Pivotal role of electron spin interactions in Nature cannot be overestimated. In many processes from energy transduction in biology to specificity of biorecognition these spin interactions appear as defining contributors. Another role involves determining the properties of molecular and functional materials’ systems that drive today’s technology by finding uses in electronic, spintronic, and magnetic devices.

Electron spin effects are manifesting in the fundamental quantum phenomenon of spin exchange. This interaction enables a number of important elementary processes including electron transfer, triplet energy transfer, and interspin crossing. One should consider interactions of both electronic and nuclear spins including electron–electron, electron–nuclear dipolar, and electron–nuclear contact interactions among the others. Such interactions could be precisely studied by electron magnetic resonance, nuclear magnetic resonance, and related hyphenated resonance techniques providing researchers with unique spectroscopic tools to investigate detailed molecular structure and dynamics of both small and large chemical and biological molecules.

For rather long time the scientists were stuck with paradigm that chemical and biochemical reactions are only ruled by interactions that energetically prevail over the thermal motion. However, contrary to such a strong thermodynamic argument, the last decades of intense research resulted in conclusive evidence of many essential chemical and biological processes being governed by very weak interactions originating from electronic spin systems instead. Advancing the knowledge of molecular mechanisms responsible for photosynthesis in plants and model compounds, radical reactions and influence of magnetic field on these and other processes, as well as rational design of advanced molecular magnets, spintronic devices, catalysts, etc., would not be possible without understanding the spin effects in these systems.

This book represents a collective perspective from physical chemist with long and broad expertise in spin phenomena and related fields. The main intention was not to provide the reader with an exhaustive survey of each topic of vast literature, but rather to discuss the key theoretical and experimental background and focus on
recent developments. Thus, chemists and biologists would find the fundamentals of spin phenomena, instrumentation and data interpretation, and a review of the major milestones. This gained knowledge is expected to promote some critical thinking to solve new emerging problem in their fields. Physicists and experts, for example, in magnetic resonance and photoluminescence methods and instrumentation may know already about the above-mentioned technical and quantum mechanical aspects, but would benefit from overview of current problems and achievements in various areas of chemistry and molecular biology, including rapidly evolving fields of natural and artificial photosynthesis, photochemistry, material science, etc.

The Chap. 1 of the monograph provides a brief outline of fundamental theories of spin exchange and electron transfer. Non-radiative spin exchange processes involving excited triplet state is the subject of Chap. 2. Electron spin dipolar and electron-nuclear spin contact interactions are described in Chap. 3 as the basis for investigation of molecular structures. A general survey of fundamentals and recent results on spin-selective processes of electron and nuclear spins is presented in the Chap. 4. Three subsequent Chaps. 5–7 are dedicated to experimental methods of investigation of electron spin interactions based on measurements by continuous wave and pulse EPR and by other physical methods. These spectroscopic methods form an experimental basis for investigation of electron spin effects in chosen chemical and physical processes (Chap. 8), effects of magnetic and electromagnetic fields on chemical and biological processes (Chap. 9), establishing structure and spin state of organic and metalloorganic compounds (Chap. 10), and electron transfer in biological systems focusing on the light energy conversion (Chap. 11). Chapter 12 is a brief review of the fundamentals and main results obtained by the methods of spin and triplet (phosphorescence) labels. Chapter 11, Preface and Conclusion have been written in collaboration with professor Alex I. Smirnov

This monograph is intended for scientists working in basic areas related to spin interactions such as spin chemistry and biology, electron transfer, light energy conversion, photochemistry, radical reactions and magneto-chemistry and magneto-biology. The book will be also useful for engineers designing advance magnetic materials, optical and spintronic devices, and photocatalysts. This text as a whole or as separate chapters can also be employed as subsidiary manuals for instructors and graduate and undergraduate students of university physics, biophysics, chemistry, and chemistry engineering departments.

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