Ocean Acoustic Propagation by Finite Differnece Methods

D. LEE & S. T. McDANIEL

General Editor E.Y. RODIN

OCEAN ACOUSTIC PROPAGATION BY FINITE DIFFERENCE METHODS

International Series in MODERN APPLIED MATHEMATICS AND COMPUTER SCIENCE

General Editor E. Y. Rodin

Volume 15

Pergamon Titles of Related Interest

AVULA et al Mathematical Modelling in Science and Technology

BELLMAN et al Mathematical Aspects of Scheduling and Applications

CERCONE Computational Linguistics

CLARKE Population Geography, 2nd Edition

COOPER AND COOPER Introduction to Dynamic Programming

HARGITTAI Symmetry: Unifying Human Understanding

MARCHUCK AND KAGAN Ocean Tides (Mathematical Models and Numerical Experiments)

PUGACHEV et al Probability Theory and Mathematical Statistics for Engineers

SAATY AND ALEXANDER Thinking with Models

SCHULTZ AND LEE Computational Ocean Acoustics

SURI Resource Management Concepts for Large Systems

WITTEN Hyperbolic Partial Differential Equations, Volumes I, II, III and IV

WITTEN Diseases and Epidemics

YAVIN AND PACHTER Persuit-Evasion Differential Games

Related Journals*

Analysis Mathematica

Applied Mathematics Letters

Computers and Mathematics with Applications

Computers in Biology and Medicine

Journal of Applied Mathematics and Mechanics

Mathematical Modelling

Nonlinear Analysis

Problem of Control and Information Theory

Topology

*Full details of all Pergamon publications/free specimen copy of any Pergamon journal available on request from your nearest Pergamon office.

OCEAN ACOUSTIC PROPAGATION BY FINITE DIFFERENCE METHODS

by

D. LEE

Naval Underwater Systems Center, New London, CT 06320, U.S.A.

S. T. McDANIEL

Applied Research Laboratory, The Pennsylvania State University, University Park, PA 16802, U.S.A.



PERGAMON PRESS

OXFORD · NEW YORK · BEIJING · FRANKFURT SÃO PAULO · SYDNEY · TOKYO · TORONTO

U. K .	Pergamon Press plc, Headington Hill Hall, Oxford OX3 0BW, England
U.S.A.	Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523, U.S.A.
PEOPLE'S REPUBLIC OF CHINA	Pergamon Press, Room 4037, Qianmen Hotel, Beijing, People's Republic of China
FEDERAL REPUBLIC OF GERMANY	Pergamon Press GmbH, Hammerweg 6, D-6242 Kronberg, Federal Republic of Germany
BRAZIL	Pergamon Editora Ltda, Rua Eça de Queiros, 346, CEP 04011, Paraiso, São Paulo, Brazil
AUSTRALIA	Pergamon Press Australia Pty Ltd., P.O. Box 544, Potts Point, N.S.W. 2011, Australia
JAPAN	Pergamon Press, 5th Floor, Matsuoka Central Building, 1-7-1 Nishishinjuku, Shinjuku-ku, Tokyo 160, Japan
CANADA	Pergamon Press Canada Ltd., Suite No. 271, 253 College Street, Toronto, Ontario, Canada M5T 1RS

Copyright © 1988 Pergamon Press plc

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means: electronic, electrostatic, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing from the publishers.

ISBN 0-08-034871-8

Published as a special issue of the journal *Computers & Mathematics with Applications*, Volume 14 Number 5 and supplied to subscribers as part of their normal subscription. Also available to non-subscribers.

In the interests of economy and rapid publication this edition has not been re-paginated.

Printed in Great Britain by A. Wheaton & Co. Ltd, Exeter

CONTENTS

OCEAN ACOUSTIC PROPAGATION BY FINITE DIFFERENCE METHODS

Foreword by E. Y. Rodin	vii
Preface	ix
Chapter 1: Introduction	305
Chapter 2: Ocean Acoustic Wave Propagation Problems	309
2.1. The governing wave equation	309
2.2. The parabolic approximation	311
Chapter 3: Finite Difference Schemes	317
3.1. Formulation	318
3.2. Consistency	320
3.3. Stability	323
3.4. Convergence	324
Chapter 4: Initial and Boundary Conditions	327
4.1. The initial field	327
4.2. A Neumann bottom boundary condition	328
4.3. Interface treatment	330
4.4. Discussion	337
Chapter 5: Range Step Size Analysis	341
5.1. The heat equation model	341
5.2. An extension of the model heat equation	343
5.3. The PE	346
Chapter 6: Wide-angle Capability	351
6.1. Rational function approximation	353
6.2. IFD implementation	353
6.3. Estimation of the propagation angle	357
Chapter 7: Applicable Solution Methods Other Than The Implicit Finite Difference Scheme	361
7.1. The split-step Fourier algorithm	361
7.2. The numerical ordinary differential equation method	363
7.3. A stable explicit finite difference scheme	366
Chapter 8: Representative Test Examples	369
8.1. Burgers' equation	369
8.2. Range-independent problems	374
8.3. A range-dependent problem	376
8.4. Wide-angle propagation	378
Chapter 9: Listing of Computer Codes	385
Reference Citation Index	421
Subject Index	423
Softstrip® data strip containing the table of contents of this issue	Ι

This page intentionally left blank