CONTEMPORARY MATHEMATICS

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Inverse Problems and Spectral Theory

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October 28–November 1, 2002
Research Institute for Mathematical Sciences
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http://dx.doi.org/10.1090/conm/348

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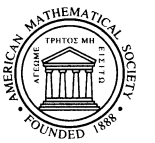

American Mathematical Society
Providence, Rhode Island

This volume contains proceedings of the workshop, "Spectral theory of differential operators and the inverse problems", held at the Research Institute for Mathematical Sciences in Kyoto University, Kyoto, Japan, from October 28 to November 1, 2002.

2000 *Mathematics Subject Classification.* Primary 34A55, 34K29, 35R30, 44A12, 58J50, 65L15, 65N21, 81U40.

Library of Congress Cataloging-in-Publication Data

Workshop on Spectral Theory of Differential Operators and Inverse Problems (2002: Kyoto University).

Inverse problems and spectral theory: proceedings of the Workshop on Spectral Theory of Differential Operators and Inverse Problems, October 28–November 1, 2002, Research Institute for Mathematical Sciences, Kyoto University, Kyoto, Japan /Hiroshi Isozaki, editor.

p. cm. — (Contemporary mathematics, ISSN 0271–4132; v. 348)

Includes bibliographical references.

ISBN 0-8218-3421-5 (alk. paper)

1. Differential operators—Congresses. 2. Spectral theory (Mathematics)—Congresses. 3. Inverse problems (Differential equations)—Congresses. I. Isozaki, Hiroshi, 1950– . II. Title. III. Series. IV. Contemporary Mathematics (American Mathematical Society); v. 348.

QA329.4.W67 2002

515′.7242—dc22 2004043758

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Preface

This is the proceedings of the workshop *Spectral theory of differential operators and the inverse problems* held in the Research Institute for Mathematical Science in Kyoto University from October 28 to November 1 in 2002. In all, almost 100 participants were present at RIMS during this conference, which shows the increasing interest in this field at the intersection of pure and applied mathematics. In the wide range of research on inverse problems, we tried to focus on spectral theory for differential operators and related inverse problems. The titles of the talks were as follows.

V. G. Romanov (Sobolev Inst.) : An inverse problem of electrodynamics
Y. Kurylev (Loughborough Univ.) : Inverse boundary spectral problem for the system of electromagnetism
H. Kang (Seoul National Univ.) : Asymptotic expansion for the Helmholtz equation and applications
S. Kim (Univ. of Tokyo) : Uniqueness in determining inhomogeneities of conductivity in Maxwell's equation with a single measurement
M. Yamamoto (Univ. of Tokyo) : On some uniqueness in inverse scattering problems
M. Ikehata (Gunma Univ.) : Extracting from finitely many noisy Cauchy data
J. Ralston (UCLA) : On the inverse boundary value problem of linear, isotropic elasticity
G. Nakamura (Hokkaido Univ.) : Identification of cavity in inhomogeneous media
K. Tanuma (Gunma Univ.) : Reconstruction of anisotropic elastic tensor at the boundary from the localized Dirichlet to Neumann map
S. Nakagiri (Kobe Univ.) : Constant parameters identification problems for sine-Gordon equation
M. Watanabe (Tokyo Metropolitan Univ.) : Inverse scattering problem for the nonlinear Schrödinger equations with cubic convolution nonlinearity
G. Eskin (UCLA) : Inverse boundary value problems and Aharonov-Bohm effect
E. Korotyaev (Humboldt Univ.) : Inverse problem for the harmonic oscillators
A. Melin (Lund Univ.) : Hyperbolicity and intertwining techniques in the backscattering problem
A. Vasy (M.I.T.) : Inverse problems in many-body scattering
J. Cheng (Fudan Univ.) : The numerical method for finding the discontinuous solutions of some ill-posed problems
A. Katsuda (Okayama Univ.) : Asymptotics of heat kernels for nilpotent coverings
R. Kuwabara (Tokushima Univ.) : Quantum energies and classical orbits in a

magnetic field
G. Vodev (Nantes Univ.) : High frequency estimates of the resolvent of the Laplace-Beltrami operator on infinite volume Riemannian manifolds
G. Uhlmann (Washington Univ.) : On determining a Riemannian manifold from the length of geodesics
H. Isozaki (Tokyo Metropolitan Univ.) : Inverse spectral problems and hyperbolic manifolds
K. Onishi (Ibaraki Univ.) : Numerical method for inverse boundary value problems by the adjoint method
T. Takiguchi (National Defense Acad.) : Reconstruction of measurable plane sets from their orthogonal projections
T. Kako (Univ. of Electro Communication) : Discrete approximation of the Dirichlet-Neumann map and its applications
H. Urakawa (Tohoku Univ.) : Dirichlet eigenvalue problem, finite element method and graph theory
R. Geller (Univ. of Tokyo) : Numerical methods for efficient and accurate calculation of seismic wave propagation and applications to inverse problems
K. M. Schmidt (Cardiff Univ.) : Critical values and spectral asymptotics of singularly perturbed periodic differential operators

As one sees from the titles above, we selected topics from the following subjects which have seen intense activity recently

Electromagnetism, Elasticity, Schrödinger equation, Differential geometry, Numerical analysis.

Electromagnetism: The conference began with Romanov's talk on the inverse problem for Maxwell's equations of the uniqueness of coefficients with the given data observed on a sphere in a finite time interval. Kurylev applied the boundary control method for the reconstruction of coefficients of Maxwell's equations on a 3-manifold from given boundary spectral data. Kang stated results on the reconstruction of small diameter inclusions via boundary measurements. Kim talked about the determination of inhomogeneities in conductivity for the boundary value problem for Maxwell's equations. The inverse scattering by obstacles in 2-dimension was discussed by Yamamoto. Ikehata used Mittag-Leffer's function to extract information on inclusions (or defects) of conductivities in 2-dimensions. Nakamura talked about the reconstruction procedure for a cavity in an inhomogeneous transversally isotropic medium from the Dirichlet-to-Neumann map.

Elasticity: The inverse boundary value problem for the elastic equation is of no less importance than the Maxwell's equations. Tanuma talked about the computation of the stress tensor and its normal derivative on the boundary from the DN map. Ralston discussed the uniqueness of the Lamé parameters with the given DN map as well as the solvability of the Cauchy-Riemann systems, an essential tool in solving inverse problems for systems of PDE.

Schrödinger equation: Since this is the very source of inverse problems, both the forward and inverse problems were discussed. Nakagiri considered the estimation of coefficients in the sine-Gordon equation by cost functionals. Watanabe talked about the reconstruction of nonlinear terms from the scattering operator for the Schrödinger equation. Eskin discussed the uniqueness of the electromagnetic

potentials associated with the Aharonov-Bohm effect. Korotyaev gave a characterization of the spectrum of the 1-dimensional harmonic oscillator perturbed by a potential. Melin constructed the intertwining operator for the Schrödinger operator and applied it to the back-scattering problem. Vasy talked about the inverse problem for the many-body Schrödinger equation from the various S-matrices. Schmidt gave a survey on the perturbed periodic Sturm-Liouville operator and the Dirac operator and the asymptotic distribution of its eigenvalues.

Differential geometry: Katsuda studied the decay of the heat kernels on nilpotent coverings over finite graphs or compact manifolds and asymptotic properties of closed geodesics for nilpotent extensions. Kuwabara derived a quantization condition for the magnetic Schrödinger operator on a compact Riemannian manifold. Vodev talked about high-energy estimates for the resolvent of the Laplace-Beltrami operator on non-compact Riemmanian-manifolds and its applications to the problem of resonance. Uhlmann gave a survey on the determination of Riemannian manifold from the knowledge of its geodesics. This problem has its origin in the seismology. Isozaki gave a new idea on the use of hyperbolic manifolds for solving inverse problems and its applications. Takiguchi gave a result on the reconstruction of a domain in the plane from its projections along the x and y axes.

Numerical analysis: Cheng talked about numerical differentiation by the use of Tikhonov's regularization and its application to the reconstruction of discontinuities. Onishi studied the elliptic boundary value problem with Dirichlet data on some part of the boundary and the Neumann data on another part and gave the numerical results. Kako talked about a numerical treatment of the 2-D Helmholtz equation in an unbounded domain by the domain decomposition technique and its application to voice generating phenomena. Urakawa discussed relations between the Dirichlet eigenvalue problem in a bounded planar domain, the finite element method and the graph theory. Geller's talk was on the error estimates for the numerical treatment of the elastic equation and numerical examples.

Although we could not include all of these topics, the papers in this volume present lots of new results, new ideas and comprehensive surveys of a variety of fields in inverse problems. We appreciate deeply the cooperation of Professors H. Soga, O. Yamada, M. Yamamoto, Y. Iso and M. Kawashita whose support by Grants-in-Aide made it possible to organize this conference. We also thank the referees for their careful reading and useful suggestions to the contributed papers.

Hiroshi ISOZAKI
Department of Mathematics,
Graduate School of Science,
Tokyo Metropolitan University,
Minami-Osawa, Hachioji, 192-0397, Japan

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This volume grew out of a workshop on spectral theory of differential operators and inverse problems held at the Research Institute for Mathematical Sciences (Kyoto University). The gathering of nearly 100 participants at the conference suggests the increasing interest in this field of research.

The focus of the book is on spectral theory for differential operators and related inverse problems. It includes selected topics from the following areas: electromagnetism, elasticity, the Schrödinger equation, differential geometry, and numerical analysis. The material is suitable for graduate students and researchers interested in inverse problems and their applications.

ISBN 0-8218-3421-5

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CONM/348