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Modern Methods in Scientific Computing with applications

Bourlioux, A. (ed.); Gander, Martin Jakob (ed.); Sabidussi, Gert (ed.)

This publication URL: <https://archive-ouverte.unige.ch/unige:8320>

Publication DOI: [10.1007/978-94-010-0510-4](https://doi.org/10.1007/978-94-010-0510-4)

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Modern Methods in Scientific Computing and Applications

edited by

Anne Bourlioux

Département de Mathématiques et de Statistique,
Université de Montréal,
Montréal, Québec, Canada

Martin J. Gander

Department of Mathematics and Statistics,
McGill University,
Montréal, Québec, Canada

and

Technical Editor

Gert Sabidussi

Département de Mathématiques et de Statistique,
Université de Montréal,
Montréal, Québec, Canada



Springer-Science+Business Media, B.V.

Proceedings of the NATO Advanced Study Institute and Séminaire de Mathématiques
Supérieures on Modern Methods in Scientific Computing and Applications
Montréal, Québec, Canada
9–20 July 2001

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-1-4020-0782-8 ISBN 978-94-010-0510-4 (eBook)
DOI 10.1007/978-94-010-0510-4

Printed on acid-free paper

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Originally published by Kluwer Academic Publishers in 2002

Softcover reprint of the hardcover 1st edition 2002

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Preface

When we first heard in the spring of 2000 that the Séminaire de mathématiques supérieures (SMS) was interested in devoting its session of the summer of 2001—its 40th—to scientific computing the idea of taking on the organizational work seemed to us somewhat remote. More immediate things were on our minds: one of us was about to go on leave to the Courant Institute, the other preparing for a research summer in Paris. But the more we learned about the possibilities of such a seminar, the support for the organization and also the great history of the SMS, the more we grew attached to the project. The topics we planned to cover were intended to span a wide range of theoretical and practical tools for solving problems in image processing, thin films, mathematical finance, electrical engineering, moving interfaces, and combustion. These applications alone show how wide the influence of scientific computing has become over the last two decades: almost any area of science and engineering is greatly influenced by simulations, and the SMS workshop in this field came very timely. We decided to organize the workshop in pairs of speakers for each of the eight topics we had chosen, and we invited the leading experts worldwide in these fields. We were very fortunate that every speaker we invited accepted to come, so the program could be realized as planned.

Four of the eight sessions focused on the techniques of scientific computing: the domain decomposition session with lectures by Laurence Halpern and Frédéric Nataf from France introduced the audience to absorbing boundary conditions and one-way operators, which are key ingredients for fast domain decomposition methods. The new methods proposed were optimized Schwarz methods and a new preconditioner for non-symmetric Schur methods. The multigrid session, given by Gundolf Haase and Ulrich Langer from Austria, provided an introduction to the convergence analysis of multi-grid methods and a new multi-grid technique for the three-dimensional Maxwell equations with impressive performance. Algebraic multi-grid techniques were also presented. The lectures in the session on dynamical systems, given by Tony Humphries and Andrew Stuart from England, started with continuous and discrete dynamical systems, and then went on to stochastic dynamical systems with an analysis of numerical methods for the stochastic case. Finally, the matrix analysis session, led by Zhaojun Bai and Gene Golub from the US, focused on reduced order model techniques for extremely large systems of ordinary differential equations, using a very elegant link to Krylov methods, estimates for entries of functions of matrices through quadrature, and relating orthogonal polynomials to Lanczos, closing the circle.

The other four sessions combined techniques with concrete applications. The session on stochastic differential equations given by George Papanicolaou and Ronnie Sircar from the US started with an overview of limit theorems and the law of large numbers with the key techniques of asymptotic analysis for applications in mathematical finance. In particular, a new model was presented which can reproduce the skewness of the curve of implied volatilities formerly known as the smile curve. The session on image processing dealt with two major techniques: Karol Mikula from Slovakia showed how nonlinear diffusion equations based on the Perona-Malik equation can be used in image processing. The original instability in this approach was corrected with a convolution, and impressive image sequences of a beating heart illustrated the effectiveness of this approach. A full convergence proof for the nonlinear discretization was also shown. The second technique, presented by Jamie Sethian from the US, was level set methods with an almost unreal way to reconstruct missing image parts that are completed by the human brain when we look at an image. The case of the “missing tri-

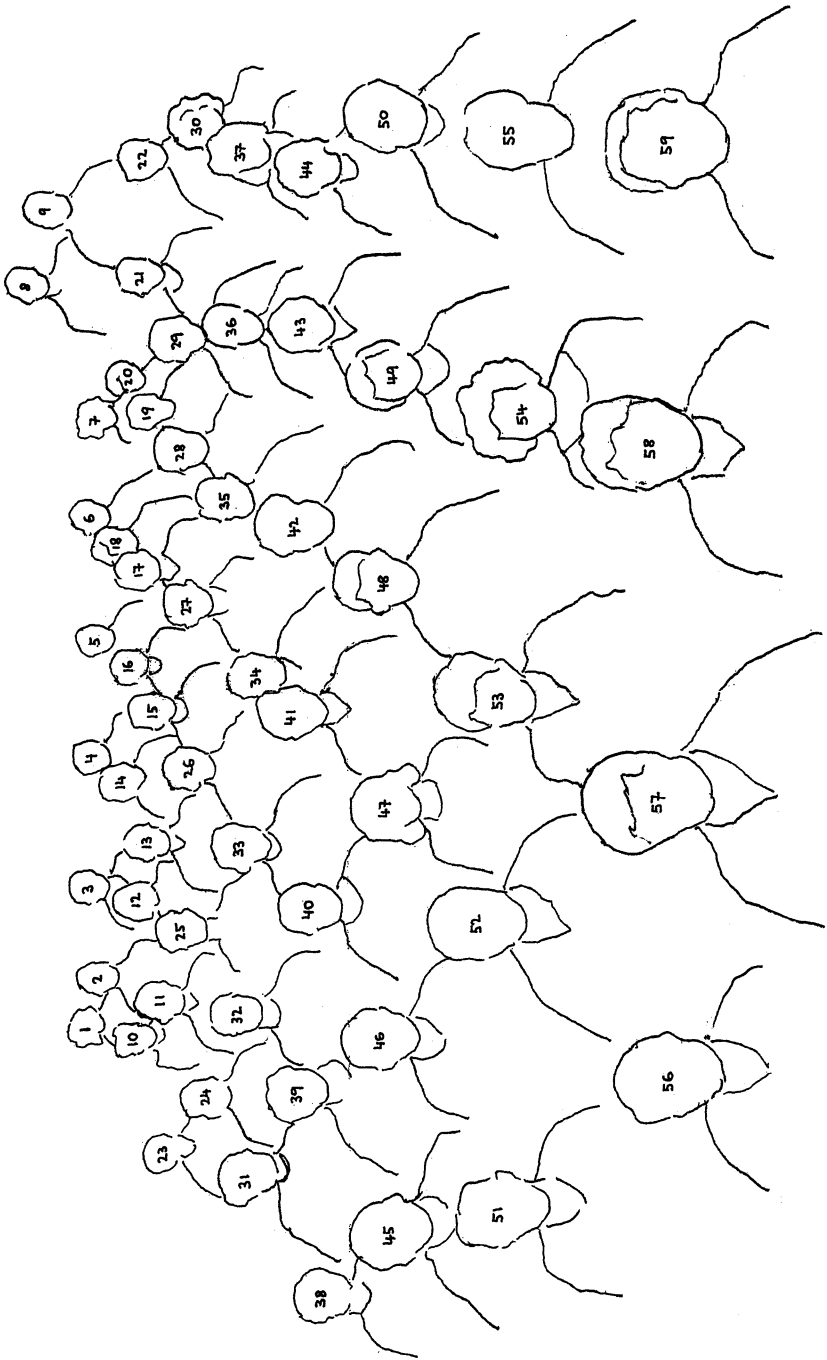
angle” is particularly spectacular. The third session, on thin films, was presented by Andrea Bertozzi and Thomas Witeliski from the US. They showed how asymptotic analysis is essential in capturing phenomena of rupturing and fingering, and how even one-dimensional flows can give insight into the behavior of thin films. The fourth session, given by Anne Bourlioux from Canada and Panagiotis Souganidis from the US, introduced asymptotic analysis for combustion problems, and concrete computations which illustrate how high resolution results can be obtained by using the asymptotic results in regions close to flame fronts, where otherwise the required high resolution would be computationally infeasible.

While the sixteen speakers came from six different countries, the total of 75 participants of the ASI come from twenty different countries. In absolute terms most came from the US (18), but in relative terms (with respect to the population of the country) most came from Slovakia (7). We are very thankful to Gert Sabidussi and Ghislaine David for the flawless organization of this international event; nobody could have done a better job! We are also grateful for NATO’s generous support through its Advanced Study Institutes Program, and to the Centre de Recherches Mathématiques (CRM) and the Université de Montréal for the local support.

The 40th session of the SMS/NATO ASI on Scientific Computing and Applications showed impressively how active the field of scientific computing is today and what tremendous impact it has in science and engineering. Scientific computing has become the third discipline together with mathematical modeling and physical experiments to explore our world and advance science.

The editors





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| 3 Sevcovic | 33 Eyriboyun |
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Participants

Victor ABRUKOV
Physical-Technical Faculty
Chuvash State University
428 015 Cheboksary
Russia
victor@chuvsu.ru

André BARBOSA
c/o Helder Coelho
Departamento de Informática
Universidade de Lisboa
Bloco C5 — Piso 1 — Campo Grande
1700 Lisboa
Portugal
andre.dias.barbosa@clix.pt

Sven BEUCHLER
Faculty of Mathematics
TU-Chemnitz
Reichenhainer Str. 39/41
09107 Chemnitz
Germany
sven.beuchler
@mathematik.tu.chemnitz.de

Jean-Philippe BOULET
Dép. de mathématiques et de statistique
Université Laval
Québec, QC, G1K 7P4
Canada
jpboulet@mat.ulaval.ca

Yves BOURGAULT
Dép. de mathématiques et de statistique
Université d'Ottawa
585 King Edward
P.O. Box 450, Station A
Ottawa, ON, K1N 6N5
Canada
ybourg@mathstat.uottawa.ca

Robert BYSTRICKY
Dept. Mathematics — Fac. Civil Engineering
Slovak University of Technology
Radlinskeho 11
813 68 Bratislava
Slovakia
rb@svf.stuba.sk

Elisabetta CARLINI
Dipartimento di Matematica
Università “La Sapienza” di Roma 1
P.le Aldo Moro, 2
00185 Roma
Italy
carlini@giove.mat.uniroma1.it

Vladimir CHALUPECKY
Department of Mathematics
Fac. Nuclear Sci. & Phys. Engineering
Czech Technical University
Trojanova 13
120 00 Praha 2
Czech Republic
chalupecky@kml.fjfi.cvut.cz

Yao-li CHUANG
Department of Physics
Duke University
Durham, NC 27708
USA
chuang@phy.duke.edu

Robert CUNDERLIK
Department of Theoretical Geodesy
Slovak University of Technology
Radlinskeho 11
813 68 Bratislava
Slovakia
cunderli@svf.stuba.sk

Marc-André DESAUTELS
 Dép. de mathématiques et de statistique
 Université de Montréal
 CP 6128, succ. Centre-ville
 Montréal, QC, H3C 3J7
 Canada
 desautel@dms.umontreal.ca

Victorita DOLEAN
 CMAP École Polytechnique
 91128 Palaiseau Cédex
 France
 dolean@cmapp.polytechnique.fr

Andrei DRAGANESCU
 Department of Mathematics
 University of Chicago
 5734 S. University Ave.
 Chicago, IL 60637
 USA
 draga@math.uchicago.edu

Mustafa EYRIBOYUN
 Mechanical Engineering Department
 Zonguldak Karaelmas University
 67100 Zonguldak
 Turkey
 eboyun@karaelmas.edu.tr

Martin J. GANDER
 Department of Mathematics & Statistics
 McGill University
 805 Sherbrooke ouest
 Montréal, QC, H3A 2K6
 Canada
 mgander@math.mcgill.ca

John GREER
 Department of Mathematics
 Duke University
 Box 90320
 Durham, NC 27708-0320
 USA
 jbg33@math.duke.edu

Robert GUÉNETTE
 Dép. de mathématiques et de statistique
 Université Laval
 Québec, QC, G1K 7P4
 Canada
 robert.guenette@mat.ulaval.ca

Aissa GUESMIA
 IRMA, UFR Mathématique & Informatique
 Université Louis Pasteur (Strasbourg I)
 7, rue René Descartes
 67084 Strasbourg Cédex
 France
 guesmia@math.u-strasbg.fr

Angela HANDLOVICOVA
 Dept. Mathematics — Fac. Civil Engineering
 Slovak University of Technology
 Radlinskeho 11
 813 68 Bratislava
 Slovakia
 angela@svf.stuba.sk

David HORAK
 Department of Applied Mathematics
 VSB-Technical University of Ostrava
 Tr. 17. Listopadu 15
 708 33 Ostrava-Poruba
 Czech Republic
 david.horak@vsb.cz

Ferenc IZSÁK
 Department of Applied Analysis
 Eötvös Loránd University
 Kecskeméti u. 10-12
 H-1053 Budapest
 Hungary
 bizsu@cs.elte.hu

Ning JU
 Department of Mathematics
 Duke University
 Box 90320
 Durham, NC 27708-0320
 USA
 ju@math.duke.edu

Boualem KHOUIDER
 Courant Institute of Mathematical Sciences
 New York University
 251 Mercer St.
 New York, NY 10012-1185
 USA
 khouider@cims.nyu.edu

Johanna KIENESBERGER
 Inst. f. Anal. & Comput. Mathematics
 Johannes Kepler University of Linz
 Altenberger Str. 69
 4040 Linz
 Austria
 kienes@numa.uni-linz.ac.at

Tomás KOZUBEK
 Department of Applied Mathematics
 VSB-Technical University of Ostrava
 Tr. 17. Listopadu 15
 708 33 Ostrava-Poruba
 Czech Republic
 tomas@kozubek@vsb.cz

Zuzana KRIVA
 Dept. Mathematics — Fac. Civil Engineering
 Slovak University of Technology
 Radlinskeho 11
 813 68 Bratislava
 kriva@svf.stuba.sk

Gennady KULIKOV
 Faculty of Mechanics and Mathematics
 Ulyanovsk State University
 L. Tolstoy Str. 42
 432 700 Ulyanovsk
 Russia
 kulgyu@mci.ulsu.ru

Jindrich MAKOVICKA
 Department of Mathematics
 Fac. Nuclear Sci. & Physical Engineering
 Czech Technical University
 Trojanova 13
 120 00 Prague 2
 Czech Republic
 makovick@kmlinux.fjfi.cvut.cz

Inessa MATVEEVA
 Sobolev Institute of Mathematics
 pr. Koptyuga 4
 630090 Novosibirsk
 Russia
 matveeva@math.nsc.ru

Tadas MESKAUSKAS
 CERFACS
 42, ave. Gaspard Coriolis
 31057 Toulouse Cédex 1
 France
 meska@cerfacs.fr

Elena MUL
 Inst. Computer Information & Technologies
 Ternopil Acad. of National Economy
 3 Peremoga Square
 46004 Ternopil
 Ukraine
 elena.mul@lycos.com

Günther OF
 Mathematisches Institut A
 Universität Stuttgart
 Pfaffenwaldring 57
 70569 Stuttgart
 Germany
 ofgr@cip.mathematik.uni-stuttgart.de

Gouri S. PADHI
 Dept. Mechanical & Aeronautical Engineer.
 University of Limerick
 Limerick
 Republic of Ireland
 gouri@padhi@ul.ie

George PAPANICOLAOU
 Department of Mathematics
 Stanford University
 Stanford, CA 94305-2125
 USA
 papanico@math.stanford.edu

Natalia PETROVSKAYA
Keldysh Inst. Applied Mathematics, RAS
Boeing Operations International, Inc.
Gazetny per 17/9
103009 Moscow
Russia
natalia.petrovskaya@boeing.com

Roger PIERRE
Dép. de mathématiques et de statistique
Université Laval
Québec, QC, G1K 7P4
Canada
rpierre@mat.ulaval.ca

Pavel PRAKS
Department of Applied Mathematics
VSB-Technical University of Ostrava
Tr. 17. Listopadu 15
708 33 Ostrava-Poruba
Czech Republic
pavel.praks@vsb.cz

Tanvir RAHMAN
Department of Physics
McGill University
3600 University
Montréal, QC, H3A 2K6
Canada
tanvir@physics.mcgill.ca

Stefan REITZINGER
Special Research Program SFB F013
University of Linz
Freistaedterstr. 313
4040 Linz
Austria
reitz@sfb013.uni-linz.ac.at

Michał REZULSKI
Institute of Telecommunications
Warsaw Technical University
15/19 Nowowiejska St.
00665 Warszawa
Poland
rezulski@tele.pw.edu.pl

Marielba ROJAS
CERFACS
42, ave. Gaspard Coriolis
31057 Toulouse Cédex 1
France
mrojas@cerfacs.fr

Laurent SAAS
Institut Français du Pétrole
4, ave. Bois Préau
92852 Rueil Malmaison Cédex
France
laurent.saas@ifp.fr

Daniel SEVCOVIC
Institute of Applied Mathematics
Faculty of Mathematics & Physics
Comenius University
Mlynska dolina
842 48 Bratislava
Slovakia
sevcovic@fmph.uniba.sk

Angela SLAVOVA
Institute of Mathematics & Informatics
Bulgarian Academy of Sciences
Acad. G. Bonchev Str., bl. 8
1113 Sofia
Bulgaria
slavova@math.bas.bg

Amik ST-CYR
Dép. de mathématiques et de statistique
Université de Montréal
CP 6128, succ. Centre-ville
Montréal, QC, H3C 3J7
Canada
stcyrdms.umontreal.ca

Gábor STIKKEL
Department of Numerical Analysis
Eötvös Loránd University
Pázmány Péter Sétány 1/D
H-1117 Budapest
Hungary
stiko@cs.elte.hu

Romy TOUMA
Dép. de mathématiques et de statistique
Université de Montréal
CP 6128, succ. Centre-ville
Montréal, QC, H3C 3J7
Canada
touma@dms.umontreal.ca

Cyril UNGVARSKY
Inst. Applied Mathematics — F.M.P.I.
Comenius University
842 15 Bratislava
Slovakia
cyril.ungvarsky@fmph.uniba.sk

Ratnam VIGNESVARAN
School of Mathematical Sciences
University of Sussex
Falmer-Brighton BN1 9QH
UK
r.vignesvaran@sussex.ac.uk

Oleg VOLKOV
Dép. de mathématiques et de statistique
Université de Montréal
CP 6128, succ. Centre-ville
Montréal, QC, H3C 3J7
Canada
volkov@dms.umontreal.ca

Markus WABRO
Inst. f. Anal. & Comput. Mathematics
Johannes Kepler University of Linz
Altenberger Str. 69
4040 Linz
Austria
markus.wabro@numa.uni-linz.ac.at

Fabien M. YOUNISSI
Dép. de mathématiques et de statistique
Université Laval
Québec, QC, G1K 7P4
Canada
fyoubi@mat.ulaval.ca

Bence ZAUPPER
Institute of Mathematics
Eötvös Loránd University
Múzeum krt 6–8
H-1088 Budapest
Hungary
benco@freemail.hu

Contributors

Zhaojung BAI
Department of Computer Science
University of California
One Shields Avenue
Davis, CA 95616
USA
bai@cs.ucdavis.edu

Andrea BERTOZZI
Department of Mathematics
Duke University
Box 90320
Durham, NC 27708-0320
USA
bertozzi@math.duke.edu

Anne BOURLIOUX
Dép. de mathématiques et de statistique
Université de Montréal
CP 6128 — succ. Centre-ville
Montréal, QC, H3C 3J7
Canada
bourliou@dms.umontreal.ca

Mark BOWEN
Department of Mathematics
Duke University
Box 90320
Durham, NC 27708-0320
USA
bowen@math.duke.edu

Gene H. GOLUB
Computer Science Department
Stanford University
Stanford, CA 94305-9025
USA
golub@scm.stanford.edu

Gundolf HAASE
Inst. Analysis & Computational Math.
Johannes Kepler University
Altenberger Str. 69
4040 Linz
Austria
ghaase@numa.uni-linz.ac.at

Laurence HALPERN
Mathématiques — Institut Galilée
Université Paris 13
99, avenue Jean-Baptiste Clément
93430 Villetaneuse
France
halpern@math.univ-paris13.fr

Anthony HUMPHRIES
School of Mathematical Sciences
University of Sussex
Falmer-Brighton BN1 9QH
UK
a.r.humphries@sussex.ac.uk

Mattias JONSSON
Department of Mathematics
University of Michigan
Ann Arbor, MI 48109-1109
USA
mattiasj@umich.edu

Ulrich LANGER
Inst. Analysis & Computational Math.
Johannes Kepler University
Altenberger Str. 69
4040 Linz
Austria
ulanger@numa.uni-linz.ac.at

Karol MIKULA
Department of Mathematics
Fac. of Civil Engineering
Slovak University of Technology
Randlinskeho 11
813 68 Bratislava
Slovakia
mikula@vox.svf.stuba.sk

Frédéric NATAF
Centre de Mathématiques Appliquées
École Polytechnique
91128 Palaiseau Cédex
France
nataf@cmmapx.polytechnique.fr

Adib RAHMOUNI
Mathématiques — Institut Galilée
Université Paris 13
99, avenue Jean-Baptiste Clément
93430 Villetaneuse
France
rahmouni@math.univ-paris13.fr

James A. SETHIAN
Department of Mathematics
University of California
Berkeley, CA 94720-3840
USA
sethian@math.berkeley.edu

Ronnie SIRCAR
Dept. of Operations Research
and Financial Engineering
Princeton University
Princeton, NJ 08544
USA
sircar@princeton.edu

Panagiotis SOUGANIDIS
Department of Mathematics
University of Texas at Austin
Austin, TX 78712-1082
USA
souganid@ma.utexas.edu

Andrew STUART
Mathematical Institute
Warwick University
Coventry CV4 7AL
UK
stuart@maths.warwick.ac.uk

Thomas WITELSKI
Department of Mathematics
Duke University
Box 90320
Durham, NC 27708-0320
USA
witelski@math.duke.edu