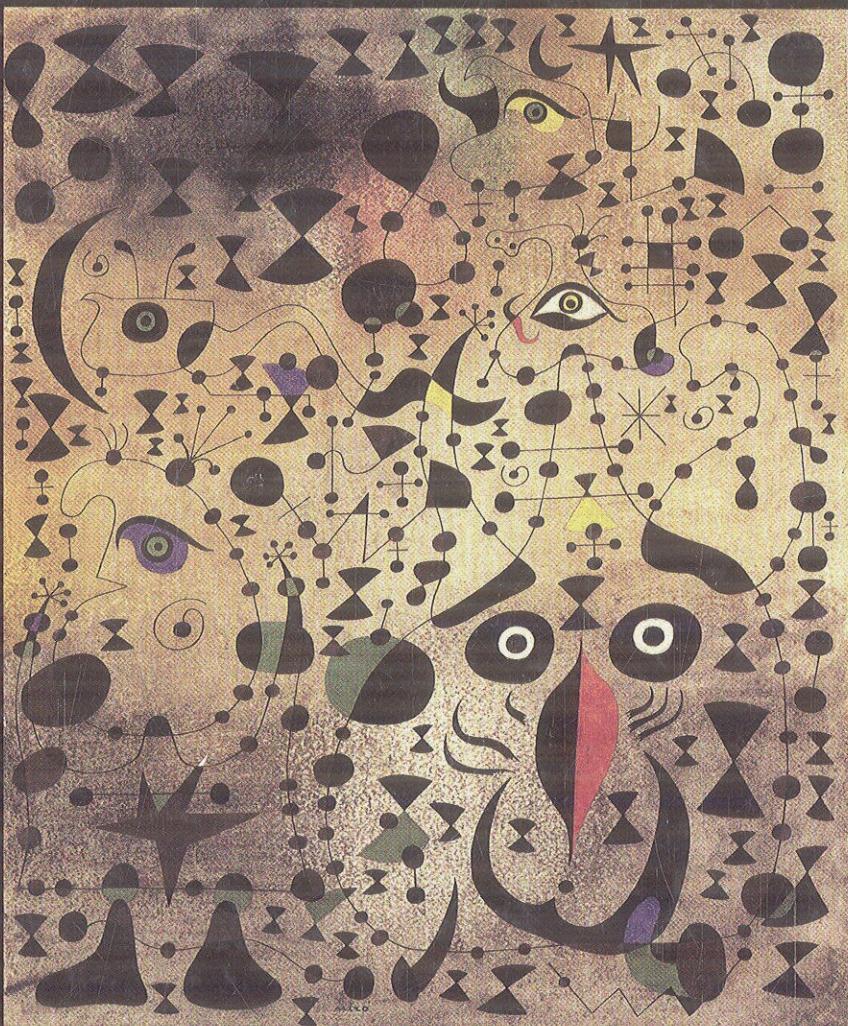


THOMAS BANKS

Modern Quantum Field Theory

A Concise Introduction



CAMBRIDGE

Contents

1	Introduction	<i>page</i> 1
1.1	Preface and conventions	1
1.2	Why quantum field theory?	3
2	Quantum theory of free scalar fields	8
2.1	Local fields	10
2.2	Problems for Chapter 2	13
3	Interacting field theory	17
3.1	Schwinger-Dyson equations and functional integrals	17
3.2	Functional integral solution of the SD equations	20
3.3	Perturbation theory	24
3.4	Connected and 1-P(article) I(irreducible) Green functions	26
3.5	Legendre's trees	28
3.6	The Källen Lehmann spectral representation	30
3.7	The scattering matrix and the LSZ formula	32
3.8	Problems for Chapter 3	36
4	Particles of spin 1, and gauge invariance	38
4.1	Massive spinning particles	38
4.2	Massless particles with helicity	39
4.3	Field theory for massive spin-1 particles	40
4.4	Problems for Chapter 4	43
5	Spin-$\frac{1}{2}$ particles and Fermi statistics	44
5.1	Dirac, Majorana, and Weyl fields: discrete symmetries	49
5.2	The functional formalism for fermion fields	56
5.3	Feynman rules for Dirac fermions	58
5.4	Problems for Chapter 5	59
6	Massive quantum electrodynamics	62
6.1	Free the longitudinal gauge bosons!	64
6.2	Heavy-fermion production in electron positron annihilation	65
6.3	Interaction with heavy fermions: particle paths and external fields	68

6.4	The magnetic moment of a weakly coupled charged particle	69
6.5	Problems for Chapter 6	74
7	Symmetries, Ward identities, and Nambu–Goldstone bosons	76
7.1	Space-time symmetries	78
7.2	Spontaneously broken symmetries	81
7.3	Nambu–Goldstone bosons in the semi-classical expansion	84
7.4	Low-energy effective field theory of Nambu–Goldstone bosons	85
7.5	Problems for Chapter 7	89
8	Non-abelian gauge theory	93
8.1	The non-abelian Higgs phenomenon	96
8.2	BRST symmetry	97
8.3	A brief history of the physics of non-abelian gauge theory	99
8.4	The Higgs model, duality, and the phases of gauge theory	101
8.5	Confinement of monopoles in the Higgs phase	103
8.6	The electro-weak sector of the standard model	113
8.7	Symmetries and symmetry breaking in the strong interactions	116
8.8	Anomalies	118
8.9	Quantization of gauge theories in the Higgs phase	130
8.10	Problems for Chapter 8	132
9	Renormalization and effective field theory	137
9.1	Divergences in Feynman graphs	139
9.2	Cut-offs	142
9.3	Renormalization and critical phenomena	145
9.4	The renormalization (semi-)group in field theory	148
9.5	Mathematical (Lorentz-invariant, unitary) quantum field theory	154
9.6	Renormalization of ϕ^4 field theory	156
9.7	Renormalization-group equations in dimensional regularization	161
9.8	Renormalization of QED at one loop	164
9.9	Renormalization-group equations in QED	173
9.10	Why is QED IR-free?	178
9.11	Coupling renormalization in non-abelian gauge theory	181
9.12	Renormalization-group equations for masses and the hierarchy problem	188
9.13	Renormalization-group equations for the S-matrix	191
9.14	Renormalization and symmetry	193
9.15	The standard model through the lens of renormalization	201
9.16	Problems for Chapter 9	203
10	Instantons and solitons	206
10.1	The most probable escape path	206
10.2	Instantons in quantum mechanics	207

10.3	Instantons and solitons in field theory	213
10.4	Instantons in the two-dimensional Higgs model	216
10.5	Monopole instantons in three-dimensional Higgs models	221
10.6	Yang–Mills instantons	226
10.7	Solitons	232
10.8	’t Hooft- Polyakov monopoles	236
10.9	Problems for Chapter 10	239
11	Concluding remarks	242
<i>Appendix A</i>	<i>Books</i>	245
<i>Appendix B</i>	<i>Cross sections</i>	247
<i>Appendix C</i>	<i>Diracology</i>	248
<i>Appendix D</i>	<i>Feynman rules</i>	251
<i>Appendix E</i>	<i>Group theory and Lie algebras</i>	256
<i>Appendix F</i>	<i>Everything else</i>	260
<i>References</i>		262
<i>Author index</i>		268
<i>Subject index</i>		269