

Contents

Foreword	iii
Preface	iv
In Memoriam	vii

1 FUNDAMENTAL CONCEPTS	1
1.1 The Stern-Gerlach Experiment	2
1.2 Kets, Bras, and Operators	10
1.3 Base Kets and Matrix Representations	17
1.4 Measurements, Observables, and the Uncertainty Relations	23
1.5 Change of Basis	36
1.6 Position, Momentum, and Translation	41
1.7 Wave Functions in Position and Momentum Space	51
Problems	60
2 QUANTUM DYNAMICS	68
2.1 Time Evolution and the Schrödinger Equation	68
2.2 The Schrödinger Versus the Heisenberg Picture	80
2.3 Simple Harmonic Oscillator	89
2.4 Schrödinger's Wave Equation	97
2.5 Propagators and Feynman Path Integrals	109
2.6 Potentials and Gauge Transformations	123
Problems	143
3 THEORY OF ANGULAR MOMENTUM	152
3.1 Rotations and Angular Momentum Commutation Relations	152
3.2 Spin 1/2 Systems and Finite Rotations	158
3.3 $SO(3)$, $SU(2)$, and Euler Rotations	168
3.4 Density Operators and Pure Versus Mixed Ensembles	174
3.5 Eigenvalues and Eigenstates of Angular Momentum	187
3.6 Orbital Angular Momentum	195
3.7 Addition of Angular Momenta	203
3.8 Schwinger's Oscillator Model of Angular Momentum	217
3.9 Spin Correlation Measurements and Bell's Inequality	223
3.10 Tensor Operators	232
Problems	242
4 SYMMETRY IN QUANTUM MECHANICS	248
4.1 Symmetries, Conservation Laws, and Degeneracies	248
4.2 Discrete Symmetries, Parity, or Space Inversion	251
4.3 Lattice Translation as a Discrete Symmetry	261
4.4 The Time-Reversal Discrete Symmetry	266
Problems	282

5 APPROXIMATION METHODS	285
5.1 Time-Independent Perturbation Theory: Nondegenerate Case	285
5.2 Time-Independent Perturbation Theory: The Degenerate Case	298
5.3 Hydrogenlike Atoms: Fine Structure and the Zeeman Effect	304
5.4 Variational Methods	313
5.5 Time-Dependent Potentials: The Interaction Picture	316
5.6 Time-Dependent Perturbation Theory	325
5.7 Applications to Interactions with the Classical Radiation Field	335
5.8 Energy Shift and Decay Width Problems	341 345
6 IDENTICAL PARTICLES	357
6.1 Permutation Symmetry	357
6.2 Symmetrization Postulate	361
6.3 Two-Electron System	363
6.4 The Helium Atom	366
6.5 Permutation Symmetry and Young Tableaux Problems	370 377
7 SCATTERING THEORY	379
7.1 The Lippmann-Schwinger Equation	379
7.2 The Born Approximation	386
7.3 Optical Theorem	390
7.4 Eikonal Approximation	392
7.5 Free-Particle States: Plane Waves Versus Spherical Waves	395
7.6 Method of Partial Waves	399
7.7 Low-Energy Scattering and Bound States	410
7.8 Resonance Scattering	418
7.9 Identical Particles and Scattering	421
7.10 Symmetry Considerations in Scattering	422
7.11 Time-Dependent Formulation of Scattering	424
7.12 Inelastic Electron-Atom Scattering	429
7.13 Coulomb Scattering Problems	434 441
Appendix A	446
Appendix B	456
Appendix C	458
Supplement I Adiabatic Change and Geometrical Phase	464
Supplement II Non-Exponential Decays	481
Bibliography	487
Index	491