

NMR: The Toolkit

Part A

1 The vector model

- 1.1 Introduction
- 1.2 Bulk magnetization
- 1.3 The rotating frame
- 1.4 Pulses
- 1.5 Free precession
- 1.6 T_1 and T_2 relaxation
- 1.7 Spin echoes

2 Fourier transform NMR

- 2.1 Introduction
- 2.2 Detection of the NMR signal
- 2.3 Two-dimensional NMR
- 2.4 Pure phase two-dimensional NMR

3 Product operators I

- 3.1 Introduction
- 3.2 Product operators for one spin
- 3.3 Product operators for two coupled spins
- 3.4 Spin echoes

4 Product operators II

- 4.1 Introduction
- 4.2 INEPT
- 4.3 Multiple-quantum coherence
- 4.4 Multi-spin systems
- 4.5 DEPT

5 Two-dimensional NMR

- 5.1 Introduction
- 5.2 COSY
- 5.3 DQF-COSY
- 5.4 NOESY
- 5.5 TOCSY
- 5.6 HMQC
- 5.7 HSQC
- 5.8 Three- and four-dimensional NMR

Appendix 5.1 NOE, cross relaxation, and the Solomon equations

6 Phase cycling and pulsed field gradients

- 6.1 Introduction
- 6.2 Coherence transfer pathways
- 6.3 Phase cycling
- 6.4 Pulsed field gradients

Part B

7 Quantum mechanics

- 7.1 Introduction
- 7.2 Ket and bra vectors
- 7.3 Operators
- 7.4 Angular momentum
- 7.5 Free precession
- 7.6 Radiofrequency pulses

Appendix 7.1 Vectors and matrices

Appendix 7.2 Operators

8 Density matrices

- 8.1 Introduction
- 8.2 The density operator
- 8.3 Solving the Liouville–von Neumann equation
- 8.4 Ensemble averages
- 8.5 Application to NMR
- 8.6 Connection to product operators

Appendix 8.1 Pure and mixed states, and coherence

Appendix 8.2 Matrix diagonalization and matrix exponentials

Appendix 8.3 The matrix exponential of \hat{I}_X

Appendix 8.4 The rotating frame

9 Weak coupling and equivalence

- 9.1 Introduction
- 9.2 Density operators in two-spin systems
- 9.3 J coupling
- 9.4 Weak coupling: a brute force approach
- 9.5 Weak coupling: a more cunning approach
- 9.6 Equivalent spins
- 9.7 Evolution of multiple-quantum coherence
- 9.8 TOCSY

Appendix 9.1 Direct products

Appendix 9.2 Matrix representations of two-spin operators

Appendix 9.3 Operator commutators

10 Strong coupling

- 10.1 Introduction
- 10.2 Free induction decay
- 10.3 Spin echoes