View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by CERN Document Server

Contents

1. The Introduction of Quarks 1
1.1 The Hadron Spectrum 1

2. Review of Relativistic Field Theory 17
2.1 Spinor Quantum Electrodynamics 17
2.1.1 The Free Dirac Equation and Its Solution 17
2.1.2 Density and Current Density 20
2.1.3 Covariant Notation 21
2.1.4 Normalization of Dirac Spinors 22
2.1.5 Interaction with a Four-Potential A^{μ} 24
2.1.6 Transition Amplitudes 25
2.1.7 Discrete Symmetries 25
2.2 Scalar Quantum Electrodynamics 26
2.2.1 The Free Klein–Gordon Equation and its Solutions . . 26
2.2.2 Interaction of a π^+ with a Potential A^{μ} 29
2.2.3 π^+K^+ Scattering 32
2.2.4 The Cross Section 35
2.2.5 Spin-1 Particles and Their Polarization 47
2.2.6 The Propagator for Virtual Photons 53
2.3 Fermion–Boson and Fermion–Fermion Scattering 58
2.3.1 Traces and Spin Summations 60
2.3.2 The Structure of the Form Factors from Invariance Considerations 70

3. Scattering Reactions and the Internal Structure of Baryons 77
3.1 Simple Quark Models Compared 77
3.2 The Description of Scattering Reactions 80
3.3 The MIT Bag Model 125

4. Gauge Theories and Quantum-Chromodynamics 155
4.1 The Standard Model: A Typical Gauge Theory 155
4.2 The Gauge Theory of Quark–Quark Interactions 165
4.3 Dimensional Regularization 184
4.4 The Renormalized Coupling Constant of QCD 203
4.5 Extended Example: Anomalies in Gauge Theories 220
4.5.1 The Schwinger Model on the Circle 220
4.5.2 Dirac Sea 222

4.5.3 Ultraviolet Regularization . . . 225
4.5.4 Standard Derivation . . . 228
4.5.5 Anomalies in QCD . . . 231
4.5.6 The Axial and Scale Anomalies . . . 232
4.5.7 Multiloop Corrections . . . 238

5. Perturbative QCD I: Deep Inelastic Scattering . . . 239
5.1 The Gribov–Lipatov–Altarelli–Parisi Equations . . . 239
5.2 An Alternative Approach to the GLAP Equations . . . 265
5.3 Common Parametrizations of the Distribution Functions and Anomalous Dimensions . . . 281
5.4 Renormalization and the Expansion Into Local Operators . . . 292
5.5 Calculation of the Wilson Coefficients . . . 328
5.6 The Spin-Dependent Structure Functions . . . 356

6. Perturbative QCD II: The Drell–Yan Process and Small-*x* Physics 387
6.1 The Drell–Yan Process . . . 387
6.2 Small-*x* Physics . . . 430

7. Nonperturbative QCD . . . 441
7.1 Lattice QCD Calculations . . . 442
7.1.1 The Path Integral Method . . . 442
7.1.2 Expectation Values . . . 447
7.1.3 QCD on the Lattice . . . 449
7.1.4 Gluons on the Lattice . . . 451
7.1.5 Integration in SU(2) . . . 454
7.1.6 Discretization: Scalar and Fermionic Fields . . . 456
7.1.7 Fermionic Path Integral . . . 461
7.1.8 Monte Carlo Methods . . . 463
7.1.9 Metropolis Algorithm . . . 465
7.1.10 Langevin Algorithms . . . 466
7.1.11 The Microcanonical Algorithm . . . 468
7.1.12 Strong and Weak Coupling Expansions . . . 474
7.1.13 Weak-Coupling Approximation . . . 476
7.1.14 Larger Loops in the Limit of Weak and Strong Coupling . . . 477
7.1.15 The String Tension . . . 479
7.1.16 The Lattice at Finite Temperature . . . 482
7.1.17 The Quark Condensate . . . 485
7.1.18 The Polyakov Loop . . . 487
7.1.19 The Center Symmetry . . . 488
7.2 QCD Sum Rules . . . 490

8. Phenomenological Models for Nonperturbative QCD Problems . . . 515
8.1 The Ground State of QCD . . . 515
8.2 The Quark–Gluon Plasma . . . 530

Appendix 541
A The Group SU(N) 541
B Dirac Algebra in Dimension d 543
C Some Useful Integrals 546

Subject Index 549