santa Barbara, CA 93106

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

FRANK W. J. OLVER, Inst. for Physical Science and Technology, Univ. of Maryland, College Park, MD 20742

STANLEY OSHER, Dept. of Mathematics, Univ. of California, Los Angeles, CA 90024

BERESFORD PARLETT, Dept. of Mathematics, Univ. of California, Berkeley, CA 94720

PHILIP RABINOWITZ, Dept. of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel

RIDGWAY SCOTT, Dept. of Mathematics, Univ. of Michigan, Ann Arbor, MI 48109

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, Weidner Haupstrasse 6-10, A-1040, Wien, Austria

G. W. STEWART, Dept. of Computer Science, Univ. of Maryland, College Park, MD 20742 VIDAR C. THOMÉE, Mathematics Dept., Chalmers Univ. of Technology, Göteborg, Sweden LARS B. WAHLBIN, Dept. of Mathematics, Cornell Univ., Ithaca, NY 14853

JOHN W. WRENCH, JR., 6310 Jefferson 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 44 and 45 (1985) are \$150.00 list; \$120.00 institutional member; \$98.00 member of CBMS organizations; \$90.00 individual AMS member. A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Subscribers outside the United States and India must pay a postage surcharge of \$5.00; subscribers in India must pay a postage surcharge of \$10.00. Combination paper and microfiche subscription prices are \$200.00 list; \$160.00 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, \$80.00 list, \$64.00 member; for Volumes 22-33, \$120.00 list, \$96.00 member; for Volumes 34-43, \$80.00 list, \$64.00 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.

MATHEMATICS OF COMPUTATION is published quarterly by the American Mathematical Society, 201 Charles Street, Providence, RI 02904. 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.

> Copyright © 1985, 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.

MATHEMATICS OF COMPUTATION TABLE OF CONTENTS

October 1985

Lloyd N. Trefethen, Stability of Finite-Difference Models Containing Two Boundaries or Interfaces	279
Marsha J. Berger, Stability of Interfaces with Mesh Refinement	301
Endre Süli, Boško Jovanović and Lav Ivanović, Finite Difference Approxima- tions of Generalized Solutions	319
Vassilios A. Dougalis and Ohannes A. Karakashian, On Some High-Order Accurate Fully Discrete Galerkin Methods for the Korteweg-de Vries Equation	329
Haroon Kheshgi and Mitchell Luskin, Analysis of the Finite Element Variable Penalty Method for Stokes Equations	347
Rolf Jeltsch and Klaus-Günther Strack, Accuracy Bounds for Semidiscretiza- tions of Hyperbolic Problems	365
M. N. Spijker, Stepsize Restrictions for Stability of One-Step Methods in the Numerical Solution of Initial Value Problems	377
J. Bigge and E. Bohl, Deformations of the Bifurcation Diagram Due to Discretization	393
Heinz W. Engl and Andreas Neubauer, An Improved Version of Marti's Method for Solving Ill-Posed Linear Integral Equations	405
Hermann Brunner, The Numerical Solution of Weakly Singular Volterra Integral Equations By Collocation on Graded Meshes	417
P. J. van der Houwen and H. J. J. te Riele, Linear Multistep Methods for Volterra Integral and Integro-Differential Equations	439
Ch. Lubich, Fractional Linear Multistep Methods for Abel-Volterra Integral Equations of the Second Kind	463
R. Fletcher and S. P. J. Matthews , A Stable Algorithm for Updating Triangular Factors Under a Rank One Change	471
T. A. Porsching , Estimation of the Error in the Reduced Basis Method Solution of Nonlinear Equations	487
C. de Boor and R. DeVore, A Geometric Proof of Total Positivity for Spline Interpolation	497
J. F. Traub and D. Lee, Optimal Integration for Functions of Bounded Varia- tion	505
G. Akrivis, The Error Norm of Certain Gaussian Quadrature Formulae	513
Stanisław Lewanowicz, Recurrence Relations for Hypergeometric Functions of Unit Argument	521
C. L. Frenzen and R. Wong, A Note on Asymptotic Evaluation of Some Hankel Transforms	537
Henry E. Fettis, Further Extensions of a Legendre Function Integral	549
J. H. McCabe and G. M. Phillips, Aitken Sequences and Generalized Fibonacci Numbers	553
John F. Monahan, Accuracy in Random Number Generation	559
Theresa P. Vaughan, On Computing the Discriminant of an Algebraic Number Field	569

Veikko Ennola and Reino Turunen, On Cyclic Cubic Fields	585
V. Ennola, S. Mäki and R. Turunen, On Real Cyclic Sextic Fields	591
Ezra Brown , Sets in Which $xy + k$ is Always a Square	613
Alice A. Deanin, A Counterexample to a Conjecture of Mahler on Best P-Adic	
Diophantine Approximation Constants	621
Reviews and Descriptions of Tables and Books	633
Ferziger 11, Carey and Oden 12, Thomée 13, Ratschek and Rokne 14, Pulleyblank 15	
Corrigendum	637
Jaeschke	
Indices to Volumes XLIV and XLV	639
Supplement to "Linear Multistep Methods for Volterra Integral and Integro-	
Differential Equations" by P. J. van der Houwen and H. J. J. te Riele.	S21

Information for Contributors

Manuscripts should be typewritten double-spaced in the format used by the journal. For journal abbreviations, see the latest *Mathematical Reviews* volume index. An author should submit the original and two copies of the manuscript and retain one copy. The author may suggest an appropriate editor for his paper. It is recommended that the author acquaint himself with the pertinent material contained in "A Manual for Authors of Mathematical Papers," which is available from the American Mathematical Society. All contributions intended for publication and all books for review should be addressed to Walter Gautschi, Chairman, Editorial Committee, Mathematics of Computation, Department of Computer Sciences, Purdue University, West Lafayette, Indiana 47907. The date received, which is published with the final version of an accepted paper, is the date received in the office of the Chairman of the Editorial Committee, and it is the responsibility of the author to submit manuscripts directly to this office. Institutions sponsoring research reported in the journal are assessed page and microfiche charges.

Each article submitted for publication must be accompanied by a brief and reasonably self-contained abstract, and by 1980 *Mathematics Subject Classification* (1985 *Revision*) numbers. If a list of key words and phrases is included, it will be printed as a footnote on the first page. A list of the classification numbers may be found in the 1984 Subject Index to Mathematical Reviews.

The research journals of the American Mathematical Society carry a page charge of \$50.00 per page to help defray the cost of publication. This amount is charged to the institution or to a contract supporting the research reported in the published paper. The publication charge policy of the United States Federal Council for Science and Technology (FCST) is reported on page 112 of the February, 1975 issue of the NOTICES of the American Mathematical Society. In no case is the author personally responsible for paying the page charge, nor is acceptance of the author's paper for publication dependent upon payment of the page charge.

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 acknowledgement of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication (including abstracts) is permitted only under license from the American Mathematical Society. Requests for such permission should be addressed to the Executive Director, American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940.

The appearance of the code on the first page of an article in this journal indicates the copyright owner's consent for copying beyond that permitted by Sections 107 or 108 of the U. S. Copyright Law, provided that the fee of \$1.00 plus \$.25 per page for each copy be paid directly to Copyright Clearance Center, Inc., 21 Congress Street, Salem, Massachusetts 01970. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotion purposes, for creating new collective works, or for resale.