

# CONTEMPORARY MATHEMATICS

## Nonstrictly Hyperbolic Conservation Laws

Proceedings of an AMS Special  
Session held January 9–10, 1985

AMERICAN MATHEMATICAL SOCIETY

VOLUME 60

## Titles in This Series

---

### Volume

- 1 **Markov random fields and their applications**, Ross Kindermann and J. Laurie Snell
- 2 **Proceedings of the conference on integration, topology, and geometry in linear spaces**, William H. Graves, Editor
- 3 **The closed graph and P-closed graph properties in general topology**, T. R. Hamlett and L. L. Herrington
- 4 **Problems of elastic stability and vibrations**, Vadim Komkov, Editor
- 5 **Rational constructions of modules for simple Lie algebras**, George B. Seligman
- 6 **Umbral calculus and Hopf algebras**, Robert Morris, Editor
- 7 **Complex contour integral representation of cardinal spline functions**, Walter Schempp
- 8 **Ordered fields and real algebraic geometry**, D. W. Dubois and T. Recio, Editors
- 9 **Papers in algebra, analysis and statistics**, R. Lidl, Editor
- 10 **Operator algebras and K-theory**, Ronald G. Douglas and Claude Schochet, Editors
- 11 **Plane ellipticity and related problems**, Robert P. Gilbert, Editor
- 12 **Symposium on algebraic topology in honor of José Adem**, Samuel Gitler, Editor
- 13 **Algebraists' homage: Papers in ring theory and related topics**, S. A. Amitsur, D. J. Saltman, and G. B. Seligman, Editors
- 14 **Lectures on Nielsen fixed point theory**, Boju Jiang
- 15 **Advanced analytic number theory. Part I: Ramification theoretic methods**, Carlos J. Moreno
- 16 **Complex representations of  $GL(2, K)$  for finite fields  $K$** , Ilya Piatetski-Shapiro
- 17 **Nonlinear partial differential equations**, Joel A. Smoller, Editor
- 18 **Fixed points and nonexpansive mappings**, Robert C. Sine, Editor
- 19 **Proceedings of the Northwestern homotopy theory conference**, Haynes R. Miller and Stewart B. Priddy, Editors
- 20 **Low dimensional topology**, Samuel J. Lomonaco, Jr., Editor
- 21 **Topological methods in nonlinear functional analysis**, S. P. Singh, S. Thomeier, and B. Watson, Editors
- 22 **Factorizations of  $b^n \pm 1$ ,  $b = 2, 3, 5, 6, 7, 10, 11, 12$  up to high powers**, John Brillhart, D. H. Lehmer, J. L. Selfridge, Bryant Tuckerman, and S. S. Wagstaff, Jr.
- 23 **Chapter 9 of Ramanujan's second notebook—Infinite series identities, transformations, and evaluations**, Bruce C. Berndt and Padmini T. Joshi
- 24 **Central extensions, Galois groups, and ideal class groups of number fields**, A. Fröhlich
- 25 **Value distribution theory and its applications**, Chung-Chun Yang, Editor
- 26 **Conference in modern analysis and probability**, Richard Beals, Anatole Beck, Alexandra Bellow, and Arshag Hajian, Editors
- 27 **Microlocal analysis**, M. Salah Baouendi, Richard Beals, and Linda Preiss Rothschild, Editors
- 28 **Fluids and plasmas: geometry and dynamics**, Jerrold E. Marsden, Editor
- 29 **Automated theorem proving**, W. W. Bledsoe and Donald Loveland, Editors
- 30 **Mathematical applications of category theory**, J. W. Gray, Editor
- 31 **Axiomatic set theory**, James E. Baumgartner, Donald A. Martin, and Saharon Shelah, Editors
- 32 **Proceedings of the conference on Banach algebras and several complex variables**, F. Greenleaf and D. Gulick, Editors

# Titles in This Series

---

## Volume

- 33 **Contributions to group theory**, Kenneth I. Appel, John G. Ratcliffe, and Paul E. Schupp, Editors
- 34 **Combinatorics and algebra**, Curtis Greene, Editor
- 35 **Four-manifold theory**, Cameron Gordon and Robion Kirby, Editors
- 36 **Group actions on manifolds**, Reinhard Schultz, Editor
- 37 **Conference on algebraic topology in honor of Peter Hilton**, Renzo Piccinini and Denis Sjerve, Editors
- 38 **Topics in complex analysis**, Dorothy Browne Shaffer, Editor
- 39 **Errett Bishop: Reflections on him and his research**, Murray Rosenblatt, Editor
- 40 **Integral bases for affine Lie algebras and their universal enveloping algebras**, David Mitzman
- 41 **Particle systems, random media and large deviations**, Richard Durrett, Editor
- 42 **Classical real analysis**, Daniel Waterman, Editor
- 43 **Group actions on rings**, Susan Montgomery, Editor
- 44 **Combinatorial methods in topology and algebraic geometry**, John R. Harper and Richard Mandelbaum, Editors
- 45 **Finite groups—coming of age**, John McKay, Editor
- 46 **Structure of the standard modules for the affine Lie algebra  $A_1^{(1)}$** , James Lepowsky and Mirko Primc
- 47 **Linear algebra and its role in systems theory**, Richard A. Brualdi, David H. Carlson, Biswa Nath Datta, Charles R. Johnson, and Robert J. Plemmons, Editors
- 48 **Analytic functions of one complex variable**, Chung-chun Yang and Chi-tai Chuang, Editors
- 49 **Complex differential geometry and nonlinear differential equations**, Yum-Tong Siu, Editor
- 50 **Random matrices and their applications**, Joel E. Cohen, Harry Kesten, and Charles M. Newman, Editors
- 51 **Nonlinear problems in geometry**, Dennis M. DeTurck, Editor
- 52 **Geometry of normed linear spaces**, R. G. Bartle, N. T. Peck, A. L. Peressini, and J. J. Uhl, Editors
- 53 **The Selberg trace formula and related topics**, Dennis A. Hejhal, Peter Sarnak, and Audrey Anne Terras, Editors
- 54 **Differential analysis and infinite dimensional spaces**, Kondagunta Sundaresan and Srinivasa Swaminathan, Editors
- 55 **Applications of algebraic K-theory to algebraic geometry and number theory**, Spencer J. Bloch, R. Keith Dennis, Eric M. Friedlander, and Michael R. Stein, Editors
- 56 **Multiparameter bifurcation theory**, Martin Golubitsky and John Guckenheimer, Editors
- 57 **Combinatorics and ordered sets**, Ivan Rival, Editor
- 58 **The Lefschetz centennial conference. Part I: Proceedings on algebraic geometry**, D. Sundararaman, Editor
- 59 **Function estimates**, J. S. Marron, Editor
- 60 **Nonstrictly hyperbolic conservation laws**, Barbara Lee Keyfitz and Herbert C. Kranzer, Editors

# **Nonstrictly Hyperbolic Conservation Laws**

# **CONTEMPORARY MATHEMATICS**

**Volume 60**

## **Nonstrictly Hyperbolic Conservation Laws**

**Proceedings of an AMS Special  
Session held January 9–10, 1985**

**Barbara Lee Keyfitz and  
Herbert C. Kranzer, Editors**

**AMERICAN MATHEMATICAL SOCIETY**

**Providence • Rhode Island**

## EDITORIAL BOARD

Irwin Kra, managing editor	W. H. Jaco Gerald J. Janusz
Thomas F. Banchoff	Jan Mycielski
M. Salah Baouendi	Johannes C. C. Nitsche
Alan D. Weinstein	

The Proceedings of the Special Session on Nonstrictly Hyperbolic Conservation Laws held at the 816th Meeting of the American Mathematical Society in Anaheim, California, January 9–10, 1985.

1980 *Mathematics Subject Classification (1985·Revision)*. Primary 35B65, 35C99, 35L65, 35L67, 65M10, 76N99, 76W05.

---

### Library of Congress Cataloging-In-Publication Data

Special Session on Nonstrictly Hyperbolic Conservation Laws (1985: Anaheim, Calif.)

(Contemporary mathematics, ISSN 0271-4132; v. 60)

"Proceedings of the Special Session on Nonstrictly Hyperbolic Conservation Laws, held at the 816th Meeting of the American Mathematical Society in Anaheim, California, January 9-10, 1985"—T.p. verso.

Bibliography: p.

1. Fluid dynamics—Congresses. 2. Conservation laws (Physics)—Congresses.  
3. Differential equations, Partial—Congresses. I. Keyfitz, Barbara Lee. II. Kranzer, Herert C.  
III. American Mathematical Society. Meeting (816th: 1985: Anaheim, Calif.) IV. Title.  
V. Series: Contemporary mathematics (American Mathematical Society); v. 60.  
QA911.S67 1985 532'.05 86-28690  
ISBN 0-8218-5069-5 (pbk.: alk. paper)

---

Copyright ©1987 by the American Mathematical Society. All rights reserved.

The American Mathematical Society retains all rights except those granted to the United States Government.

Printed in the United States of America.

Information on copying and reprinting can be found at the back of this volume.

This volume was printed directly from author-prepared copy.

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

## TABLE OF CONTENTS

### Preface

<b>Waves in nonlinearly viscoelastic media</b> S.S. ANTMAN AND R. MALEK-MADANI	1
<b>The generalized Riemann problem in compressible duct flow</b> M. BEN-ARTZI	11
<b>Characteristic fields for the equations of magnetohydrodynamics</b> M. BRIO AND C.C. WU	19
<b>The equations of incompressible elasticity</b> D. G. EBIN AND R.A. SAXTON	25
<b>Elementary waves for hyperbolic equations in higher space dimensions: an example from petroleum reservoir modeling</b> J. GLIMM AND D.H. SHARP	35
<b>Cauchy-Kovalevsky theorems for hyperbolic systems of conservation laws with piecewise analytic initial data</b> E. HARABETIAN	43
<b>The entropy rate admissibility criterion and the double phase boundary problem</b> H. HATTORI	51
<b>Some elementary connections among nonstrictly hyperbolic conservation laws</b> B.L. KEYFITZ	67
<b>The scalar Riemann problem in two spatial dimensions: piecewise smoothness of solutions</b> W.B. LINDQUIST	79
<b>A model for two phase flow with hysteresis</b> D. MARCHESIN, H.B. MEDEIROS AND P.J. PAES-LEME	89
<b>On the transonic flow past an airfoil</b> C.S. MORAWETZ	109

Phase jumps near the Maxwell line M. SHEARER	111
Measure-valued solutions to a problem in dynamic phase transitions M. SLEMROD AND V. ROYTBURD	115
Degenerate systems of conservation laws B. TEMPLE	125



## Preface

The papers in this volume represent the proceedings of a Special Session, "Nonstrictly Hyperbolic Conservation Laws," which took place at the AMS Winter Meeting in Anaheim, California, on January 9th and 10th, 1985. Our motivation in organizing the session was the hope of identifying common themes and viewpoints in the recent work of people working on diverse nonclassical applications of conservation laws. The enthusiasm of the participants further motivated production of this volume of proceedings. We are grateful to Hugo Rossi, Associate Secretary of the AMS, for helping us to organize the Special Session, and to Ronny Wells, then managing editor of the Contemporary Mathematics series, for encouraging us to publish the proceedings. We would also like to thank Stuart Antman, Constantine Dafermos, Ron DiPerna, Brent Lindquist, Tai-Ping Liu, Jim Ralston, Marshall Slemrod, and David Wagner, who refereed manuscripts for us.

Barbara Lee Keyfitz

Herbert C. Kranzer

**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 volume 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.

