Solution to Homework set 1

PHYS 129

Problem 1

For $u\bar{u}$, $d\bar{d}$, and $s\bar{s}$ quarks the factor

$$R = \underbrace{3}_{\text{color}} \times \left[\underbrace{\left(\frac{2}{3}\right)^2}_{u\bar{u}} + \underbrace{\left(\frac{1}{3}\right)^2}_{d\bar{d}} + \underbrace{\left(\frac{1}{3}\right)^2}_{s\bar{s}} \right] = 2$$

Once above charm threshold,

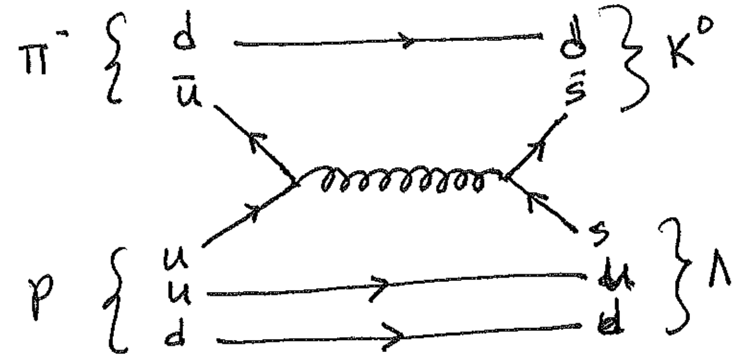
$$R = 3 \times \left[\left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \underbrace{\left(\frac{2}{3}\right)^2}_{c\bar{c}} \right] = \frac{10}{3}$$

above $b\bar{b}$ threshold

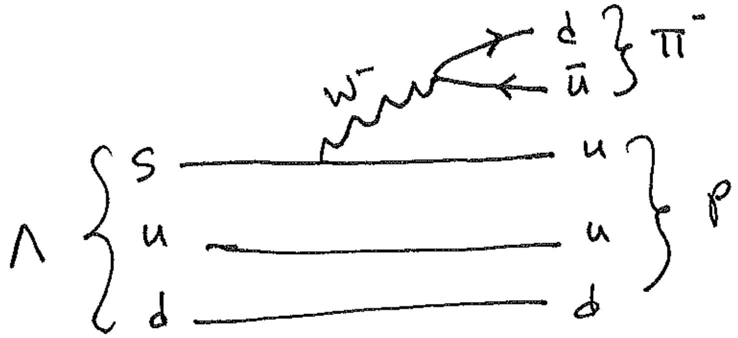
$$R = 3 \times \left[\left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \left(\frac{2}{3}\right)^2 + \underbrace{\left(\frac{1}{3}\right)^2}_{b\bar{b}} \right] = \frac{11}{3}.$$

problems

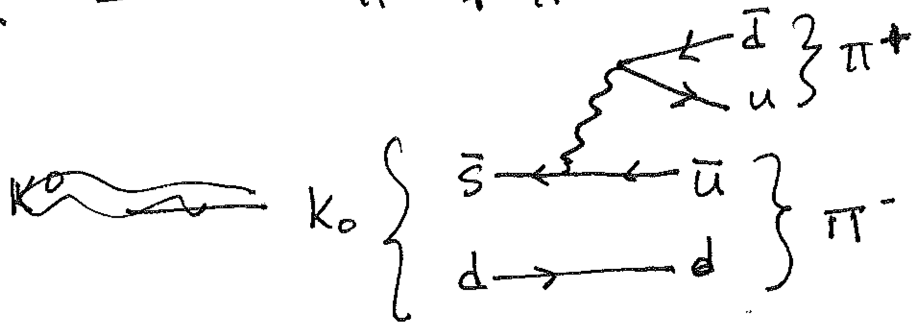
$\pi^- + p \longrightarrow \Lambda + K^0$ is an strong interaction.



$\Lambda \longrightarrow p + \pi^-$ is weak.



$K^0 \longrightarrow \pi^+ + \pi^-$ is also weak.



Since strong ~~interaction~~ coupling α_s is of order unity, the production cross-section is much larger.

Problem 1.4

Proper life-time $\tau = \frac{1}{\Gamma} = \frac{1}{120}(\text{MeV})^{-1}$

Putting $\hbar$

$$\tau = \frac{\hbar}{\Gamma} = \frac{6.59\times10^{-25}\,\text{GeV s}}{0.120\,\text{GeV}} \approx 5.49\times10^{-24}\,\text{s}.$$

Now due to time dilation life time in Labframe $\Delta t = \gamma\tau$

So $\gamma = \frac{E}{m}$ ← in natural unit.

$$= \frac{100\,\text{GeV}}{1.232\,\text{GeV}} \approx 81.17$$

then distance travelled $d \approx c\gamma\tau$

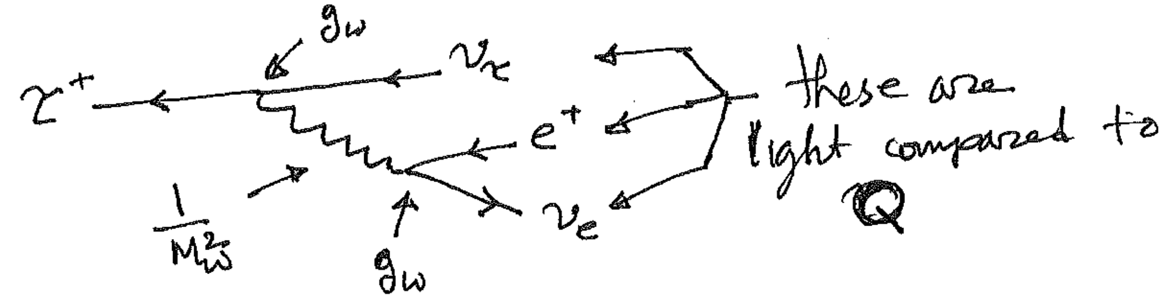
$$\approx 1.33\times10^{-13}\,\text{m}.$$

Problem 1.6

the reaction rate $W = \left(\frac{2\pi}{\hbar}\right) |T_{if}|^2 \rho_f$

Here only term that depends of dynamics is

T_{if}.



So $T_{if} \propto \frac{g_W^2}{M_W^2}$

Since $W \sim$ [Energy]

$$|T_{if}|^2 \propto \frac{g_W^4}{M_W^4} Q^5 = G_F^2 Q^5$$

There are other ~~factor~~ numerical factors present but we do not care about them. ~~so Since~~ ~~we only a want~~

Notice if both ⓐ, ⓑ, ⓒ, ⓓ, and ⓔ are described by the same process then for each case $\frac{W}{Q}$ should be exactly same.

However as shown in the back of the book

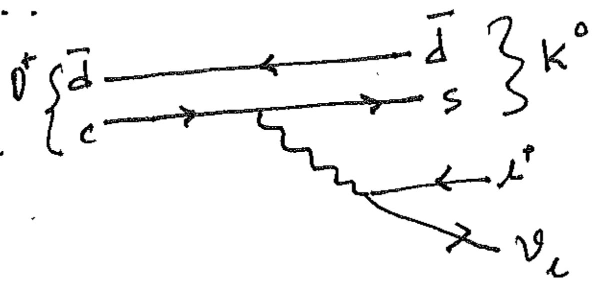
$$\left.\frac{W}{Q}\right|_{(a)} < \left.\frac{W}{Q}\right|_{(b)} < \left.\frac{W}{Q}\right|_{(c)} < \left.\frac{W}{Q}\right|_{(d)} < \left.\frac{W}{Q}\right|_{(e)}$$

This is because as Q decreases

$m_e << Q$ is no longer a good aproximation

(1.7) $\Longrightarrow$ See at the back of the text book!!!

(1.10) $D^+ \to K^0 + \ell^+ + \nu_\ell$



Now from (1.6)(b) we see that

$$\Gamma_{D^+\to \ell^+} = W = (\text{constant}) \times Q^5 = (3.6\times10^{-5}\ \text{MeV}^{-5}\,s^{-1}) \times (1.6\,\text{GeV})^5$$

$$= 3.77\times10^{11}\ s^{-1}$$

But

$$\frac{\Gamma_{D^+\to\ell^+}}{\Gamma_{tot}} = 0.15 \Rightarrow \Gamma_{tot} = \frac{\Gamma_{D^+\to\ell^+}}{0.15}$$

$$= 2.5\times10^{12}\ s^{-1}$$

Then,

$$\tau = \frac{1}{\Gamma_{tot}} \approx 4 \times 10^{-13}\ s$$

Problem 7

(a) $\mu^- \rightarrow e^- + \gamma$ **Not possible in SM** Violates lepton Number

~~(b) μ^+ ...~~

(b) Allowed.

(c) Allowed

(d) **Not allowed** Violate lepton number and charge conservation

(e) **Not allowed** $m_\Lambda < m_p + m_K$ Violates energy conservation

(f) Allowed.

(g) Allowed

(h) Allowed.