

CONTEMPORARY MATHEMATICS

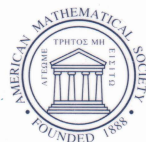
335

Advances in Quantum Dynamics

AMS-IMS-SIAM
Joint Summer Research Conference on
Advances in Quantum Dynamics

June 16-20, 2002
Mount Holyoke College
South Hadley, Massachusetts

Geoffrey L. Price
Editor-in-Chief
B. Mitchell Baker
Palle E.T. Jorgensen
Paul S. Muhly
Editors



Advances in Quantum Dynamics

CONTEMPORARY MATHEMATICS

335

Advances in Quantum Dynamics

AMS-IMS-SIAM
Joint Summer Research Conference on
Advances in Quantum Dynamics

June 16-20, 2002
Mount Holyoke College
South Hadley, Massachusetts

Geoffrey L. Price
Editor-in-Chief
B. Mitchell Baker
Palle E.T. Jorgensen
Paul S. Muhly
Editors



American Mathematical Society
Providence, Rhode Island

Editorial Board

Dennis DeTurck, managing editor

Andreas Blass Andy R. Magid Michael Vogelius

The 2002 AMS-IMS-SIAM Joint Summer Research Conference on Advances in Quantum Dynamics was held at Mount Holyoke College, South Hadley, Massachusetts, June 16–20, 2002, with support from the National Science Foundation, grant DMS 9973450.

2000 *Mathematics Subject Classification*. Primary 46L55, 46L57, 47D03, 47N50, 46L53, 47A20, 60G20, 60A10, 46L60, 46L35.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Library of Congress Cataloging-in-Publication Data

AMS-IMS-SIAM Joint Summer Research Conference on Advances in Quantum Dynamics (2002 : Mount Holyoke College)

Advances in quantum dynamics : proceedings of the AMS-IMS-SIAM Joint Summer Research Conference on Advances in Quantum Dynamics, June 16–20, 2002, Mount Holyoke College, South Hadley, Massachusetts / Geoffrey L. Price, editor-in-chief ; B. Mitchell Baker, Palle E. T. Jorgensen, Paul S. Muhly, editors.

p. cm. — (Contemporary mathematics ; 335)

Includes bibliographical references.

ISBN 0-8218-3215-8

1. Quantum theory—Congresses. 2. Semigroups—Congresses. 3. Von Neumann algebras—Congresses. I. Price, Geoffrey L., 1952– II. Title. III. Contemporary mathematics (American Mathematical Society) ; v. 335.

QC174.17.S36A47 2003
530.12—dc22

2003059154

Copying and reprinting. Material in this book may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Acquisitions Department, American Mathematical Society, 201 Charles Street, Providence, Rhode Island 02904-2294, USA. Requests can also be made by e-mail to reprint-permission@ams.org.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

© 2003 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.

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

Visit the AMS home page at <http://www.ams.org/>

10 9 8 7 6 5 4 3 2 1 08 07 06 05 04 03

Contents

Preface	vii
Four lectures on noncommutative dynamics WILLIAM ARVESON	1
Construction of E_0 -semigroups of $\mathfrak{B}(\mathfrak{H})$ from CP -flows ROBERT T. POWERS	57
Atomic dilations B. V. RAJARAMA BHAT	99
Strong solutions to the Dirichlet problem for differential forms: A quantum dynamical semigroup approach FABIO CIPRIANI AND JEAN-LUC SAUVAGEOT	109
Modular invariants and their fusion rules DAVID E. EVANS AND PAULO R. PINTO	119
A decomposition of E_0 -semigroups REMUS FLORICEL	131
A duality between extension and dilation ROLF GOHM	139
On the structure of spectral algebras and their generalizations ILAN HIRSHBERG AND JOACHIM ZACHARIAS	149
Outer actions of a countable discrete amenable group on an AFD factor YOSHIKAZU KATAYAMA AND MASAMICHI TAKESAKI	163
A construction of C^* -algebras from C^* -correspondences TAKESHI KATSURA	173
Classification of operator algebraic conformal field theories YASUYUKI KAWAHIGASHI	183
Rohlin property for flows AKITAKA KISHIMOTO	195
Survey on a quantum stochastic extension of Stone's theorem CLAUS KÖSTLER	209
Quantized convolution semigroups DANIEL MARKIEWICZ	223

A model for quantum Markov semigroups PAUL S. MUHLY AND BARUCH SOLEL	235
A predual characterization of semi-finite von Neumann algebras TIMUR OIKHBERG, HASKELL P. ROSENTHAL, AND ERLING STØRMER	243
Pure states on C^* -algebras SHÔICHIRO SAKAI	247
Commutants of von Neumann modules, representations of $\mathcal{B}^a(E)$ and other topics related to product systems of Hilbert modules MICHAEL SKEIDE	253
Non-commutative Brownian motions ROLAND SPEICHER	263
Non-isomorphic product systems BORIS TSIRELSON	273

PREFACE

This volume contains the proceedings of the conference on *Advances in Quantum Dynamics* held at Mount Holyoke College June 16 through 20, 2002. The conference was one in a continuing series of conferences in mathematics at Mount Holyoke sponsored by the American Mathematical Society. In keeping with the general philosophy of this series, our conference brought together experts and initiates alike to assess the current state of knowledge of quantum dynamical semigroups on von Neumann algebras and to map out directions for future research.

Since the appearance of the landmark papers by F. Murray and J. von Neumann *On Rings of Operators*, von Neumann algebras have been used as mathematical models in the study of the time evolution of quantum mechanical systems. Following the work of M. H. Stone, von Neumann and others on the structure of one-parameter groups of unitary transformations, many researchers have made fundamental contributions to the understanding of time-reversible dynamical systems. In the 1930's E. Wigner demonstrated that every one-parameter group of automorphisms on $\mathcal{B}(\mathcal{H})$ is implemented by a one-parameter group of unitary transformations. In light of this early success it is quite surprising to discover just how complicated the theory of irreversible dynamical systems on $\mathcal{B}(\mathcal{H})$ has proven to be. On $\mathcal{B}(\mathcal{H})$ the family of one-parameter semigroups of unital endomorphisms, or E_0 -semigroups, splits naturally into three classes that are called types *I*, *II* or *III*. It has been suggested that this subject has reached a stage of development roughly comparable to that reached in the classification of factors of types *I*, *II* and *III* forty years ago.

For over a decade W. B. Arveson and R. T. Powers have pioneered the effort to understand the structure of irreversible quantum dynamical systems on von Neumann algebras. It is particularly fortunate that both of these individuals agreed to present a series of four illuminating talks each on their research. Their papers in these proceedings will serve as an excellent introduction to the theory and provide two clear avenues to the current state of research in this area. Contributions by the many other participants contained in this volume will point the reader to the numerous ramifications of the subject. Some of the mathematical areas that have had an impact on the theory are Brownian motion, dilation theory, quantum probability and free probability. In particular, the contribution by B. Tsirelson to this volume shows how to construct a continuum of nonisomorphic product systems of type *II* and of type *III* using processes associated with white noise.

We are extremely grateful to the many participants at the conference and to the contributors to this volume of proceedings. We are particularly indebted to Professors Arveson and Powers for preparing their excellent series of lectures and for the permanent record of their work that they have contributed to this volume. Our contacts at the American Mathematical Society, especially James W. Maxwell, Wayne Drady and Christine Thivierge, were consistently helpful to us. Mr. Drady's cheerful assistance made our job of planning and carrying out the conference a

very easy one. Finally we are deeply indebted to our technical consultant, Brian Treadway, for his meticulous record keeping and his masterful work in guiding our contributors from rough to final drafts.

Geoffrey Price, Editor-in-Chief

B. Mitchell Baker

Palle Jorgensen

Paul Muhly

This volume contains the proceedings of the conference "Advances in Quantum Dynamics". The purpose of the conference was to assess the current state of knowledge and to outline future research directions of quantum dynamical semigroups on von Neumann algebras.

For over a decade, W. B. Arveson and R. T. Powers have pioneered the effort to understand the structure of irreversible quantum dynamical systems on von Neumann algebras. Their papers in this volume serve as an excellent introduction to the theory. Also included are contributions in other areas which have had an impact on the theory, such as Brownian motion, dilation theory, quantum probability, and free probability.

The volume is suitable for graduate students and research mathematicians interested in the dynamics of quantum systems and corresponding topics in the theory of operator algebras.

ISBN 0-8218-3215-8



9 780821 832158

CONM/335

AMS *on the Web*
www.ams.org