



# Contents

Unmarked sections are the basic part of the book; those labelled with an asterisk contain details that may be omitted upon a first reading. Sections and chapters marked with a dagger are elementary introductions to advanced topics that are somewhat outside the book's main line of development.

## PART I

<b>1</b>	<b>Basics in field quantization</b>	
1.1	Review of canonical quantization formalism	4
1.2	Introduction to path integral formalism	11
1.3*	Fermion field quantization	22
<b>2</b>	<b>Introduction to renormalization theory</b>	
2.1	Conventional renormalization in $\lambda\phi^4$ theory	31
2.2	BPH renormalization in $\lambda\phi^4$ theory	39
2.3	Regularization schemes	45
2.4	Power counting and renormalizability	56
<b>3</b>	<b>Renormalization group</b>	
3.1	Momentum subtraction schemes and the Callan–Symanzik equation	67
3.2*	The minimal subtraction scheme and its renormalization-group equation	77
3.3	Effective coupling constants	81
	<b>Group theory and the quark model</b>	
4.1	Elements of group theory	86
4.2	SU(2) and SU(3)	90
4.3	The tensor method in SU( $n$ )	102
4.4	The quark model	113
<b>5</b>	<b>Chiral symmetry of the strong interaction</b>	
5.1	Global symmetries in field theory and current commutators	126
5.2*	Symmetry currents as physical currents	134
5.3	Spontaneous breaking of global symmetry, the Goldstone theorem	141
5.4*	PCAC and soft pion theorems	151
5.5*	Pattern of chiral symmetry breaking	160

<b>6</b>	<b>Renormalization and symmetry</b>	
6.1*	The vector-current Ward identity and renormalization	169
6.2*	Axial-vector-current Ward identity anomaly and $\pi^0 \rightarrow 2\gamma$	173
6.3†	Renormalization in theories with spontaneous symmetry breaking	182
6.4†	The effective potential and radiatively induced spontaneous symmetry breakdown	189
<b>7</b>	<b>The Parton model and scaling</b>	
7.1	The parton model of deep inelastic lepton-hadron scattering	199
7.2	Sum rules and applications of the quark-parton model	208
7.3	Free-field light-cone singularities and Bjorken scaling	218
<b>PART II</b>		
<b>8</b>	<b>Gauge symmetries</b>	
8.1	Local symmetries in field theory	229
8.2*	Gauge invariance and geometry	235
8.3	Spontaneous breaking of gauge symmetry, the Higgs phenomenon	240
<b>9</b>	<b>Quantum gauge theories</b>	
9.1	Path-integral quantization of gauge theories	248
9.2	Feynman rules in covariant gauges	257
9.3*	The Slavnov-Taylor identities	267
<b>10</b>	<b>Quantum chromodynamics</b>	
10.1*	The discovery of asymptotic freedom	280
10.2	The QCD Lagrangian and the symmetries of the strong interaction	291
10.3	Renormalization group analysis of scaling and scaling violation	295
10.4*	The parton model and perturbative QCD	311
10.5†	Lattice gauge theory and colour confinement	322
<b>11</b>	<b>Standard electroweak theory I: basic structure</b>	
11.1	Weak interactions before gauge theories	336
11.2	Construction of the standard $SU(2) \times U(1)$ theory	339
11.3	Fermion family replication	355
<b>12</b>	<b>Standard electroweak theory II: phenomenological implications</b>	
12.1	Flavour-conserving neutral-current processes	364
12.2	Weak mixing angles, the GIM mechanism, and CP violation	371
12.3	The W and Z intermediate vector bosons	386
12.4	The Higgs particle	394
<b>13</b>	<b>Selected topics in quantum flavourdynamics</b>	
13.1†	Dynamical symmetry breaking and technicolour models	401
13.2*	Neutrino masses, mixings and oscillations	409
13.3*	$\mu \rightarrow e\gamma$ , An example of $R_\xi$ gauge loop calculations	420

<b>14</b>	<b>Grand unification</b>	
14.1	Introduction to the SU(5) model	428
14.2	Spontaneous symmetry breaking and gauge hierarchy	434
14.3	Coupling constant unification	437
14.4	Proton decay and baryon asymmetry in the universe	442
14.5	Fermion masses and mixing angles in the minimal SU(5) model	447
<b>15</b>	<b>†Magnetic monopoles</b>	
15.1	Dirac's theory of magnetic poles	453
15.2	Solitons in field theory	460
15.3	The 't Hooft–Polyakov monopole	466
<b>16</b>	<b>†Instantons</b>	
16.1	The topology of gauge transformations	476
16.2	The instanton and vacuum tunnelling	482
16.3	Instantons and the U(1) problem	487
<b>Appendix A</b>	<b>Notations and conventions</b>	494
<b>Appendix B</b>	<b>Feynman rules</b>	498
<b>Bibliography</b>		513
<b>References</b>		517
<b>Subject Index</b>		527