

Preface

The field of quantum computation is rapidly evolving. Quantum computing promises to solve problems that are intractable on digital computers. Quantum algorithms can decrease the computational time for some problems by many orders of magnitude. The main advantage of quantum computation is the rapid parallel execution of logic operations achieved by using superposition (entangled) states. To build a working quantum computer several problems must be solved, including the utilization of entangled states, the creation of quantum data bases and implementation of quantum computation algorithms.

The book explains how quantum computation works and how it can do many amazing things. It is intended to be useful for students and scientists who are interested in quantum computation but face difficulties in reading the original papers and reviews.

In the Introduction we present a very short history of quantum computation. The basic ideas on the Turing Machine are explained in Chapter 2. In Chapter 3 we describe the binary system and Boolean algebra, which are widely used in computer science. Some initial ideas on quantum computing are presented in Chapter 4. Using simple examples, we discuss the following quantum algorithms in Chapters 5 and 6: the discrete Fourier transform and Shor's algorithm on prime factorization. In Chapters 7, 8, and 9 we give an overview of digital logic gates and discuss reversible and irreversible logic gates, and how to implement these gates in semiconductor devices and transistors. Some important quantum logic gates are discussed in Chapters 10–14. A summary of unitary transformations and elements of quantum dynamics are given in Chapter 15. Quantum dynamics at finite temperature is discussed in Chapter 16. The implementation of quantum computation in real physical systems is considered in Chapter 17. In Chapters 18 and 19, we describe a realization of quantum logic gates in an ion trap. In Chapters 20, 21, and 22, quantum logic gates and quantum computation are discussed in linear chains of nuclear spins. Experimental logic gates and their achievements and possibilities are described in Chapter 23. One

of the simplest schemes for error correction is discussed in Chapter 24. The dynamics of quantum CONTROL-NOT gate is described in Chapter 25. Quantum logic gates in a spin ensemble at room temperature are discussed in Chapters 26, 27 and 28. Concluding remarks are given in Chapter 29.

This is a many-author book, and each of us has contributed to different parts of the book. Berman, Tsifrinovich, and Doolen produced the first draft of the book. They were then joined by Mainieri who also produced the figures and tables for the book. In the rapidly changing field of quantum computation it is difficult to judge what should be covered in an introductory text, and we hope that we have covered the essentials.

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