

# Contents

Prologue .....	1
----------------	---

---

## Part A. Fall Quarter: Quantum Kinematics

---

<b>1. Measurement Algebra .....</b>	<b>29</b>
1.1 Stern–Gerlach experiment .....	29
1.2 Measurement symbols .....	31
1.3 State vectors .....	36
1.4 Successive measurements. Probabilities .....	38
1.5 Probability amplitudes. Interference .....	41
1.6 “Measurement disturbs the system” .....	45
1.7 Observables .....	47
1.8 Algebra of Pauli’s operators .....	50
1.9 Adjoint symbols, Hermitian symbols .....	52
1.10 Matrix representations .....	55
1.11 Traces .....	57
1.12 Unitary geometry .....	59
1.12.1 Column and row vectors, wave functions .....	59
1.12.2 Two arbitrary components of Pauli’s vector operator ..	62
1.13 Unitary operators .....	66
1.14 Unitary operator bases. Complementarity .....	68
1.15 Quantum degrees of freedom .....	75
1.16 The continuum limit .....	81
1.16.1 Heisenberg’s commutation relation .....	81
1.16.2 Schrödinger’s differential-operator representation ....	84
Problems .....	86
<b>2. Continuous <math>q, p</math> Degree of Freedom .....</b>	<b>99</b>
2.1 Wave functions .....	99
2.2 Expectation values and their spreads .....	107
2.3 States of minimal uncertainty .....	109
2.4 States of stationary uncertainty .....	112
2.5 Hermite polynomials .....	116

2.6	Completeness of stationary-uncertainty states .....	120
2.7	Eigenvectors of non-Hermitian operators .....	122
2.8	Classical limit .....	129
2.9	More about stationary-uncertainty states .....	132
	Problems .....	133
<b>3.</b>	<b>Angular Momentum</b> .....	145
3.1	Infinitesimal unitary transformations .....	145
3.2	Infinitesimal rotations .....	146
3.3	Common eigenvectors of $\mathbf{J}^2$ and $J_z$ .....	148
3.4	Decomposition into spins .....	151
3.5	Angular momentum of a composite system .....	154
3.6	Finite rotations. Eulerian angles .....	158
3.7	Rotated angular-momentum eigenvectors .....	164
	Problems .....	172
<b>4.</b>	<b>Galilean Invariance</b> .....	177
4.1	Generators of infinitesimal transformations .....	177
4.2	Hamilton operator for a system of elementary particles .....	183
	Problems .....	184
<hr/>		
<b>Part B. Winter Quarter: Quantum Dynamics</b>		
<hr/>		
<b>5.</b>	<b>Quantum Action Principle</b> .....	189
5.1	Equations of motion .....	189
5.2	Conservation laws .....	191
5.3	Sets of $q, p$ pairs of variables .....	193
5.4	Wave functions for force-free motion .....	196
5.5	Quantum action principle .....	201
5.6	Principle of stationary action .....	203
5.7	Change of description .....	206
5.8	Permissible variations .....	207
	Problems .....	210
<b>6.</b>	<b>Elementary Applications</b> .....	215
6.1	Time transformation functions .....	215
6.1.1	Free particle .....	215
6.1.2	Constant force .....	216
6.1.3	Linear restoring force: Harmonic oscillator .....	218
6.2	Short times .....	219
6.3	Harmonic oscillator: Energy eigenvalues .....	221
6.4	Free particle and constant force: State density .....	222
6.5	Harmonic oscillator: Energy eigenstates .....	226
6.6	Free particle and constant force: Energy eigenstates .....	228

6.7	Constant force: Asymptotic wave functions .....	230
6.8	WKB approximation .....	235
6.9	Zeros and extrema of the Airy function .....	240
6.10	Constant restoring force .....	243
6.11	Rayleigh–Ritz variational method .....	246
	Problems .....	249
<b>7.</b>	<b>Harmonic Oscillators .....</b>	<b>259</b>
7.1	Non-Hermitian operators .....	259
7.2	Driven oscillator .....	262
7.2.1	Time-independent drive .....	264
7.2.2	Slowly varying drive .....	266
7.2.3	Temporary drive .....	268
7.3	Remarks on Laguerre polynomials .....	275
7.4	Two-dimensional oscillator .....	277
7.5	Three-dimensional oscillator .....	284
	Problems .....	287
<b>8.</b>	<b>Hydrogenic Atoms .....</b>	<b>293</b>
8.1	Bound states .....	293
8.2	Parameter dependence of energy eigenvalues .....	297
8.3	Virial theorem .....	299
8.4	Parabolic coordinates .....	302
8.5	Weak external electric field .....	305
8.6	Weak external magnetic field .....	309
8.7	Insertion: Charge in a homogeneous magnetic field .....	313
8.8	Scattering states .....	318
	Problems .....	322
<hr/> <b>Part C. Spring Quarter: Interacting Particles</b> <hr/>		
<b>9.</b>	<b>Two-Particle Coulomb Problem .....</b>	<b>331</b>
9.1	Internal and external motion .....	331
9.2	Rutherford scattering revisited .....	334
9.3	Additional short-range forces .....	340
9.4	Scattering of identical particles .....	343
9.5	Conserved axial vector .....	346
9.6	Weak external fields .....	352
	Problems .....	355
<b>10.</b>	<b>Identical Particles .....</b>	<b>361</b>
10.1	Modes. Creation and annihilation operators .....	361
10.2	One-particle and two-particle operators .....	367
10.3	Multi-particle states .....	371

10.4	Dynamical basics .....	372
10.5	Example: General spin dynamics .....	373
10.6	General dynamics .....	377
10.7	Operator fields .....	380
10.8	Non-interacting particles .....	382
	Problems .....	388
<b>11.</b>	<b>Many-Electron Atoms .....</b>	<b>391</b>
11.1	Hartree–Fock method .....	391
11.2	Semiclassical treatment: Thomas–Fermi model .....	396
11.3	Correction for strongly bound electrons .....	405
11.4	Quantum corrections and exchange energy .....	410
11.5	Energy oscillations .....	414
	Problems .....	416
<b>12.</b>	<b>Electromagnetic Radiation .....</b>	<b>423</b>
12.1	Lagrangian, modes, equations of motion .....	423
12.2	Effective action .....	427
12.3	Consistency check .....	429
12.4	Free-space photon mode functions .....	433
12.5	Physical mass .....	435
12.6	Infrared photons .....	437
12.7	Effective Hamiltonian .....	441
12.8	Energy shift .....	444
12.9	Transition rates .....	447
12.10	Thomson scattering .....	450
	Problems .....	453
<b>Index</b>	.....	<b>457</b>

Quantum Mechanics

Symbolism of Atomic Measurements

Schwinger, J. - Englert, B.-G. (Ed.)

2001, XIV, 484 p., Hardcover

ISBN: 978-3-540-41408-7