QUANTUM CONCEPTS IN THE SOCIAL, ECOLOGICAL AND BIOLOGICAL SCIENCES

Quantum mechanics is traditionally associated with microscopic systems; however, quantum concepts have also been successfully applied to a diverse range of macroscopic systems both within and outside of physics. This book describes how complex systems from a variety of fields can be modeled using quantum mechanical tools, from biology and ecology to sociology and decision-making. The mathematical basis of these models is covered in detail, furnishing a self-contained and consistent approach. This book provides unique insight into the dynamics of these macroscopic systems and opens new interdisciplinary research frontiers. It will be an essential resource for students and researchers in applied mathematics or theoretical physics who are interested in applying quantum mechanics to dynamical systems in the social, biological or ecological sciences.

FABIO BAGARELLO is Professor of Mathematical Physics and Mathematical Methods at the University of Palermo. His research interests include the application of quantum mechanics to macroscopic systems and the application of functional analysis and operator theory to quantum mechanics. He is the author of numerous scientific articles on these topics in addition to four books and several edited volumes.

QUANTUM CONCEPTS IN THE SOCIAL, ECOLOGICAL AND BIOLOGICAL SCIENCES

FABIO BAGARELLO
University of Palermo

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India

79 Anson Road, #06-04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108492126
DOI: 10.1017/9781108684781

First published 2019

Printed in the United Kingdom by TJ International Ltd, Padstow Cornwall

A catalog record for this publication is available from the British Library.

ISBN 978-1-108-49212-6 Hardback

As always, I dedicate this book to my beloved parents, Giovanna and Benedetto, and to Federico, Giovanna and Grazyna, with pure and diverging (to $+\infty$!) love. I wish for them to enjoy their lives much more than I do (and please consider that I am already quite satisfied).

Contents

Preface

I like to do research, and I like to move from one topic to another. Otherwise, I easily get bored! But from time to time, I feel the necessity to stop and think of what I have produced up to that moment, alone or with a group of colleagues, who quite often are also friends. And this is exactly the right moment to stop and summarize what has been done during the past few years after adopting my operatorial approach to mathematical modeling – which is exactly what this book is about. Writing a book also gives you a nice opportunity: one needs to reflect again and again on things which, when you write an article, may appear simple and clear. But sometimes you realize that what appeared to be simple years ago is not simple at all, and it possibly deserves a deeper analysis and a better understanding. And this is something I like: my old (or recent) results live again, give new suggestions and drive me toward unexpected directions. I am forced to read material on topics which are, in principle, far away from my usual *know-how*: ecology, economy, biology and anthropology are just a few such topics, but aren't the only ones. And this is a nice way to learn many amazing things.... Hence, I consider this book as the conclusion of a long period of study and the beginning of a new one. At least, this is what I hope. And I also do hope that you will enjoy reading this book, and that it will spark your curiosity, encourage you to start forming ideas of your own and then see if those ideas can be transformed into formulas according to the framework described in the chapters to follow. In fact, this is also what a book is for: to attract people! So, please, come and join me: everyone is welcome!

Acknowledgments

It is really a pleasure to thank all the people who significantly contributed to my research in this field along the years, starting with the old ones, Franco Oliveri and Francesco Gargano, going to the recent friends, Emmanuel Haven and Rosa Di Salvo, and ending with the brand-new ones, Andrei Khrennikov, Irina Basieva, Emmanuel Pothos, Lucia Tamburino and Giangiacomo Bravo. Their help has been precious in ∞^{∞} situations! And they will soon discover I still need them!

Some of the figures you will see appeared (as they are, or in some slightly modified form) in a few articles of mine. The editors kindly gave me the permission to use them, and for this reason I thank all of them. In particular, I wish to thank SIAM for some figures in Chapters 3 and 4, Elsevier for others in Chapters 3, 5, 6, 8 and 12 and Springer for more figures in Chapter 3. I also wish to thank Entropy, Plos One and Phylosophical Transaction A for allowing me to use the figures in Chapters 7, 9 and 11.