

Standard Model

Program for exam 2007

1. Introduction
 - Gauge group $U(1) \times SU(2) \times SU(3)$
 - Gauge bosons (1+3+8)
 - Masses of gauge bosons, how far they can propagate
 - Fermions, three generations
 - Leptons
 - Quarks
 - Elementary particles
 - Interactions
 - Examples of electromagnetic interactions
 - Weak interactions
 - Strong interactions
 - Leptons, quarks, elementary particles
2. Gauge Invariance in Abel case
 - Global gauge transformations
 - Local gauge invariance
3. Gauge Invariance, Non-Abelian case
 - $SU(2)$ gauge group
 - Local $SU(2)$ transformations for the wave function
 - Gauge potentials, $su(2)$ algebra
 - Gauge transformation for potentials
 - Covariant derivative, its gauge transformation
 - Gauge field, its gauge transformations
4. Actions and Lagrangians
 - Lagrangian of scalar field
 - Lagrangian of Abelian and non-Abelian gauge fields
5. Dirac field
 - Dirac equation
 - Right and left components of Dirac spinors
 - Dirac equation in massless case, separation of left and right-handed chiralities
 - Dirac Lagrangian
6. ∇_μ for $U(1) \times SU(2) \times SU(3)$
 - $U(1)$, hypercharge for left and right leptons
 - $SU(2)$
 - representation with the help of the Pauli matrixes
 - left-handed fermions as $SU(2)$ doublets, right-handed states as $SU(2)$ singlets
 - Covariant derivative for leptons
 - $U(1)$
 - $SU(2)$

- Neutrino current and necessity to mix the fields B_μ and W_μ^0 in order to obtain A_μ and Z_μ
 - Hypercharges of the left and right chiral states for leptons
 - Electron charge, its relation to gauge charges g_1, g_2
 - Weinberg angle
 - Neutrino interaction with the neutral current (Z_μ)
 - Electron interaction with the neutral current
- 7. Feynman diagrams describing interaction of fermions with gauge bosons
 - Scattering of fermions
 - Creation and annihilation of fermion pairs
 - Decays
- 8. Higgs mechanism
 - Spontaneous symmetry breaking.
 - Example of a superconductor
 - Vacuum expectation value of the scalar field as a tool to generate the spontaneous symmetry breaking in the non-Abelian case
 - Generation of masses for gauge bosons
 - Example of SU(2) gauge group, triplet of massive gauge bosons
 - Weinberg-Salam case: $U(1) \times SU(2)$. Generation of mass for Z_μ .
- 9. Important qualitative features of QCD, theory of SU(3) gauge group
 - Asymptotic freedom
 - Confinement