



SS 2022

LV 705825-7

Thomas C. Lang

Quantum Field Theory

Thomas C. Lang, SS 2022

1. Introduction

- 1.1 What is QFT?
- 1.2 Why do we need QFT?
- 1.3 Where does it apply?
- 1.4 History
- 1.5 What is a field? (Lagrangians)

2. Second quantization

- 2.1 Mass on a spring
- 2.2 Phonons
- 2.3 Occupation number representation & particle statistics
- 2.4 Continuum limit
- 2.5 Operator valued distributions
- 2.6 Canonical quantization
- 2.7 The vacuum and normal ordering

3. Relativity in QFT

- 3.1 Lagrangians
- 3.2 Relativistic normalization (states)
- 3.3 Heisenberg picture (operators)
- 3.4 Causality
- 3.5 Propagators
 - 3.5.1 Green's functions
 - 3.5.2 Feynman propagator

4. Interacting fields & scattering

- 4.1 Weakly coupled theories
- 4.2 The interaction picture
- 4.3 Wick's theorem
- 4.4 Feynman diagrams & rules for ϕ^4 theory
 - 4.4.1 Position space
 - 4.4.2 Momentum space
 - 4.4.3 Generalization
- 4.5 Feynman diagrams & rules for $\psi^\dagger\psi\phi$ (Yukawa) theory
 - 4.5.1 Complex scalar fields
 - 4.5.2 Yukawa interaction & Feynman rules
 - 4.5.3 Yukawa Potential
- 4.6 Conventions
 - 4.6.1 Mandelstamm variables
 - 4.6.2 Transition matrix and invariant amplitude
- 4.7 Scattering & cross sections
 - 4.7.1 Fermi's golden rule
 - 4.7.2 Decay rates
 - 4.7.3 Cross section

- 5. Gauge theory
 - 5.1 Gauge invariance
 - 5.2 Electromagnetism
 - 5.3 Canonical quantization

- 6. Statistical QFT & Lattice field theory
 - 6.1 Path integral (general)
 - 6.1.1 Wick rotation
 - 6.1.2 Basic path integral
 - 6.2 Path integral for scalar field theory
 - 6.2.1 Lattice regularization
 - 6.2.2 Euclidean transporter
 - 6.2.3 Quantization via path integral
 - 6.2.4 Measurements & continuum limit
 - 6.3 Pure lattice gauge theory

- 7. The Dirac equation & Dirac field
 - 7.1 Lorentz Lie algebra
 - 7.2 Spinor representation
 - 7.3 The Dirac equation
 - 7.4 Weyl spinors, Chirality, Helicity & Parity
 - 7.5 Majorana fermions
 - 7.6 Quantization of the Dirac field
 - 7.7 Fermion propagator
 - 7.8 Feynman rules for fermions
 - 7.9 Quantum electro dynamics
 - 7.10 Gross Neuveu Yukawa