

Lecture Notes in Mathematics

Edited by A. Dold and B. Eckmann

416

Michael Taylor

Pseudo Differential
Operators



Springer-Verlag
Berlin · Heidelberg · New York 1974

Dr. Michael E. Taylor
University of Michigan
Ann Arbor, MI 48104/USA

Library of Congress Cataloging in Publication Data

Taylor, Michael Eugene, 1946-

Pseudo differential operators.

(Lecture notes in mathematics ; 416)

Bibliography: p.

Includes index.

1. Differential equations, Partial. 2. Pseudo-differential operators. I. Title. II. Series:

Lecture notes in mathematics (Berlin) ; 416.

QA3.L28 no. 416 [QA374] 510'.8s [515'.724] 74-23846

AMS Subject Classifications (1970): 35-02, 35S05

ISBN 3-540-06961-5 Springer-Verlag Berlin · Heidelberg · New York

ISBN 0-387-06961-5 Springer-Verlag New York · Heidelberg · Berlin

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically those of translation, reprinting, re-use of illustrations, broadcasting, reproduction by photocopying machine or similar means, and storage in data banks.

Under § 54 of the German Copyright Law where copies are made for other than private use, a fee is payable to the publisher, the amount of the fee to be determined by agreement with the publisher.

© by Springer-Verlag Berlin · Heidelberg 1974. Printed in Germany.

Offsetdruck: Julius Beltz, Hemsbach/Bergstr.

TABLE OF CONTENTS

Introduction	1
Chapter I. Singular Integral Operators on the circle	4
1. The algebra of singular integral operators	6
2. The oblique derivative problem	10
3. C^* algebras and singular integral operators	14
Chapter II. Pseudo Differential Operators	19
1. The Fourier integral representation	19
2. The pseudo local property	22
3. Asymptotic expansions of a symbol	24
4. Adjoints and products	31
5. Coordinate changes, operators on a manifold	33
6. Continuity on H^s	37
7. Families of pseudo differential operators	41
8. Gårding's inequality	44
Chapter III. Elliptic and Hypoelliptic Operators	45
1. Elliptic operators	45
2. Hypoelliptic operators with constant strength	48
3. References to further work	57
Chapter IV. The Initial Value Problem. Hyperbolic Operators	58
1. Reduction to a first order system	59
2. Symmetric hyperbolic systems	62
3. Strictly hyperbolic equations	66
4. Finite propagation speed; finite domain of dependence	72

IV

5.	The vibrating membrane problem	76
6.	Parabolic evolution equations	79
7.	References to further work	82
Chapter V.	Elliptic Boundary Value Problems; Petrowsky Parabolic Operators	84
1.	A priori estimates and regularity theorems	91
2.	Closed range and Fredholm properties	98
3.	Regular boundary value problems	107
4.	A subelliptic estimate; the oblique deriva- tive problem	115
5.	References to further work	119
Chapter VI.	Propagation of Singularities; Wave Front Sets	120
1.	The wave front set of a distribution	120
2.	Propagation of singularities; the Hamilton flow	125
3.	Local existence	131
4.	Systems; an exponential decay result	135
Chapter VII.	The Sharp Gårding Inequality	139
1.	A multiple symbol	140
2.	Friedrichs symmetrization	144
3.	The sharp Gårding inequality	147
	Bibliography	150