Chapter 1

FUNDAMENTALS

INTRODUCTION

The power of quantum computing is based on several phenomena and laws of the quantum world that are fundamentally different from those one encounters in classical computing: complex probability amplitudes, quantum interference, quantum parallelism, quantum entanglement and the unitarity of quantum evolution. In order to understand these features, and to make a use of them for the design of quantum algorithms, networks and processors, one has to understand several basic principles which quantum mechanics is based on, as well as the basics of Hilbert space formalism that represents the mathematical framework used in quantum mechanics.

The chapter starts with an analysis of the current interest in quantum computing. It then discusses the main intellectual barriers that had to be overcome to make a vision of the quantum computer an important challenge to current science and technology. The basic and specific features of quantum computing are first introduced by a comparison of randomized computing and quantum computing. An introduction to quantum phenomena is done in three stages. First, several classical and similar quantum experiments are analysed. This is followed by Hilbert space basics and by a presentation of the elementary principles of quantum mechanics and the elements of classical reversible computing.

LEARNING OBJECTIVES

The aim of the chapter is to learn

1. the main reasons why to be interested in quantum computing;
2. the prehistory of quantum computing;
3. the specific properties of quantum computing in comparison with randomized computing;
4. the basic experiments and principles of quantum physics;
5. the basics of Hilbert space theory;
6. the elements of classical reversible computing.