

Introduction to Quantum Mechanics

Second Edition

David J Griffiths

Reed College, Oregon



CAMBRIDGE
UNIVERSITY PRESS

CONTENTS

PREFACE vii

PART I THEORY

1 THE WAVE FUNCTION 1

- 1.1 The Schrödinger Equation 1
- 1.2 The Statistical Interpretation 2
- 1.3 Probability 5
- 1.4 Normalization 12
- 1.5 Momentum 15
- 1.6 The Uncertainty Principle 18

2 TIME-INDEPENDENT SCHRÖDINGER EQUATION 24

- 2.1 Stationary States 24
- 2.2 The Infinite Square Well 30
- 2.3 The Harmonic Oscillator 40
- 2.4 The Free Particle 59
- 2.5 The Delta-Function Potential 68
- 2.6 The Finite Square Well 78

3 FORMALISM 93

- 3.1 Hilbert Space 93
- 3.2 Observables 96
- 3.3 Eigenfunctions of a Hermitian Operator 100

- 3.4 Generalized Statistical Interpretation 106
- 3.5 The Uncertainty Principle 110
- 3.6 Dirac Notation 118

4 QUANTUM MECHANICS IN THREE DIMENSIONS 131

- 4.1 Schrödinger Equation in Spherical Coordinates 131
- 4.2 The Hydrogen Atom 145
- 4.3 Angular Momentum 160
- 4.4 Spin 171

5 IDENTICAL PARTICLES 201

- 5.1 Two-Particle Systems 201
- 5.2 Atoms 210
- 5.3 Solids 218
- 5.4 Quantum Statistical Mechanics 230

PART II APPLICATIONS

6 TIME-INDEPENDENT PERTURBATION THEORY 249

- 6.1 Nondegenerate Perturbation Theory 249
- 6.2 Degenerate Perturbation Theory 257
- 6.3 The Fine Structure of Hydrogen 266
- 6.4 The Zeeman Effect 277
- 6.5 Hyperfine Splitting 283

7 THE VARIATIONAL PRINCIPLE 293

- 7.1 Theory 293
- 7.2 The Ground State of Helium 299
- 7.3 The Hydrogen Molecule Ion 304

8 THE WKB APPROXIMATION 315

- 8.1 The “Classical” Region 316
- 8.2 Tunneling 320
- 8.3 The Connection Formulas 325

9 TIME-DEPENDENT PERTURBATION THEORY 340

- 9.1 Two-Level Systems 341
- 9.2 Emission and Absorption of Radiation 348
- 9.3 Spontaneous Emission 355

10 THE ADIABATIC APPROXIMATION 368

- 10.1 The Adiabatic Theorem 368
- 10.2 Berry’s Phase 376

11	SCATTERING	394
11.1	Introduction	394
11.2	Partial Wave Analysis	399
11.3	Phase Shifts	405
11.4	The Born Approximation	408
12	AFTERWORD	420
12.1	The EPR Paradox	421
12.2	Bell's Theorem	423
12.3	The No-Clone Theorem	428
12.4	Schrödinger's Cat	430
12.5	The Quantum Zeno Paradox	431
	APPENDIX LINEAR ALGEBRA	435
A.1	Vectors	435
A.2	Inner Products	438
A.3	Matrices	441
A.4	Changing Bases	446
A.5	Eigenvectors and Eigenvalues	449
A.6	Hermitian Transformations	455
	INDEX	459