

Introduction to Lattice QCD



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● Lecture 1: Introduction to the lattice formulation

▶ Motivation

- Standard Model of Elementary Particles
- QCD versus QED

▶ Path Integrals-An overview

- Paths integrals in Quantum Mechanics
- Rotation to Euclidean time
- The Metropolis Algorithm
- Statistical errors

▶ Scalar field theory on the lattice

▶ Coherent States

- Bosons
- Fermions

▶ Formulation of Lattice Gauge Theories

- Discrete symmetries of lattice theory
- Local gauge symmetry
- $U(1)$ gauge theory
- Evaluation of observables: String tension
- Strong coupling expansion

▶ Continuum limit and Renormalization

- Asymptotic freedom
- Continuum limit

● Lecture 2: Fermions actions

- ▶ Fermion action
 - Symmetries of fermion action
 - Doubling of “naive” fermions
- ▶ Wilson fermions (WF)
 - Properties of Wilson Fermions
 - Symmetries of Wilson fermions
- ▶ Staggered fermions (SF)
 - Symmetries of Staggered Fermions
- ▶ Hopping-parameter expansion
- ▶ Improvement Program
 - Symanzik's improvement program
 - Elimination of redundant terms
- ▶ Improved fermion actions
 - The Sheikholeslami-Wohlert (clover) action
 - The twisted mass Wilson action
 - Chiral actions
- ▶ Improved gauge actions
 - Lüscher-Weisz action

● Lecture 3: Hadron Spectroscopy

- ▶ Spectrum calculations
 - Introduction to the basic techniques
 - Smearing techniques
 - Stochastic sources
- ▶ Masses of low-lying hadrons
 - Setting the scale
 - Comparison of results
- ▶ Excited States
 - Variational principle
 - χ^2 -method
 - Excited states of the nucleon
- ▶ Exotics
 - Glueballs
 - Multi-quark states
- ▶ Resonances

● Lecture 4: Hadron Structure

- ▶ Introduction to the basic techniques
 - Meson decay constants
 - Evaluation of three-point functions
- ▶ Meson sector
 - Pion form factor
 - ρ four point function and deformation
- ▶ Baryon sector
 - Nucleon form factors
 - Nucleon Generalized Parton Distributions-Definitions
 - Lattice evaluation
 - Results on nucleon form factors
 - Results on nucleon lower moments
 - N to Δ form factors
 - Δ form factors and structure
- ▶ Conclusions

Bibliography

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