

PHY331 - PARTICLE PHYSICS

(1.) Brief Historical Background

Large Scale vs Small Scale Physics, First Rational Attempts to Describe the Structure of Matter, Ancient Greek Philosophers, Chemical Elements, Unification of Electricity with Magnetism, Radioactivity, Atomic Model, Quantum Mechanics, Light: Particles or Waves? , Discovery of Particles.

(2.) Particles of Matter and Fundamental Interactions

Strong-Electromagnetic-Weak-Gravitational Force, Fundamental Particles of Matter, Interaction Carriers, Uncertainty Principle, Vacuum Polarisation, Screening and Antiscreening, Color, Asymptotic Freedom, Confinement.

(3.) Interactions of Particles and Radiation with Matter

Energy Loss Mechanism, Minimum Ionising Particle, δ -Rays, Density Effect, Range, Multiple Scattering, Landau Distribution, Interactions of γ -Rays with Matter (Photoelectric Effect, Compton Scattering, Pair Production), Bremsstrahlung Radiation, Radiation Length, Electromagnetic Showers, Cerenkov Radiation.

(4.) Particle Detectors and Accelerator Systems

Operational Parameters of Detectors, Scintillation Counters, Cerenkov Detectors, Bubble Chambers, Spark Chambers, Streamer Chambers, Ionisation Chambers, Scattering and Mobility of Ions, Drifting of Electrons, Lorentz Angle, Signal Determination in an Ionization Chamber, Operational Modes of Ionisation Chambers, Proportional Ionisation Chambers, Geiger Mueller Counters, Drift Chambers, Transition Radiation Detectors (TRD's), Semiconductor Detectors, Electromagnetic and Hadronic Calorimetry, Radiation and Interaction Length, Homogeneous and Sampling Calorimeters, Linear and Circular Particle Accelerators.

(5.) Symmetries, Quantum Numbers and Conservation Laws

Euler-Lagrange Equations, Continuous and Discrete Symmetries, Noether's Theorem, Conserved Currents, Symmetry Generators, Spin, Isotopic Spin, Particle Multiplets, Supercharge, Conservation Rules, Parity(P), Parity Violation in Weak Interactions, Particle Helicities, Charge Conjugation(C), Time Reversal(T), CP and CPT Symmetry, Kaons, Strangeness Oscillations, CP Violation, Unitary Symmetry, SU(2) and SU(3) Representations, Quark Content of Composite Particles.

(6.) Quantum Electrodynamics

Basic Feynman Diagrams, Global and Local Gauge Transformations, Local Gauge Symmetry, General Properties of Quantum Electrodynamics.

(7.) Weak Interactions

Brief History of Weak Interactions at Low Energies, Fermi Theory of Beta Decay, V-A Theory, Selection Rules, Cabibbo Angle, CKM Matrix, Manifest vs Hidden Gauge Symmetry, Spontaneous Symmetry Breaking, Higgs Mechanism, Intermediate Vector Bosons, Weinberg Angle, Charged and Neutral Currents, Glashow-Weinberg-Salam Electroweak Theory.

(8.) Quantum Chromodynamics

Local Gauge Transformations, Gluonic Fields, General Properties of Quantum Chromodynamics, Screening and Antiscreening, Color, Asymptotic Freedom, Confinement.

(9.) Unification Theories

Problems of the Standard Model, Grand Unification Theories, SU(5), Extrapolation of Coupling Constants, Proton's Lifetime, $\sin^2\theta_w$, Supersymmetry and Supersymmetric Particles.

(10.) Applications

Classification of Areas of Applications arising from the Studies of Atoms, Nuclei and Fundamental Particles (Telecommunications, Electronics, Computers, Medicine, Archeometry, Energy Production, Industry, New Materials, Applications in other Natural Sciences).

Suggested Textbooks

1. "Introduction to Elementary Particles", David Griffiths, John Wiley & Sons, Inc. (1987).
2. "Introduction to High Energy Physics", Donald H. Perkins, Addison Wesley (1987).
3. "Modern Elementary Particle Physics", Gordon Kane, Addison Wesley (1993).
4. "Quarks & Leptons", Francis Halzen, Alan D. Martin, John Wiley and Sons (1984).
5. "Gauge Theories in Particle Physics", I. J. R. Aitchison & A. J. G. Hey, Graduate Student Series in Physics, Institute of Physics Publishing Ltd (1989).
6. "Στοιχειώδη Σωματίδια", Ι. Δ. Βέργαδος, Η. Τριανταφυλλόπουλος, Εκδόσεις Συμεών (1990).
7. "Πυρηνική Φυσική", Δεύτερος Τόμος, Παναγιώτης Α. Ασημακόπουλος, Εκδοτική Παραγωγή: Επτάλοφος Α.Β.Ε.Ε. (1984).
8. "Φυσική Στοιχειωδών Σωματιδίων", Παναγιώτης Τσιλιμίγκρας, Εκδοτικός Οργανισμός: Γρηγόρης Φούντας.
9. "Particle Physics and Introduction to Field Theory", T. D. Lee, Contemporary Concepts in Physics-Volume 1, Harwood Academic Publishers (1981).
10. "Gauge Theory of Elementary Particle Physics", Ta-Pei Cheng and Ling-Fong Li, Oxford Science Publications (1984).
11. "Weak Interactions of Leptons and Quarks", E. D. Commins and P. H. Bucksbaum, Cambridge University Press (1983).
12. "Leptons and Quarks", Lev Borisovic Okun, North-Holland (1982).
13. Additional Bibliography on specialized topics will be provided during the course.