
Contents

Foreword	ix
Preface	xi
Introduction	xiii
Chapter 1. The State of the Art in Quantum Communications	1
1.1. Quantum mechanics as a generalized probability theory	1
1.2. Contextuality	3
1.3. Indeterminism and contextuality	3
1.4. Contextuality and hidden variables.	4
1.5. Non-locality and contextuality	5
1.6. Bell states.	6
1.7. Violation of the Leggett–Garg inequality	7
1.8. Violation of the Bell inequality.	8
1.9. EPR paradox	8
Chapter 2. Concepts in Communications	13
2.1. Quantum limits.	13
2.2. Qubits.	15
2.3. Qudit and qutrit	20
2.3.1. Qudit	20
2.3.2. Qutrit.	23
2.4. Pauli matrices	24
2.4.1. Definition	24
2.4.2. Properties of these matrices	25
2.5. Decoherence	26
2.6. Entanglement.	28

Chapter 3. Quantum Signal Processing	31
3.1. Wigner distribution	32
3.2. Quantum Fourier transform	34
3.3. Gauss sums in a quantum context	36
3.4. Geometry for quantum processing	37
Chapter 4. Quantum Circuits	41
4.1. Reversible logic	41
4.1.1. Physical reversibility	41
4.2. Reversible circuits	42
4.2.1. Reversible calculation models	42
4.2.2. Reversibility in quantum calculation	43
4.3. Quantum gates	44
4.3.1. Hadamard gate	44
4.3.2. Pauli-X gate	45
4.3.3. Pauli-Y gate	45
4.3.4. Pauli-Z gate	46
4.3.5. Swap gate	46
4.4. Toffoli gate	47
4.5. Deutsch gate	48
4.6. Quantum dots	49
4.7. QCA	52
Chapter 5. Optical Fibers and Solitons	53
5.1. Introduction	53
5.2. Optical fibers	54
5.2.1. The fiber's parameters	55
5.2.2. Birefringence in optical fibers	58
5.2.3. Dispersion in optical fibers	58
5.3. Soliton solutions for differential equations	60
5.3.1. Introduction	60
5.3.2. Nonlinear Schrodinger equation	61
5.3.3. Focusing soliton oscillations	63
5.3.4. Wave packet autostriction (modulation instability)	65
5.3.5. Evolution of the initial disturbance	69
5.4. Conclusion	73
Chapter 6. Photonic Crystals	75
6.1. General introduction	75
6.2. Photonic crystals	76

6.2.1. Photonic crystals with one dimension (Bragg network)	77
6.2.2. Band diagram	80
6.2.3. Maps of forbidden bands	81
6.3. Three-dimensional photonic crystals	82
6.4. Filters and multiplexors	82
6.5. Add-drop filters	83
6.6. Digital methods for photonic crystal analysis	84
6.6.1. Introduction	84
6.6.2. Modeling periodic dielectric structures	85
6.6.3. FDTD method	85
6.6.4. Available digital tools	86
6.7. Conclusion	88
Chapter 7. ROADM	89
7.1. Technological advances	89
7.2. “Router”-type filter	90
Chapter 8. WDM	95
8.1. Operating principle	95
8.2. Using WDM systems	96
8.3. DWDM networks	98
Chapter 9. Quantum Algorithms	99
Chapter 10. Applications	101
10.1. Laser satellites	101
10.1.1. The Doppler effect in inter-satellite laser communications	102
10.1.2. Modeling the Doppler effect in inter-satellite laser communications	103
10.1.3. Calculation software	108
10.1.4. Calculation software	108
Chapter 11. Quantum Cryptography	121
11.1. Cloning photons	123
11.2. Quantum cryptography	123
11.2.1. Introduction	123
11.2.2. Methodology	124
11.2.3. Results and discussion	126
11.2.4. Conclusion	129

11.3. Solutions to the practical limits of quantum cryptography	130
11.3.1. Introduction	130
11.3.2. Theoretical considerations	130
11.3.3. Practical considerations	131
11.3.4. Quantum noise.	132
11.3.5. The QBER in quantum transmissions	133
11.3.6. Error correction methods in quantum cryptography	138
11.3.7. The correcting code for error correction in BB84	140
11.3.8. Time coding for error correction in BB84.	142
11.3.9. Conclusion	144
11.4. Quantum error correcting codes.	145
11.4.1. Introduction	145
11.4.2. Classical error correcting code	145
11.4.3. Quantum error correcting code	148
11.4.4. The time coding method for error correction: application in BB84.	157
11.4.5. Correction of time code errors using the repetition method	158
11.4.6. Conclusion	161
Conclusion	163
Bibliography	167
Index	179