

Quantum Field Theory

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Part I

1. Introductory words; using a model of a crystalline solid to discover QFT
2. Discovery of Fock space
3. Scalar field theory with some extra adjectives
4. Quantization of the radiation field by analogy; Noether's theorem and its converse
5. Casimir effect; fields mediate forces
6. Fields mediate forces; Wick rotation and time-ordering
7. Big picture recap; Feynman diagrams in 0+0-dimensional QFT
8. Lorentz invariance and causality
9. Path integral subtlety; propagators; where is single-particle QM in QFT?
10. The S-matrix and Dyson expansion
11. Wick's theorem; time-ordered Green's functions and diagrams
12. The exponentiation of the disconnected diagrams
13. The LSZ reduction formula
14. Observable physics from the S-matrix
15. Observable physics from the retarded Green's function; Group theory
16. Representations of the Lorentz group on fields
17. Spinor Lagrangians
18. The quanta of a spinor field are fermions
19. Scattering of fermions
20. Vector fields and gauge invariance

Part II

1. Goals, parable on violation of scale invariance by QM
2. Beta function; a simple example of perturbative renormalization
3. First steps towards quantum corrections to the Coulomb force law
4. Electron self energy; self-energy in ϕ^4 theory
5. Where is the cutoff dependence?
6. QED vertex correction
7. Soft photons
8. Vacuum polarization
9. Spectral density
10. Optical theorem and cutting rules
11. Hadrons with perturbative QCD; Parable on integrating out heavy modes
12. Anderson-Higgs mechanism
13. Interlude on differential forms
14. Gauge fields as connections; fermion path integrals
15. Lattice gauge theory
16. Gauge fixing
17. The QCD beta function
18. Wilsonian RG, briefly
19. Renormalization of composite operators; Callan-Symanzik equation; Introductory words about Effective Field Theory
20. The color of the sky; loops in effective field theory; the Standard Model as an effective field theory

Part III

1. Goals; Anomalies
2. Anomalies; emergence of the Dirac equation in 1+1d
3. More anomalies
4. Effective field theory of gravity and of particle physics
5. Effective field theory of superconductors and superfluids
6. Effective field theory of metal
7. Effective field theory of metal, continued
8. Coherent state path integrals for bosons and fermions
9. Path integrals and sums for spins; geometric quantization
10. Coherent state path integrals for spins
11. Topological terms from integrating out fermions; pions
12. More on pions
13. Nucleons as solitons; Field theory of spin systems
14. Field theory of the Neel phase
15. Large N
16. Transverse-field Ising model
17. Field theory of the transverse-field Ising model
18. Superfluid-insulator transition and T-duality
19. Bosonization
20. Holographic duality

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