

Contents

I	Background in Maxwell's Electromagnetism and Maxwell's Equations	1
I.1	General Maxwell's Equations in Cartesian Coordinates	1
I.1.1	Maxwell's Equations in Free Space	2
I.1.2	Maxwell's Equations in Matter	3
I.1.3	Boundary Conditions	5
I.1.4	Constitutive Relationships	6
I.1.5	The Formulation in Fourier Space	8
I.1.6	Time Harmonic Fields and Complex Representatives	10
I.2	Special Maxwell's Equations for l.l.h.i Media	11
I.2.1	Special Maxwell's Equations in Cartesian Coordinate Systems	12
I.2.2	Special Maxwell's Equations in Orthogonal Curvilinear Coordinate Systems	12
I.2.3	Special Maxwell's Equations in Spherical Coordinate Systems	13
I.2.4	Boundary Conditions	14
I.2.5	Energy Propagation and Poynting Theorem	15
I.2.6	Momentum Propagation	17
I.2.7	Wave-Vector, Refractive Index and Impedance	18
I.2.8	Potentials	21

II	Resolution of Special Maxwell's Equations	23
II.1	Special Orthogonal Curvilinear Coordinate Systems and Separability	23
II.2	Bromwich Potentials	24
II.2.1	Generalities	24
II.2.2	Transverse Magnetic Wave	25
II.2.3	Transverse Electric Wave	28
II.3	Explicit Time Harmonic Dependence	29
II.4	Use of Spherical Coordinate Systems	30
II.5	BSP-Solutions	31
II.5.1	Reduction to Ordinary Differential Equations	31
II.5.2	Harmonic Equation	32
II.5.3	Associated Legendre Equation	33
II.5.4	Spherical Bessel Equation	34
II.5.5	General Expressions for BSPs	35
III	Generalized Lorenz-Mie Theory in the Strict Sense, and Other GLMTs	37
III.1	The Scattering Problem and Global Strategy	37
III.2	BSPs for the Incident Wave	39
III.3	Quadratures to Evaluate BSCs g_n^m	40
III.3.1	The First Method to Derive Quadrature Expressions	40
III.3.2	The Second Method to Derive Quadrature Expressions	45
III.3.3	Other Approaches	46
III.4	BSPs for Scattered and Sphere Waves	50
III.5	Expansions of Field Components	51
III.6	Boundary Conditions and Generalized Scattering Coefficients	55
III.7	Scattered Field Components	57
III.8	Scattered Field Components in the Far Field Region	58
III.9	Scattered Intensities	59
III.10	Phase Angle	60
III.11	Radiative Energy Balance and Associated Cross-Sections	61
III.11.1	Generalities	61
III.11.2	Incident Field Balance	62
III.11.3	Scattering Cross-Section C_{sca}	64
III.11.4	Extinction Cross-Section C_{ext}	64
III.12	Momentum Balance and Radiation Pressure	66
III.12.1	Generalities	66

III.12.2	Longitudinal Radiation Pressure (z -Direction)	67
III.12.3	Transverse Radiation Pressure (x and y Directions)	70
III.13	Efficiency Factors	75
III.14	Complement, Other GLMTs	76
IV	Gaussian Beams and Other Beams	89
IV.1	Gaussian Beam Description	90
IV.1.1	The Solving Paradox	90
IV.1.2	Elementary Description	92
IV.1.3	Historical	93
IV.1.4	Davis Formulation	94
IV.1.5	The Order L of Approximation	96
IV.1.6	The Order L^- of Approximation	96
IV.1.7	Kogelnik's Model	98
IV.1.8	Inaccuracies at Orders L and L^-	99
IV.2	GLMT at Orders L and L^-	102
IV.2.1	Radial Field Components E_r and H_r	102
IV.2.2	Beam Shape Coefficients	105
IV.3	Numerical Computations of Beam Shape Coefficients by Using Quadratures	108
IV.4	Other Beams	108
V	Finite Series	117
V.1	The General Procedure	117
V.2	The NET Procedure for Gaussian Beams	120
V.2.1	Basic Relations	120
V.2.2	BSCs $g_{n,TM}^m$, n and m Even	124
V.2.3	Other BSCs $g_{n,TM}^m$	130
V.2.4	BSCs $g_{n,TE}^m$	135
V.3	Numerical Computations of BSCs by Using Finite Series	136
V.3.1	Dimensionless Formulation	136
V.3.2	Formulae Modifications for Programming	137
VI	Special Cases of Axisymmetric and Gaussian Beams	139
VI.1	Axisymmetric Beams	139
VI.2	The LSC-Decomposition and Gaussian-Like Beams	141
VI.3	Axis Location in a Gaussian Beam	145
VI.4	Lorenz-Mie Theory	150
VI.5	A Theorem for the Special BSCs	153

VI.6	Numerical Computations of Special BSCs by Using Quadratures	155
VI.6.1	Computer Programs	155
VI.6.2	More on the Plane Wave Case	156
VI.6.3	Numerical Behaviour of Quadratures.....	157
VI.7	Computations of Special BSCs by Using Finite Series ...	161
VI.7.1	The Formulation	161
VI.7.2	Routines	165
VII	The Localized Approximation and Localized Beam Models	169
VII.1	Generalities	169
VII.2	The Waist Center Location Case	171
VII.2.1	The Principle of Localization	171
VII.2.2	Special BSCs	171
VII.2.3	Numerical Evidence of Validity.....	172
VII.2.4	Physical Evidence of Validity	174
VII.2.5	Difference of Behaviour between Rigorous Methods and Localized Approximation	175
VII.3	Axis Location Case	176
VII.4	Arbitrary Location	181
VII.4.1	A Well Posed Problem	181
VII.4.2	BSCs g_n^{+1} and g_n^{-1} for Axis Location.....	182
VII.4.3	BSCs g_n^m for Arbitrary Location: First Attempt	185
VII.4.4	Final Generalization	189
VII.4.5	Improved Formulation and Routines	190
VII.4.6	Examples of Results	191
VII.5	Complement on the Localized Approximation	191
VII.6	Complement on the Evaluation of Beam Shape Coefficients	195
VIII	Applications, and Miscellaneous Issues	199
VIII.0.1	Measurement Techniques	199
VIII.0.2	Internal Fields and Morphology-Dependent-Resonances	211
VIII.0.3	Mechanical Effects.....	214
VIII.0.4	Multiple Scattering	227
VIII.0.5	Miscellaneous Topics.....	228

IX Conclusion	231
A Evaluation of Quadratures, Rels (III.130) and (III.131)	233
B Evaluation of Quadratures, Rels (III.151) and (III.152)	235
C Evaluation of Quadratures, Rels (III.169) and (III.170)	237
D To Reduce the Double Summations of Chapter IV to Single Summations	241
E Useful Relations to Derive the BSCs of Chapter IV.....	245
F Computer Programs	247