

Contents

Preface	8
Conventions and notation	11
1 Beta decay	13
1.1 Kinematics	13
1.2 Fermi theory	16
1.3 Generalization of Fermi theory and parity violation	20
1.4 The electron energy spectrum	24
1.5 The $e - \bar{\nu}$ angular correlation	32
1.6 Longitudinal polarization of electrons	35
1.7 Neutrino helicity	41
1.8 The V and A coupling constants	43
1.9 Mean lifetime of the neutron	47
Problems	51
2 Universal $V - A$ theory	52
2.1 Two-component neutrino	52
2.2 Left-handed chiral leptons	55
2.3 Muon decay	57
2.4 Universal interaction of $V - A$ currents	64
2.5 Cabibbo angle and selection rules for strangeness	66
2.6 Pion decays into leptons	72
2.7 Beta decay of charged pion	80
2.8 Nucleon matrix elements of the weak current	87
2.9 C, P and CP	92
Problems	95

3	Intermediate vector boson W	98
3.1	Difficulties of Fermi-type theory	98
3.2	The case for intermediate vector boson	104
3.3	Difficulties of the simple IVB model	111
3.4	Electromagnetic interactions of W bosons	115
3.5	The case for electroweak unification	120
	Problems	125
4	Gauge invariance and Yang–Mills field	126
4.1	Abelian gauge invariance	126
4.2	Non-Abelian gauge invariance	130
	Problems	137
5	Electroweak unification and gauge symmetry	138
5.1	$SU(2) \times U(1)$ gauge theory for leptons	138
5.2	Charged current weak interaction	143
5.3	Electromagnetic interaction	144
5.4	Unification condition and W boson mass	148
5.5	Weak neutral currents	150
5.6	Low energy neutrino-electron scattering	152
5.7	Interactions of vector bosons	157
5.8	Cancellation of leading divergences	160
	Problems	164
6	Higgs mechanism for masses	167
6.1	Residual divergences: need for scalar bosons	167
6.2	Goldstone model	171
6.3	Abelian Higgs model	177
6.4	Higgs mechanism for $SU(2) \times U(1)$ gauge theory	183
6.5	Higgs boson interactions	191
6.6	Yukawa couplings and lepton masses	194
6.7	Higgs–Yukawa mechanism and parity violation	199
6.8	Custodial symmetry	201
6.9	Non-standard Higgs multiplets	207
	Problems	211
7	Standard model of electroweak interactions	213
7.1	Leptonic world – brief recapitulation	213
7.2	Difficulties with three quarks	216
7.3	Fourth quark and GIM construction	219

7.4	GIM construction	223
7.5	Kobayashi–Maskawa matrix	231
7.6	<i>R</i> -gauges	240
7.7	Gauge independence of scattering amplitudes	249
7.8	Equivalence theorem for longitudinal vector bosons	256
7.9	Effects of ABJ anomaly	262
7.10	Synopsis of the GWS standard model	272
	Problems	284
A	Dirac equation and its solutions	286
B	Scattering amplitudes, cross sections and decay rates	302
C	Beta decay of polarized neutron	314
D	Massive vector bosons	317
E	Basics of the ABJ anomaly	329
	References	337
	Bibliography	342
	Index	346