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978-0-521-10771-6 - The Theory of Nuclear Magnetic Relaxation in Liquids

James McConnell

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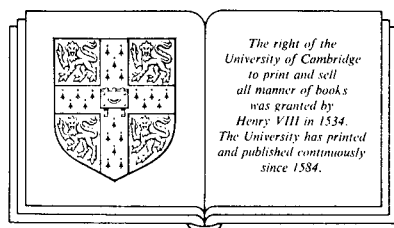
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THE THEORY OF

*nuclear magnetic relaxation
in liquids*

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for Advanced Studies*



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Frontmatter

[More information](#)

Contents

<i>Preface</i>	ix
1 Phenomenological theory of relaxation	
1.1 Nuclear magnetic relaxation	1
1.2 The Bloch equations	6
1.3 The Bloembergen, Purcell and Pound theory	12
1.4 The different relaxation processes	15
2 Random motion	
2.1 Probability distributions	17
2.2 Averaging processes	20
2.3 Correlation functions and spectral densities	21
2.4 Models of random motion	
2.4.1 <i>Random flights</i>	23
2.4.2 <i>Brownian motion</i>	27
2.4.3 <i>Extended diffusion</i>	30
2.4.4 <i>General assumptions in future calculations</i>	31
3 Equations of relaxation theory	
3.1 The density operator	32
3.2 Interaction representation	35
3.3 The Redfield equations	37
3.4 Application to nuclear magnetic relaxation	44
4 Dipolar interactions	
4.1 The dipole–dipole interaction	47
4.2 Systems of like spins	51
4.3 Systems of unlike spins	60
5 Relaxation by intermolecular dipolar interactions	
5.1 Intermolecular interactions	67
5.2 Random walk models	67
5.3 Brownian motion models	74
5.4 Other models	76

Cambridge University Press

978-0-521-10771-6 - The Theory of Nuclear Magnetic Relaxation in Liquids

James McConnell

Frontmatter

[More information](#)

vi

Contents

6	Relaxation by intramolecular dipolar interactions	
6.1	Intramolecular interactions of like spins	78
6.2	Spherical molecules	79
6.3	Linear molecules	81
6.4	Asymmetric molecules	83
6.5	Symmetric molecules	86
6.6	General observations	88
6.7	Intramolecular interactions of unlike spins	90
7	Relaxation by scalar interaction	
7.1	The scalar interaction	92
7.2	Scalar relaxation by chemical exchange	93
7.3	Scalar relaxation of the second kind	97
8	Relaxation by chemical shift	
8.1	Nuclear shielding	99
8.2	Relaxation by anisotropic chemical shift	105
8.3	Relaxation times for molecular models	107
9	Relaxation by quadrupole interaction	
9.1	Quadrupole interactions	113
9.2	Relaxation times for quadrupole interactions	118
9.3	Quadrupole relaxation for molecular models	121
10	Relaxation by spin-rotational interaction	
10.1	The spin-rotational Hamiltonian	127
10.2	The spin-rotational relaxation times	129
10.3	Calculation of spectral densities	131
10.4	Spin-rotational relaxation for molecular models	134
11	Theory and experiment for relaxation processes	
11.1	Introductory remarks	143
11.2	Summary of theoretical results	148
11.3	Intermolecular dipole–dipole interactions	150
11.4	Intramolecular dipolar and spin-rotational interactions	152
11.5	Anisotropic chemical shift and spin-rotational interaction	154
11.6	Quadrupole relaxation	155
11.7	Internal rotations	157
	Appendix A Representation of operators	159
	Appendix B The rotation operator	163
	Appendix C Construction of spherical tensors	169
	Appendix D Spectral densities for molecular models	175

Cambridge University Press

978-0-521-10771-6 - The Theory of Nuclear Magnetic Relaxation in Liquids

James McConnell

Frontmatter

[More information](#)***Contents*****vii**

<i>References</i>	187
<i>Author Index</i>	192
<i>Subject Index</i>	194

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

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Frontmatter

[More information](#)

x

Preface

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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James McConnell