

Contents

1	Optical Transitions in Semiconductors	1
1.1	Effective-Mass Theory	2
1.1.1	Electron in a Periodic Potential	3
1.1.2	$\mathbf{k} \cdot \mathbf{p}$ Perturbation Theory	7
1.1.3	Low-Dimensional Structures	13
1.2	Electron–Light Interaction	17
1.2.1	Transition Matrix Elements	18
1.2.2	The Optical Density of States	20
1.2.3	Examples	23
1.3	Excitons	29
1.3.1	The Semiconductor Bloch Equations	31
1.3.2	The Elliott Formula	35
1.3.3	Examples	39
1.4	Summary and Conclusions	44
2	Numerical Calculation	47
2.1	Preliminaries	48
2.1.1	Formulation of the Problem	49
2.1.2	Overview	54
2.2	Approximation in Space	60
2.2.1	Orthonormal Base Functions	61
2.2.2	Non-Orthonormal Base Functions	69
2.2.3	Finite Differences	76
2.3	Solution of the Initial-Value Problem	83
2.3.1	The Time-Propagation Scheme	84
2.3.2	Two Examples	89
2.3.3	Absorbing Boundary Conditions	93
2.4	Summary and Conclusions	99
3	Fano Resonances	101
3.1	The Fano Model	102
3.1.1	One Resonance and One Continuum	103
3.1.2	The General Case	107
3.2	Fano Resonances as a General Feature	114
3.2.1	The Channel Picture	114

3.2.2	The Subband Picture	119
3.3	Examples	122
3.3.1	Overview	122
3.3.2	Bulk Semiconductor in a Magnetic Field	126
3.3.3	Quantum Well	136
3.4	Summary and Conclusions	142
4	Zener Breakdown in Superlattices	145
4.1	Bloch Electron in One Dimension	149
4.1.1	General Properties	150
4.1.2	Tightly Bound and Nearly Free Electrons	151
4.1.3	Two Samples	154
4.2	Bloch Electron in an Electric Field	158
4.2.1	Discrete Model and Tight-Binding Approximation	158
4.2.2	Kane Functions	162
4.2.3	Breakdown of Wannier–Stark Ladders	169
4.3	The Optical Spectrum	172
4.3.1	Optical Density of States	173
4.3.2	Optical Absorption	181
4.3.3	Optical Absorption in a Perpendicular Magnetic Field	188
4.4	The Tunneling Rate	191
4.4.1	Semiclassical Approach	192
4.4.2	Perturbation Theory	196
4.4.3	Discussion	203
4.5	Summary and Conclusions	206
A	Mathematical Supplement	209
A.1	Basic Definitions and Relations	209
A.2	Special Functions of Mathematical Physics	215
A.3	Miscellaneous Relations	217
B	Physical Supplement	223
B.1	Physical Constants and Material Parameters	223
B.2	Dimensionless Quantities	225
B.3	Crystal Symmetry	227
C	Essentials of Quantum Mechanics	231
C.1	The Quantum-Mechanical Eigenvalue Problem	231
C.1.1	The Spectrum of Schrödinger Operators	231
C.1.2	Selected Eigenvalue Problems	234
C.2	Angular Momentum in Quantum Mechanics	244
C.2.1	The Eigenvalue Problem	245
C.2.2	Orthogonal Transformations	247
C.2.3	Addition of Angular Momenta	248
C.2.4	Time Reversal	249

C.3	Perturbation Theory	250
C.3.1	Degenerate Time-Independent Perturbation Theory ...	250
C.3.2	Time-Dependent Perturbation Theory	251
D	Computer Programs	255
D.1	Cartesian Coordinates	255
D.2	Polar Coordinates	260
D.3	Time-Reversal Symmetry	264
D.4	Absorbing Boundary Conditions	265
D.5	Cylindrical Coordinates	268
	References	273
	Index	289

Excitons in Low-Dimensional Semiconductors

Theory Numerical Methods Applications

Glutsch, S.

2004, XI, 298 p., Hardcover

ISBN: 978-3-540-20240-0