ICTP DIPLOMA PROGRAMME IN HIGH ENERGY PHYSICS 2013-14

SYLLABUS

The Standard Model - {21 Lectures = 31.5 hours} A. Romanino

PART I TECHNICAL TOOLS I (symmetries)

Collect the relevant tools given in previous courses and their extension to the SM
SM = spontaneously broken non-abelian gauge theories

- non-abelian gauge theories (see QFT) - with fermions
- gauge theories (see QED) - non-abelian
- chiral fermions

a. QFT
b. Continuous symmetry groups (Lie groups) - mainly SU(N), U(1)

1. Global symmetries (isospin)
2. Gauge symmetries (QED, QCD)

a. representations of the Lorentz group on fermions, L and R fermions + P, C, T
b. explicit form of a generic gauge theory with scalars and femions
c. [renormalization]

PART II CONSTRUCTION OF THE SM LAGRANGIAN I (EW gauge interactions)

1. The starting point: QED + QCD + Fermi interaction for weak interactions
2. The unitarity problem and renormalizability
3. Inferring the gauge structure the SM - the electroweak (EW) symmetry
4. Anomalies

PART III TECHNICAL TOOLS II (spontaneous symmetry breaking)

1. SSB of global symmetries - abelian + non-abelian?
2. SSB of gauge symmetries (Higgs mechanism) - abelian + non-abelian?

PART IV CONSTRUCTION OF THE SM LAGRANGIAN II (EWSB, terms involving Higgs)

1. The Higgs quantum numbers from Yukawas
2. The Higgs sector
3. The Yukawa sector

PHENOMENOLOGICAL ANALYSIS OF THE SM LAGRANGIAN

i) find the mass eigenstates, iii) find interactions
i) linear terms, ii) bilinear terms, iii) trilinear and higher order terms

PART V EWSB

1. Vacuum
2. The spontaneous breaking of the SM group into QED+QCD
3. Goldstones

PART VI SYMMETRIES

0. P, C, CP, T
1. U(3)^5
2. Custodial symmetry and exact U(1)
3. Accidental symmetries

PART VII GAUGE BOSONS (spin 1)

1. Gauge boson spectrum
2. Gauge self-interactions
3. The covariant derivative
4. Gauge interactions
5. Tests (EWPT)

PART VIII FERMIONS (spin 1/2)

1. Fermion masses
2. The lagrangian in terms of fermion mass eigenstates
3. The CKM matrix, neutral currents

PART IX HIGGS (spin 0)

1. Higgs spectrum
2. Higgs self-interactions
3. Unitarity bounds on the Higgs mass
4. Perturbativity and stability bounds
5. Experimental bounds

PART X BEYOND THE STANDARD MODEL

1. The need of extending the SM
2. Neutrinos
3. The hierarchy problem
4. Nice features of the SM and challenges for NP