

Contents

<i>Preface</i>	v
1. Oscillator Model	1
1.1 Optical Susceptibility	2
1.2 Absorption and Refraction	6
1.3 Retarded Green's Function	12
2. Atoms in a Classical Light Field	17
2.1 Atomic Optical Susceptibility	17
2.2 Oscillator Strength	21
2.3 Optical Stark Shift	23
3. Periodic Lattice of Atoms	29
3.1 Reciprocal Lattice, Bloch Theorem	29
3.2 Tight-Binding Approximation	36
3.3 k-p Theory	41
3.4 Degenerate Valence Bands	45
4. Mesoscopic Semiconductor Structures	53
4.1 Envelope Function Approximation	54
4.2 Conduction Band Electrons in Quantum Wells	56
4.3 Degenerate Hole Bands in Quantum Wells	60
5. Free Carrier Transitions	65
5.1 Optical Dipole Transitions	65
5.2 Kinetics of Optical Interband Transitions	69

5.2.1	Quasi- D -Dimensional Semiconductors	70
5.2.2	Quantum Confined Semiconductors with Subband Structure	72
5.3	Coherent Regime: Optical Bloch Equations	74
5.4	Quasi-Equilibrium Regime: Free Carrier Absorption	78
6.	Ideal Quantum Gases	89
6.1	Ideal Fermi Gas	90
6.1.1	Ideal Fermi Gas in Three Dimensions	93
6.1.2	Ideal Fermi Gas in Two Dimensions	97
6.2	Ideal Bose Gas	97
6.2.1	Ideal Bose Gas in Three Dimensions	99
6.2.2	Ideal Bose Gas in Two Dimensions	101
6.3	Ideal Quantum Gases in D Dimensions	101
7.	Interacting Electron Gas	107
7.1	The Electron Gas Hamiltonian	107
7.2	Three-Dimensional Electron Gas	113
7.3	Two-Dimensional Electron Gas	119
7.4	Multi-Subband Quantum Wells	122
7.5	Quasi-One-Dimensional Electron Gas	123
8.	Plasmons and Plasma Screening	129
8.1	Plasmons and Pair Excitations	129
8.2	Plasma Screening	137
8.3	Analysis of the Lindhard Formula	140
8.3.1	Three Dimensions	140
8.3.2	Two Dimensions	143
8.3.3	One Dimension	145
8.4	Plasmon Pole Approximation	146
9.	Retarded Green's Function for Electrons	149
9.1	Definitions	149
9.2	Interacting Electron Gas	152
9.3	Screened Hartree-Fock Approximation	156

10. Excitons	163
10.1 The Interband Polarization	164
10.2 Wannier Equation	169
10.3 Excitons	173
10.3.1 Three- and Two-Dimensional Cases	174
10.3.2 Quasi-One-Dimensional Case	179
10.4 The Ionization Continuum	181
10.4.1 Three- and Two-Dimensional Cases	181
10.4.2 Quasi-One-Dimensional Case	183
10.5 Optical Spectra	184
10.5.1 Three- and Two-Dimensional Cases	186
10.5.2 Quasi-One-Dimensional Case	189
11. Polaritons	193
11.1 Dielectric Theory of Polaritons	193
11.1.1 Polaritons without Spatial Dispersion and Damping	195
11.1.2 Polaritons with Spatial Dispersion and Damping	197
11.2 Hamiltonian Theory of Polaritons	199
11.3 Microcavity Polaritons	206
12. Semiconductor Bloch Equations	211
12.1 Hamiltonian Equations	211
12.2 Multi-Subband Microstructures	219
12.3 Scattering Terms	221
12.3.1 Intraband Relaxation	226
12.3.2 Dephasing of the Interband Polarization	230
12.3.3 Full Mean-Field Evolution of the Phonon-Assisted Density Matrices	231
13. Excitonic Optical Stark Effect	235
13.1 Quasi-Stationary Results	237
13.2 Dynamic Results	246
13.3 Correlation Effects	255
14. Wave-Mixing Spectroscopy	269
14.1 Thin Samples	271
14.2 Semiconductor Photon Echo	275

15. Optical Properties of a Quasi-Equilibrium Electron–Hole Plasma	283
15.1 Numerical Matrix Inversion	287
15.2 High-Density Approximations	293
15.3 Effective Pair-Equation Approximation	296
15.3.1 Bound states	299
15.3.2 Continuum states	300
15.3.3 Optical spectra	300
16. Optical Bistability	305
16.1 The Light Field Equation	306
16.2 The Carrier Equation	309
16.3 Bistability in Semiconductor Resonators	311
16.4 Intrinsic Optical Bistability	316
17. Semiconductor Laser	321
17.1 Material Equations	322
17.2 Field Equations	324
17.3 Quantum Mechanical Langevin Equations	328
17.4 Stochastic Laser Theory	335
17.5 Nonlinear Dynamics with Delayed Feedback	340
18. Electroabsorption	349
18.1 Bulk Semiconductors	349
18.2 Quantum Wells	355
18.3 Exciton Electroabsorption	360
18.3.1 Bulk Semiconductors	360
18.3.2 Quantum Wells	368
19. Magneto-Optics	371
19.1 Single Electron in a Magnetic Field	372
19.2 Bloch Equations for a Magneto-Plasma	375
19.3 Magneto-Luminescence of Quantum Wires	378
20. Quantum Dots	383
20.1 Effective Mass Approximation	383
20.2 Single Particle Properties	386
20.3 Pair States	388

20.4 Dipole Transitions	392
20.5 Bloch Equations	395
20.6 Optical Spectra	396
21. Coulomb Quantum Kinetics	401
21.1 General Formulation	402
21.2 Second Born Approximation	408
21.3 Build-Up of Screening	413
22. Quantum Optical Effects	421
22.1 Quantum Optics for Semiconductors	421
22.2 Cluster Expansion	424
22.2.1 Cluster Expansion for Fermions	424
22.2.2 Quantum Optical Cluster Expansion	428
22.3 Semiconductor Luminescence Equations	429
22.4 Quasi-Stationary Luminescence	432
Appendix A Field Quantization	437
A.1 Lagrange Functional	437
A.2 Canonical Momentum and Hamilton Function	442
A.3 Quantization of the Fields	444
Appendix B Contour-Ordered Green's Functions	451
B.1 Interaction Representation	452
B.2 Langreth Theorem	455
B.3 Equilibrium Electron-Phonon Self-Energy	458
<i>Index</i>	461