The theory of nuclear magnetic relaxation in liquids

THE THEORY OF

nuclear magnetic relaxation in liquids

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Preface

Shortly after the detection of nuclear magnetic resonance signals phenomenological theories of nuclear magnetic relaxation were proposed by Bloch (1946) and by Bloembergen, Purcell & Pound (1948). Their results constituted a framework for further investigations and provided reference points for comparison with later theories. Subsequent developments were the random walk theory of Torrey (1953) and the rotational diffusion theory of Abragam (1961). A further impetus towards providing a theory of nuclear magnetic relaxation was given by investigations on the rotational Brownian motion of an asymmetric molecule (Ford, Lewis & McConnell, 1979).

In spite of the rapidly increasing number of publications on nuclear magnetic resonance it is still difficult to find an intelligible and complete account of relaxation theory. It is the purpose of the present book to provide, as far as space allows, a self-contained account of this theory. Basic formulae are derived for relaxation times resulting from dipolar, quadrupolar, scalar and spin-rotational interactions, and from anisotropic chemical shift. Analytical expressions are then deduced for the relaxation times in the case of different molecular shapes. The level of knowledge presupposed in the reader would be found in undergraduate courses in mathematics, physics and chemistry. In the earlier chapters the notions of probability distributions and of random motion are introduced, and the method of applying quantum mechanical perturbation theory is explained. Specific mathematical results required for a proper understanding of the main text are collected together in four appendixes.

Random walk and translational Brownian motion theories are used in the study of relaxation by intermolecular dipolar interactions. Relaxation by intramolecular interactions is investigated by employing rotational Brownian motion theory. On account of the relatively small values of nuclear magnetic moments a one-molecule theory is adequate. The calculations for intramolecular interactions provide not only rotational diffusion results but also results that take account of the inertial effects of the molecule. While the latter are not required in the present state of nuclear magnetic resonance experimental accuracy, they may be of some consequence in the future. For this reason and also because the mathematical methods are applicable to other relaxation processes, including dielectric relaxation where inertial effects can be very important, results are given for both inertial and rotational diffusion theory.

It is hoped that physicists, physical chemists and others interested in nuclear magnetic resonance may find in this book a readable but not superficial account of the derivation of the main results in relaxation theory. For the applied mathematician the book may serve as an illustration of the application of stochastic processes. The appendixes, Chapters 2 and 3, and parts of later chapters could be of assistance to theorists whose interests are outside nuclear magnetic resonance.

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Dublin *James McConnell*
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