

Contents

Preface

v

- 1. Klein-Gordon Equation** **1**
Klein-Gordon equation — Klein-Gordon equation in Schrödinger form
— Klein-Gordon equation with potential
- 2. Dirac Equation** **13**
Four vector notation — Electromagnetic coupling in Dirac equation —
Some properties of the γ -matrices
- 3. Relativistic Covariance of the Dirac Equation** **33**
Lorentz group — Demonstration of Pauli's theorem — Explicit expression
for $S(\Lambda)$ — Discrete transformation properties of $\psi(x)$ — Time reversal
operation — Charge conjugation — Gordon decomposition
- 4. Solutions to the Dirac Equation** **59**
Free particle solutions — Hydrogen atom in Dirac's theory — Dirac
electron in a constant magnetic field
- 5. Helicity, Velocity Operators in Dirac's Theory** **81**
Helicity and Velocity operators — Foldy-Wouthuysen (F-W)
transformation — Free particle — Extreme relativistic case — F-W
transformation with electromagnetic coupling — F-W transformation
for Klein-Gordon equation
- 6. Hole Theory of Dirac** **101**
Radiative transition and stability of hydrogen atom — Hole theory —
Properties of ψ_c — Expectation values with charge conjugated states —
conjugated states
- 7. Scattering in Dirac Theory** **117**
Schrödinger — Heisenberg — Dirac pictures — Scattering by static
Coulomb potential (spins not observed and observed) — Coulomb
scattering of positrons — An important generalization — Electron-proton
scattering — The process $e+e^- \rightarrow \mu^+\mu^-$
- 8. The Neutrino** **151**
Two component theory — CP symmetry of the Dirac neutrino equation
— Majorana neutrino — Neutrino oscillations

Contents

9. Some Formal Aspects of Dirac Theory 173

Curved space-time — Local orthonormal frames (tetrad) — Spin connections — Covariant derivative of a spinor ψ — Spin structure on S^2 — Non-existence of spin structure in CP^2 — Metric on CP^2 — Riemann connections for CP^2 — Spin connections in CP^2 — Generalized spin structure — Index of Dirac operator

Suggested Reading 207

Index 209