

ICTP DIPLOMA PROGRAMME IN HIGH ENERGY PHYSICS 2013-14

SYLLABUS

Quantum Electrodynamics- {22 Lectures = 33 hours} G. Villadoro

- Classical Field Theory
 - Poincaré Transformation properties of Fields
 - Least Action Principle
 - Equations of Motion
 - Hamiltonian Density
 - Solutions of free equations of motion and with external sources
 - Green Functions

- Noether Theorem
 - Conserved Currents
 - Energy Momentum Tensor
 - Angular Momentum Tensor
- Quantum Field Theory for free Spin-0 Fields
 - Microcausality and Commutation Relations
 - Quantization of Klein Gordon Equations
 - Creation and Annihilation operators and algebra
 - Hamiltonian and Momentum operators
 - Vacuum state, particles and Fock space
 - Boson Statistics from QFT
 - Poincaré Transformations in QFT
 - Complex Scalar Fields
 - Normal Ordering
 - Time Ordering
 - 2- and n- point functions

- Quantization of Spin-1/2 Fields
 - Spinorial Representation of the Lorentz Group
 - Fermi-Dirac and Weyl representation of spinors
 - Dirac Equation and solutions
 - Quantization of Spin-1/2 Fields
 - Anticommutation Relation and Causality
 - Fermi Statistics
 - Spin and Helicity Operators
 - 2- and n- point functions
 - Conserved current and Charge
 - C, P (and T) symmetries

- Quantization of Spin-1 fields
 - Physical polarization
 - Gauge redundancy and Lorentz invariance
 - Gauge invariant Lagrangian and Gauge Fixing
 - Quantization of Massless Spin-1 fields, physical and unphysical polarizations
 - Spin-1 propagator and physical interpretation
 - Coupling to other fields, Gauge invariance and Covariant Derivatives

-Interactions

Interacting Lagrangian and particle non-conservation

Scattering Amplitudes and S-Matrix

Optical Theorem

Dyson Series and perturbation theory

Wick Theorem, Feynman Rules and Diagrams

QED to first and second order

Cross Section: 2 to n

Unstable Particles: Decay rates

Phase Space integrals

-QED at tree level

$e^+e^- \rightarrow \mu^+\mu^-$ cross section: polarized and unpolarized

Compton Scattering: unpolarized

-Introduction to Effective Field Theories

Relevant, Marginal and Irrelevant Interactions

Low Energy Limit and decoupling of Heavy Particles

Examples: Euler-Heisenberg Lagrangian and Rayleigh scattering