

Preface

The intimate connection between information and quantum physics has received considerable emphasis in the past two decades, in large part due to the successes of quantum information science (QIS). The field of quantum computing/quantum information processing is revolutionary in physical science for the future of information technology. There are a wide variety of platforms that may be adapted for useful information-processing protocols. This book specifically addresses the areas of electron spin-qubit-based quantum computing and quantum information processing with a strong focus on background and applications based on EPR/ESR technique/spectroscopy, and organization of the book places emphasis on relevant molecular qubit spectroscopy. The issues have never been included in a comprehensive volume that covers the theory, physical basis, technological basis, and a selection of various applications and new advances in this emerging field. QIS links the advanced electron magnetic resonance technology and sophisticated chemistry/materials science for preparing realistic molecular spin qubits and their physical models as matter qubits. An idea of quantum entanglement overlooked so far in applied and natural sciences has attracted much attention in many a branch, recently. The authors are well-known experts in the field who draw together aspects of pulse-based magnetic resonance and computational science in the world. The philosophy and approach to this volume stem from the fact that the field of quantum computing/quantum information processing is not only a revolutionary approach for the future of information technology but also underlies disruptive methodological advances in magnetic resonance and molecular spectroscopy. “Quantum control of spin qubits” is a current and important technological issue in manipulating many addressable qubits to realize quantum computing, providing feedback on the advanced spectroscopy. EPR/ESR spectroscopy can afford suitable platforms for this issue, in spite of the fact that electron spin qubits have been the latest arrival in the emerging field of quantum computing and quantum information processing.

The volume begins with a comprehensive introduction to quantum computing or quantum information processing from the viewpoint of electron magnetic resonance superbly done by Sushil Misra. The next chapter, one of two involving

nuclear spins as well, relates to quantum effects in electron-nuclear-coupled molecular spin systems by an expert team spearheaded by Robabeh Rahimi Darabad and one of our coeditors, Takeji Takui. Next, Hideto Matsuoka and Olav Schiemann address molecular spins in biological systems. Biological spin systems relevant to the target issue have their own right. Then, emphasizing the electron spin-based computing aspect more heavily, Takui's group addresses adiabatic quantum computing, different from quantum circuit approaches, on molecular electron spin quantum computers, followed by a chapter on free-time and fixed end-point multi-target optimal control theory applied to quantum computing by Mishima and Yamashita, followed by a chapter by Koji Maruyama and Daniel Burgarth on gateway theoretical schemes of quantum control for spin networks. Both chapters above are important in terms of future development of control technology for matter spin qubits. Coming back to nuclear spins and related topics, the group of Raymond Laflamme from the Waterloo Institute for Quantum Computing provides two chapters, one covering NMR quantum information processing and the other on heat bath algorithmic cooling with spins. We note that NMR quantum computing and quantum information processing have their own disadvantages, but there have been many pioneering achievements in this particular field on the basis of the inherent advantages.

As the reader can garner, we have a world-class team of contributors addressing a relatively new, perhaps a paradigm shift in our use of this emerging technology. It is also important to avail the reader of our ongoing plans to compile a second comprehensive volume on this technology that addresses yet some of the topic areas that we were unable to include in this book.

Lastly, it is with deep regret that our coeditor Graeme Hanson left us early in 2015 as a result of a devastating cancer. Graeme worked at his endeavors up to the day he passed away and serves as an excellent role model for the rest of us. And, of course, Graeme remains as a coeditor of this book.

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