Preface

The aim of this book is to provide an introduction to some representative nonrelativistic quantum control problems and to their theoretical analysis and solution by modern computational techniques. This book is devoted to both finite-dimensional and infinite-dimensional quantum control problems. Finite-dimensional models include the three-level Lambda system arising in quantum optics and multispin systems in nuclear magnetic resonance (NMR). Infinite-dimensional models include a charged particle in a well potential, Bose–Einstein condensates, multiparticle spin systems, and multiparticle models in the density functional framework. These models are formulated in the quantum-theoretical framework of the Schrödinger picture, and the optimization theory used focuses on functional spaces and is based on the Lagrange formalism. The computational techniques discussed in this book represent recent developments resulting from the combination of modern numerical techniques for evolution equations with sophisticated optimization schemes.

This book provides an introduction to advanced topics in quantum control computation, with a detailed discussion of recent methods and new problems such that the book may serve as a research text as well as a textbook for graduate students. However, a basic knowledge of the theory and numerical solution of partial differential equations (PDEs) and of continuous optimization is required.

This is a timely book, considering the enormous interest in nanotechnologies, where quantum control problems play a major role. It should be suitable as an introduction for mathematicians, working in the field of optimization with PDEs, aiming at extending their focus into the field of quantum control, and for scientists such as physicists, chemists, and engineers, working on quantum control applications, who wish to consider the powerful methodologies of optimal control theory and computational optimization.

The purpose of this book is also to provide a bridge between the mathematical communities of scientific computing and optimization with differential models and the communities of natural sciences where quantum control methods have been developed based on physical knowledge. Therefore, this book attempts to cover the theoretical aspects of optimal quantum control problems, solution methodologies, and algorithms. This attempt is also supported by a large list of references covering background and advanced material and very recent results. However, it is clear that the content of this book and the list of references can only be limited and biased by the research interests and experience of the authors.

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