Lecture 4 : Elementary particle dynamics - 2

Flavor mixings :

a) Quark sector : True physical weak interaction fermions, here d', s' and b' quarks with definite masses m_d, m_s and m_b respectively, are linear combinations of the quark fields d_L, s_L and b_L which appear in SM Lagrangian (for the left handed chiralites) :

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

The mixing matrix V_{CKM} is called Cabibbo-Kobayashi-Maskawa mixing matrix and it contains three mixing angles and one CP violating phase. Their values are well measured experimentally :

$$\begin{pmatrix} 0.974 & 0.227 & 0.004 \\ 0.227 & 0.973 & 0.042 \\ 0.008 & 0.042 & 0.999 \end{pmatrix}$$

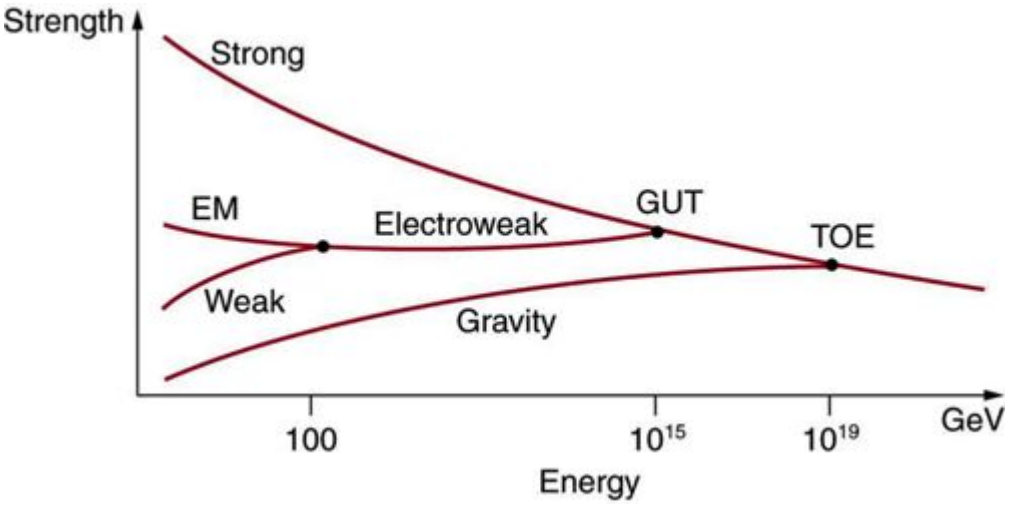
b) Lepton sector : The same idea goes over to the lepton sector. Altough in the quark sector the elements of mixing matrix sligtly differ from the unity matrix but in the neutrino mixing case two of the the Pontecorvo-Maki-Nakagawa-Sakata matrix elements are maximal.

$$\begin{aligned} \theta_{12} &= 33.62^\circ {}^{+0.78^\circ}_{-0.76^\circ} \\ \theta_{23} &= 47.2^\circ {}^{+1.9^\circ}_{-3.9^\circ} \\ \theta_{13} &= 8.54^\circ {}^{+0.15^\circ}_{-0.15^\circ} \\ \delta_{\mathrm{CP}} &= 234^\circ {}^{+43^\circ}_{-31^\circ} \end{aligned}$$

Conservation laws and their uses :

1) Conservation of the electric charge
2) Conservation of color
3) Conservation of the baryon number
4) Conservation of the lepton numbers: electron number, muon number and tau number
5) OZI (Okubo-Zweig-Iuzaka) rule

Unification of the fundamental force :



Standard model (SM) of particle physics is a well established and almost perfect theory consistent with all the existing experimental data.
However there are several reasons so that it is not the final theory.
First evidence came from the neutrino oscillations which require neutrinos to be massive and a flavor mixing of neutrinos. But SM Higgs doublet can not give mass to the neutrinos, so a new mechanism beyond the SM is needed. Also electromagnetic and weak interactions arealready unified via electroweak forces, and they unify with the strong forces at GUT energy levels. Unification of three forces with the gravity is not achived yet. Models capable to answer all such questions are still missing.

Homework

Solve the following problems at the end of the Chapter II of the textbook by D.Griffiths “Introduction to Elementary Particles J.Wiley)

Solve Problem 2.7

Solve Problem 2.8

Solve Problem 2.9

Solve Problem 2.10