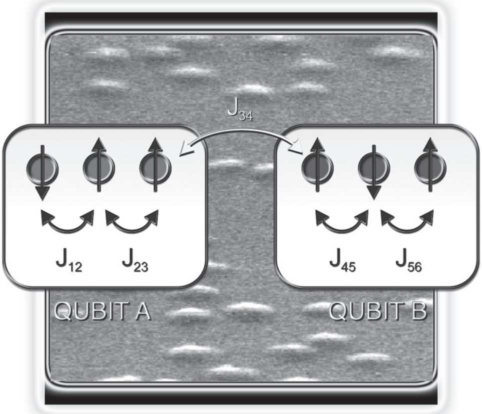

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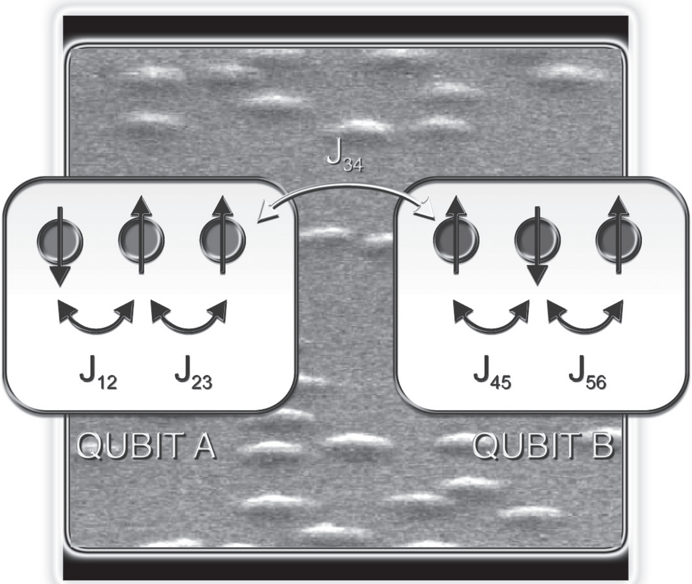

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Preface

Quantum information processing and computation (QIPC) is one of today's most active research fields. Many researchers worldwide are motivated by the fascinating prospects of controlling complex quantum systems and by the potentially huge impact of QIPC applications on our information society.

David DiVincenzo formulated five prerequisites for successful QIPC technology:

(1) A scalable physical system with well characterized quantum bits or *qubits*;
(2) The ability to initialize the state of each qubit to a simple initial state;
(3) Long relevant decoherence times, much longer than gate operations;
(4) A universal set of quantum gates (single and two-qubit gates); and
(5) A qubit-specific measurement capability.

According to these requirements there have been numerous attempts to implement and control qubits in different systems utilizing: nuclear spin in molecules, electronic states in single atoms or ions, polarization and spatial modes of photons, charge or flux quanta in superconductors, as well as charge and spin in semiconductor quantum dots. The latter two examples are of particular interest as they represent implementations in the solid-state where very rapid decoherence has long been considered a severe obstacle. Indeed, the progress in the fabrication of artificial nanostructures during the last years has enabled researchers to overcome previous limitations. Individual charge and spin carriers can be strongly decoupled from their environment so that the processes destroying the quantum coherence in the bulk are largely suppressed. In this way, the road towards miniaturized and integrated quantum logical circuits compatible with the existing semiconductor technology is opened.

In this book, we have concentrated on semiconductors as they offer spin as well as charge to implement qubits. Also, the radiative recombination of electrons and holes in semiconductors allows to use optical methods for qubit read-out and manipulation. Moreover, an efficient interface between flying and stationary qubits can be envisioned, e.g. with the help of quantum electrodynamical effects.

Our book aims to provide an overview of recent exciting results, both in experiment as well as in the theory. Leading experts in the field have provided chapters covering the many aspects of QIPC in semiconductors. We have organized the contributions as follows: The first part addresses explicit implementations and properties of charge and spin based qubits. Their manipulation, read-out, and control is the main subject of the second part. A third part is devoted to decoherence, still a central problem in solid-state systems. The generation of flying qubits and routes towards interfacing with stationary qubits are discussed in the fourth part. The last part introduces concepts, building blocks, and first demonstrations of QIPC using semiconductor based single photon sources and microcavities.

Finally, we would like to express our thanks to all authors who have provided excellent contributions to this book.

Oliver Benson and Fritz Henneberger

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