

CONTENTS

PREFACE	V
PREFACE TO THE SECOND EDITION	IX
LIST OF SYMBOLS	XI
CONTENTS	XIII

INTRODUCTION (1-7)

History and Present Status of our Knowledge on Elementary Particles	1
---	---

CHAPTER I

THE FOUR-DIMENSIONAL ORTHOGONAL GROUP (8-99)

1. <i>Mathematical Preliminaries</i>	8
1a. Basic Notions of Group Theory	8
1b. Linear Spaces and Operators	11
1c. Representations of Groups	24
1d. Rings and Algebras	32
2. <i>The Four-Dimensional Orthogonal Transformations</i>	35
2a. Definitions and Group Property; Subgroups	35
2b. Infinitesimal Transformations and the Proper Subgroups	40
2c. Topological Structure and the Improper Groups	46
2d. The Inhomogeneous Lorentz Group	51
3. <i>Representations of the Four-Dimensional Orthogonal Group and its Subgroups</i>	53
3a. Tensorial Representations of the Proper Groups	54
3b. The Product Decomposition of the Proper Groups	60
3c. The Representations of U_2	65
3d. The Representations of C_2	68
3e. The Representations of N_{3p}	71
3f. The Representations of L_p	75
3g. Spinor Calculus	80
3h. The Representations of N_{4p}	85
3j. The Representations of the Improper Groups	86
3k. Spin and the Rotation Group	94

CHAPTER II

FIELD EQUATIONS (100-174)

1. <i>Tensor Fields</i>	103
1a. The Klein-Gordon Equation	103
1b. The Proca- and the Maxwell-Fields	105

2. <i>Spinor Fields</i>	107
2a. The Weyl Equation	107
2b. Spinorial and Customary Forms of the Dirac Equation	110
2c. The Algebra of the Dirac Ring	114
2d. Special matrices of the Dirac Ring	120
2e. Some Special Representations of the Dirac Matrices	123
2f. Explicit Proof of the Covariance of Dirac's Equation	129
2g. The Adjoint Field and Dirac-Covariants	133
2h. The Non-Relativistic Limit of the Dirac Equation	137
2j. Equation of Continuity	141
3. <i>Generalized Field Equations for Arbitrary Spin</i>	141
3a. The Dirac-Fierz-Pauli Equations	141
3b. The Kemmer Equation	146
3c. General First Order Matrix Differential Equations for Arbitrary Spin	155
4. <i>Fields in Interaction</i>	160
4a. Hamiltonian Principle and the Lagrangians for the Free Fields	160
4b. The Interaction Lagrangian and the Field Equations for Coupled Fields	164

CHAPTER III

THE QUANTIZATION OF FIELDS (175-214)

1. <i>Covariant Commutation Rules for Fields</i>	180
1a. The General Form of Commutation Relations	180
1b. Commutation Rules for Specific Fields	189
2. <i>Particle Number Representation</i>	193
2a. Fourier Decomposition of Fields	193
2b. The Commutation Rules in Fourier Space	196
2c. Particle Numbers, Creation and Annihilation Operators	197
2d. Interactions of Fields in Terms of Creation and Annihilation Operators	203
3. <i>Spin and Statistics</i>	206
3a. Preparations	207
3b. Indefiniteness of Certain Physical Observables	208
3c. Decision between Commutators and Anticommutators	211

CHAPTER IV

INVARIANCE PROPERTIES AND SELECTION RULES (215-411)

1. <i>Symmetry Transformations and Associated Conservation Laws</i>	217
1a. Noether's Theorem	217
1b. Conservation Laws for Quantized Fields	220

1c. Conservation of Energy and Momentum	225
1d. Conservation of Angular Momentum	230
1e. Conservation of Charge	232
1f. Conservation of Fermions	239
2. <i>Space Inversion and Parity</i>	246
2a. Intrinsic Parity	246
2b. Space Parity and its Conservation	248
2c. Boson Decays; Spin and Parity of the π -Meson	253
2d. Intrinsic Parity of Fermions	258
2e. General Remarks on Inversion Invariance	262
3. <i>Time Reflection</i>	264
3a. Time Reflection in Systems with Electromagnetic Interaction	265
3b. Time Reflection Properties of the Dirac Bilinears	269
3c. Time Reflection in a System of an Interacting Dirac Field and Pseudoscalar Field	270
3d. Superselection Rules	271
4. <i>Charge Conjugation and Charge Parity</i>	278
4a. Charge Conjugation for a Scalar or Pseudoscalar Field	278
4b. Charge Conjugation for a Dirac Field	282
4c. Behaviour of the Dirac Covariants under Charge Conjugation	285
4d. Space Parity and Charge Conjugation	287
4e. Charge Parity and its Conservation	288
4f. Applications: Furry's Theorem; Positronium; Protonium	296
4g. Majorana Theory of the Neutrino	306
5. <i>General Treatment of \mathcal{P}, \mathcal{C}, \mathcal{T} Transformations</i>	311
5a. Space Inversion	315
5b. Charge Conjugation	319
5c. Time Reflection	321
5d. Additional Remarks on \mathcal{P} , \mathcal{C} , \mathcal{T} Transformations	325
5e. Lüders' Theorem	329
5f. Applications of Lüders' Theorem: General Remarks; Mass and Lifetime of Antiparticles	337
6. <i>"Parity Violations" in Weak Interactions</i>	346
6a. The θ - τ puzzle and the Parity-Doublet Theory	351
6b. Experiments Revealing Non-Conservation of Parity	356
6c. Violation of \mathcal{P} -Invariance in Nuclear β -Decay	362
6d. Violation of \mathcal{C} -Invariance; Combined \mathcal{PC} -Invariance	370
6e. Two-Component Theory of the Neutrino	377
6f. Generalized Phase Transformations	391
6g. Universal Fermi Interaction	399

CHAPTER V

ISOBARIC SPACE (412-559)

1. <i>Isobaric Spin</i>	415
1a. Phenomenological Introduction of Isospin for Nucleons	415
1b. Charge Independence of Nuclear Forces	420
1c. Field Theoretical Determination of Isospin	425
1d. Isospin and its Conservation for the Nucleon-Pion System	430
1e. Charge Symmetry and Combined Charge Parity	438
1f. Relationships between Cross-Sections due to Isospin Conservation	443
2. <i>Extension of Isospin Formalism</i>	449
2a. The Paradox of Strange Particles	449
2b. The Gell-Mann and Nishijima Scheme	452
2c. Consequences of the Gell-Mann Scheme; Strangeness	459
2d. Electromagnetic and Weak Interactions	466
2e. The $\Delta t = \frac{1}{2}$ Rule	473
2f. The Theory of K^0 -Mesons	480
3. <i>The Prentki-d'Espagnat Theory of Isospin</i>	492
3a. Isoparity	492
3b. Classification of Particles	498
3c. The Strong Interactions	502
3d. Very Strong and Medium Strong Interactions; Mass Spectrum	509
3e. Summary of the Properties of Isospin and of the Interactions; Additional Remarks	514
3f. Conservation Rules connected with Isobaric Reflections	517
4. <i>Four-Dimensional Isospin</i>	521
4a. Rotation Operators and the two Types of Isospin	522
4b. The Classification of Particles	530
4c. Classification of the Interactions. M -Space	535
5. <i>Other Theories of Elementary Particles</i>	550
5a. The Composite Particle Model	551
5b. Heisenberg's Non-Linear Theory	555
5c. Gauge invariant theory of strong interactions	559
LIST OF LITERATURE	566
NAME AND SUBJECT INDEX	571