ICTP DIPLOMA PROGRAMME IN HIGH ENERGY, COSMOLOGY AND ASTROPARTICLE PHYSICS 2015-2016

SYLLABUS

Quantum Electrodynamics- {23 Lectures = 34.5 hours} G. Villadoro

-Classical Field Theory
Poincar√© 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
Poincar√© 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
Massive spin-1 fields
Casimir force

-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- -> 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 Reyleigh scattering