

129A HW # 7 (due Nov 14)

Neutral K mesons are very interesting particles. K^0 meson consists of $d\bar{s}$ quarks, and \bar{K}^0 meson of $s\bar{d}$, both $J^P = 0^-$ states just like pions. Under charge conjugation, they are interchanged, $C|K^0\rangle = |\bar{K}^0\rangle$ and vice versa.

1. Take helicities of neutrinos and anti-neutrinos as examples to argue why CP may be a good symmetry of weak interaction.
2. Show that the following states are eigenstates of CP operator and determine their CP eigenvalues: $|K_1\rangle = (|K^0\rangle - |\bar{K}^0\rangle)/\sqrt{2}$, $|K_2\rangle = (|K^0\rangle + |\bar{K}^0\rangle)/\sqrt{2}$.
3. When neutral kaons decay into two or three π^0 , pions are all produced in the S -wave (*i.e.*, in $L = 0$ state) in the kaon rest frame. Determine CP eigenvalues of $|\pi^0\pi^0\rangle$ and $|\pi^0\pi^0\pi^0\rangle$ states. Assuming conservation of CP , which $K_{1,2}$ state decays into two (three) π^0 ?
4. The one which decays into two π^0 is much shorter lived than the other one which decays into three π^0 because a kaon has barely enough mass to produce three π^0 and hence such process occurs slowly. Look up the booklet to find out the lifetimes of long-lived neutral kaon K_L and short-lived neutral kaon K_S .
5. Suppose a strong interaction process creates a neutral K -meson. For instance, suppose $pn \rightarrow \Lambda p + \text{neutral } K\text{-meson}$. Which K -meson is produced?
6. The created neutral K -mesons (as above) with energies 10 GeV are 50-50 mixture of K_L and K_S . How long beam line do you need to make sure that the fraction of K_S in the kaon beam is less than 10^{-5} ?
7. You have made sure that K_S fraction is less than 10^{-5} , but have seen $\pi^0\pi^0$ final state with a fraction of about 10^{-3} from the decay of the neutral kaons. Argue that CP is violated in the neutral kaon system.