Particle Physics 2 : Exercise 7

1) K_S - K_L mass difference

The $K_s - K_L$ mass difference can be expressed as

$$\Delta m = m(K_L) - m(K_s) \approx \sum_{q,q'} \frac{G_F^2}{3\pi^2} f_K^2 m_K |V_{\mathrm{qd}} V_{\mathrm{qs}}^* V_{\mathrm{q'd}} V_{\mathrm{q's}}^*| m_{\mathrm{q}} m_{\mathrm{q'}}$$

where q and q′ are the quark flavours appearing in the box diagram. Using the values for the CKM matrix elements given in the lecture, obtain expressions for the relative contributions to Δm arising from the different combinations of quarks in the box diagrams.

2) B^0 - $\bar{B}^0$ mass difference

Show that the $B^0 - \bar{B}^0$ mass difference is dominated by the exchange of two top quarks in the box diagram.

3) Asymmetric b-factories

To produce very large numbers of $B^0\bar{B}^0$ pairs, the e^+e^- KEKB collider in Japan operated at a center-of-mass energy of 10.58 GeV, which corresponds to the mass of the $\Upsilon(4S)$ $b\bar{b}$ resonance. Consider the decay $\Upsilon(4S) \to B^0\bar{B}^0$.

a) Calculate the velocities of the B^0-mesons produced in the decay at rest of the $\Upsilon(4S)$.

b) Given the lifetimes of the neutral B-mesons are $\tau = 1.53$ ps, calculate the mean distance they travel when produced at the KEKB collider in collisions of 8 GeV electrons and 3.5 GeV positrons.

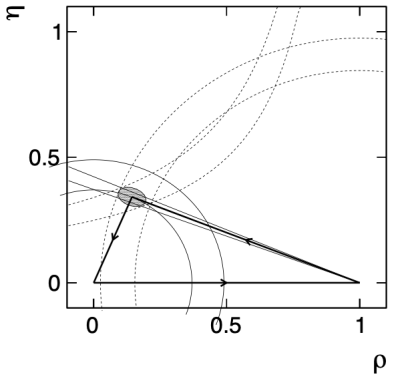
4) Unitary triangle

From the measured values

$$|V_{\mathrm{ud}}| = 0.97425 \pm 0.00022 \quad \text{and} \quad |V_{\mathrm{ub}}| = (4.15 \pm 0.49) \times 10^{-3}$$

$$|V_{\mathrm{cd}}| = 0.230 \pm 0.011 \quad \text{and} \quad |V_{\mathrm{cb}}| = 0.041 \pm 0.001$$

calculate the length of the corresponding side of the unitarity triangle in the figure below and its uncertainty. By sketching this constraint and that from the measured value of β, obtain approximate constraints on the values of ρ and η.



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