

Contents

1 Quantum Wells and Superlattices	1
2 Crystal Symmetry	9
2.1 Symmetry Operations, Groups	10
2.2 Point-Group Classification	11
2.3 Space Groups	12
2.4 Group Representations, Characters	16
2.5 Point-Group Representations	20
2.6 Spinor Representations	23
2.7 Representations of Space Groups	27
2.8 Invariance Under Time Inversion	30
2.9 Selection Rules	33
2.10 Determination of Linearly Independent Components of Material Tensors	36
3 Electron Spectrum in Crystals, Quantum Wells and Superlattices	39
3.1 The k-p Method	39
3.2 The Effective-Mass Method; Deformation Potential	43
3.3 Method of Invariants	49
3.4 Electron and Hole Spectrum in Diamond- and Zincblende-Type Cubic Crystals	53
3.5 Electron Spectra of Quantum Wells and Superlattices	73
3.6 Hole Spectrum in Quantum Wells and Superlattices for Degenerate Bands	84
3.7 Deformed and Strained Superlattices	89
3.8 Quantum Wells and Superlattices in a Magnetic Field	91
3.9 Spectrum of Quantum Wells and Superlattices in an Electric Field	95
4 Vibrational Spectra of Crystals and Superlattices Electron-Phonon Interaction	101
4.1 Normal Vibrations: Distribution in Irreducible Representations	101

4.2	Vibrational Spectra of Superlattices	111
4.3	Electron-Phonon Interaction	121
5	Localized Electron States and Excitons in Heterostructures . .	125
5.1	Shallow Impurity Centers	125
5.2	Localized States at Superlattice Defects	143
5.3	Excitons	147
5.4	Exchange Splitting of Exciton Levels	157
6	Interband Optical Transitions	162
6.1	Optical Superlattices	162
6.2	Interband Transitions and Dielectric Susceptibility of a Periodic Heterostructure	165
6.3	Coulomb Interaction Between the Electron and the Hole .	169
6.4	Exciton Polaritons in an Optical Superlattice	177
6.5	Light Reflection	180
6.6	Electro-Optical Effects in Interband Transitions	193
6.7	Magneto-Optical Spectra	197
7	Intraband Transitions	201
7.1	Cyclotron Resonance and Effective Electron Mass	201
7.2	Intersubband Absorption	212
7.3	Electron-Spin Resonance	220
7.4	IR Reflection in an Undoped Superlattice	225
8	Light Scattering	228
8.1	Theory of Light Scattering in Semiconductors	228
8.2	Scattering by Intersubband Excitations	238
8.3	Scattering by Acoustical Phonons with a Folded Dispersion Law	243
8.4	Scattering by Optical Phonons in Heterostructures	247
8.5	Acceptor Spin-Flip Raman Scattering	250
9	Polarized Luminescence in Quantum Wells and Superlattices	255
9.1	Luminescence as a Tool to Study Electronic Spectra and Kinetic Processes in Two-Dimensional Systems	255
9.2	Luminescence in the Quantum Hall Regime, Quantum Beats	256
9.3	Optical Spin Orientation and Alignment of Electron Momenta	262
9.4	Optical Orientation and Alignment of Excitons	278
9.5	Polarized Luminescence of Excitons and Impurities in an External Magnetic Field	298

10 Nonlinear Optics	305
10.1 Two-Photon Absorption	306
10.2 Photorefectance	316
10.3 Diffraction from a Light-Induced Spatial Grating	318
10.4 Third-Harmonic Generation	320
10.5 Linear and Circular Photogalvanic (Photovoltaic) Effects .	322
10.6 Current of Optically Oriented Electrons	332
10.7 Photon Drag Current	334
References	339
Subject Index	379