PHYS506B: Particle Physics II Spring 2005

Outline

- **Introduction to Gauge Theories**
  - Basics of SU(*n*)
  - Classical Fields
  - U(1) Gauge Invariance
  - SU(*n*) Gauge Invariance
  - The Standard Model
- **The Parton Model**
  - Naive Parton Model
  - QCD Improved Parton Model
- **Physics at the Large Hadron Collider**
  - The experimental Challenge
  - Precision Physics and Searches

Marking Scheme

- 60% assignments
- 40% exam

Classes: TWF 13:30 – 14:30 in HHB 116

First class: Friday Jan 7th 2005

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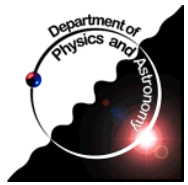

The key objective of this course is to develop a detailed understanding of the origin of the Lagrangian of the Standard Model of particle physics. Aspects of the Standard Model phenomenology will be discussed.

Introduction to Gauge Theories

- Basics of SU(*n*)
- Classical Fields
- U(1) Gauge Invariance
- SU(*n*) Gauge Invariance
- The Standard Model

Basics of SU(*n*)

- **Spin and Colour**
- **Notes on SU(*n*)**
- **Notes on SU(2)**
- **Notes on SU(3)**
- **Colour Factors**

Classical Fields

- Lagrangian Formulation for Discrete Systems
- Lagrangian Formulation for Fields
- Covariant Formulation
- Noether's Theorem
- Klein-Gordon Field
- Dirac Field
- Maxwell Field
- Proca Field

U(1) Gauge Invariance

- **Scalar Electrodynamics**
- **Electrodynamics**
- **Goldstone Model**
- **Higgs Model**

SU(*n*) Gauge Invariance

- **General Formalism**
- **Scalar SU(*n*) Dynamics**
- **SU(*n*) Dynamics**
- **Chromodynamics**
- **Non-Abelian Higgs Model**

The Standard Model

- **Chirality**
- **$U(1) \times SU(2)_L$**
- **Higgs Mechanism**
- **Masses**
- **Interactions**
- **Quarks and Families**
- **Free Parameters**
- **Running Coupling Constant**

The Parton Model

- Naive Parton Model
- QCD Improved Parton Model

Naive Parton Model

- Deep Inelastic Scattering
- Electron-Nucleon Scattering
- Neutrino-Nucleon Scattering
- Scale Invariance and Partons
- The Parton Model
- Structure Functions
- Sum Rules
- Parton Density Functions
- $e^+ + e^- \rightarrow$ Hadrons
- The Drell-Yan Process

QCD Improved Parton Model

- **Scaling Violations**
- **The Altarelli-Parisi Equation**

References Textbooks

This course does not follow a particular text. Here is a list of books I have consulted while preparing this course. Please let me know if you are aware of more recent editions or new texts!

- I.J.R. Aitchison, A.J.G. Hey, Gauge Theories in Particle Physics, 3rd edition.
- D. Bailin, A. Love, Introduction to Gauge Field Theory, revised edition, Institute of Physics, 1993.
- R.N. Cahn, G. Goldhaber, The Experimental Foundations of Particle Physics, Cambridge University Press, 1989.
- T.-P. Cheng, L.-F. Li, Gauge Theory of Elementary Particle Physics, Oxford University Press, 1984.
- P.D.B. Collins, A.D. Martin, Hadron Interactions, Adam Hilger, 1984.
- P.D.B. Collins, A.D. Martin, E.J. Squires, Particle Physics and Cosmology, John Wiley & Sons, 1989.
- J.F. Donoghue, E. Golowich, B.R. Holstein, Dynamics of the Standard Model, Cambridge University Press, 1996.
- R.K. Ellis, W.J. Stirling, QCD and Collider Physics, Fermilab-Conf-90/164-T.
- K. Gottfried, V.F. Weisskopf, Concepts of Particle Physics, Volumes I & II, Oxford University Press, 1986.

References Textbooks

- D. Griffiths, Introduction to Elementary Particles, John Wiley & Sons, 1987.
- F. Halzen, A.D. Martin, Quarks & Leptons, John Wiley & Sons, 1984.
- K. Huang, Quarks, Leptons and Gauge Fields, 2nd edition, World Scientific, 1992.
- E. Leader, E. Predazzi, An Introduction to Gauge Theories and Modern Particle Physics (Vol. I and II), Cambridge University Press, 1996.
- F. Mandl, G. Shaw, Quantum Field Theory, John Wiley and Sons, 1984.
- T. Muta, Foundations of Quantum Chromodynamics, World Scientific, 1987.
- Particle Data Group, Review of Particle Physics, Phys. Rev. **D** (2002) 1-974.
- D.H. Perkins, Introduction to High Energy Physics, 3rd edition, Addison-Wesley, 1987.
- M.E. Peskin, D.V. Schroeder, An Introduction to Quantum Field Theory, Addison-Wesley, 1995.
- L.H. Ryder, Quantum Field Theory, Cambridge University Press, 1996.

Lectures

- 07/01/2005
  - Colour
- 11/01/2005
  - Notes on SU(*n*)
- 12/01/2005
  - Notes on SU(*2*)
  - Notes on SU(3)
- 14/01/2005
  - Colour Factors
  - Young Tableaux (Kenji Hamano)
- 18/01/2005
  - Lagrangian Formulation for Discrete Systems
  - Lagrangian Formulation for Fields
  - Covariant Formulation
- 19/01/2005
  - Noether's Theorem
- 21/01/2005
  - Klein-Gordon Field
  - Dirac Field
- 25/01/2005
  - Dirac Field
  - Maxwell Field
- 26/01/2005
  - Proca Field
  - Scalar Electrodynamics
- 28/01/2005
  - Electrodynamics
  - Goldstone Model

Lectures

- 01/02/2005
  - Higgs Model
- 02/02/2005
  - General Formalism
- 04/02/2005
  - Scalar SU(*n*) Dynamics
- 08/02/2005
  - SU(*n*) Dynamics
- 09/02/2005
  - Chromodynamics
  - non-Abelian Higgs Model
- 01/03/2005
  - Chirality
  - U(1) $\times$ SU(2)
- 02/03/2005
  - Higgs Mechanism
  - Masses
- 08/03/2005
  - Interactions
  - Quarks and Families
  - Free Paramaters
- 09/03/2005
  - Running Coupling Constant
- 15-16-29/03/2005
- 30/03/2005
  - QCD Improved Parton Model
- 05-06-08/04/2005
  - Physics at the Large Hadron Collider