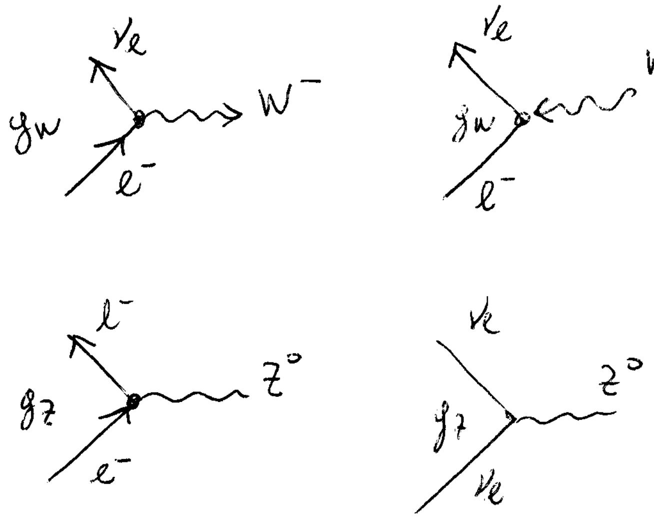
Interazione debole: leptoni & quarks

I <u>processi elementari</u> di interazione debole dei leptoni sono



correnti cariche

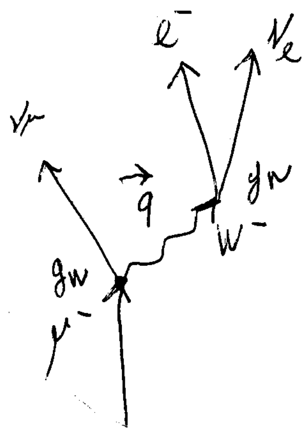
l = leptone

ν_l = neutrino corrispondente

correnti neutre

e analogamente per gli anti leptoni

<u>non</u> <u>c'è "mixing" tra famiglie diverse</u> (conservazione del numero leptonico per famiglia)



teoria di Fermi

$$V \simeq G_F\, \delta(\vec{r}_\mu - \vec{r}_{\nu_\mu})\, \delta(\vec{r}_\mu - \vec{r}_e)\, \delta(\vec{r}_\mu - \vec{r}_{\nu_e})$$

G_F quasi la stessa del decadimento β

$$G_F = .824\ 10^{-5}\ GeV^{-2}$$

$$\hookrightarrow \frac{(g_W/\hbar c)^2}{(M_W c^2)^2 + q^2 c^2} \simeq \frac{(g_W/\hbar c)^2}{(M_W c^2)^2} \cong G_F$$

$$\frac{1}{4\pi}\left(\frac{g_W}{\hbar c}\right)^2 = 4.2\ 10^{-3} = 0.58\ \underbrace{\frac{e^2}{4\pi\,\hbar c}}_{\alpha}$$

$$M_W c^2 = 80.33 \pm .0.15\ GeV$$

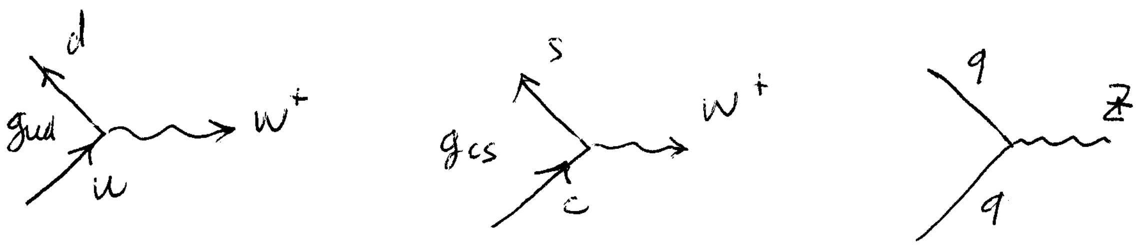
l'interazione debole è dello stesso ordine di grandezza della elettromagnetica: è la massa dei W che rende la probabilità di transizione molto + piccola.

Adroni

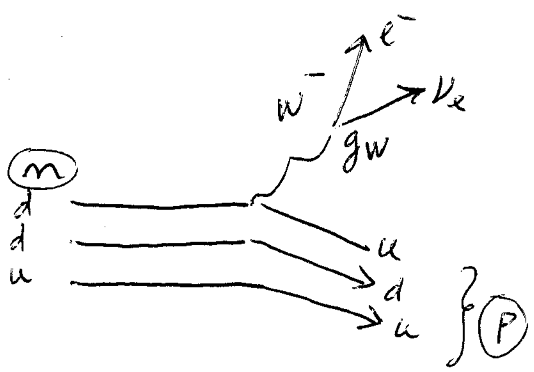
Riuniamo i quarks in "doppietti" come per i leptoni

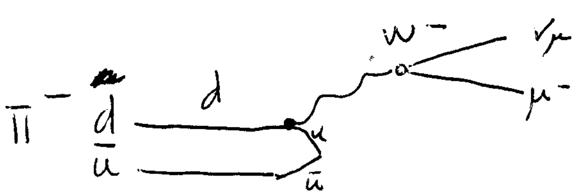
$$\begin{pmatrix} u \\ d \end{pmatrix} \quad \begin{pmatrix} c \\ s \end{pmatrix} \quad \begin{pmatrix} t \\ b \end{pmatrix}$$

• Simmetria leptoni quark



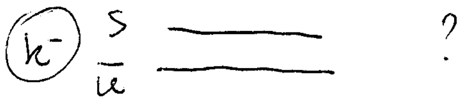
$$g_{ud} \simeq g_{cs} = g_W$$





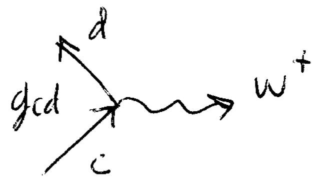
Ma questo non descrive i decadimenti degli adroni strani, tipo

$$K^- \to \mu^- + \bar{\nu}_\mu$$



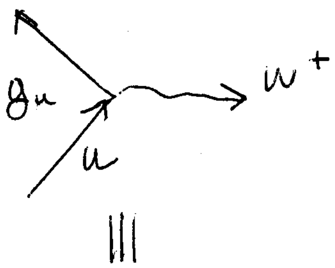
Se il quark s fosse stabile, esisterebbero nuclei formati da p, n, Λ!

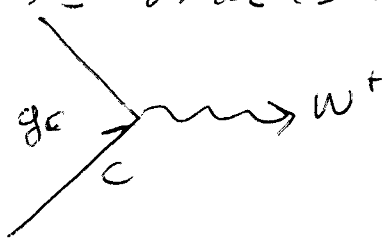
Ci sono anche i processi:

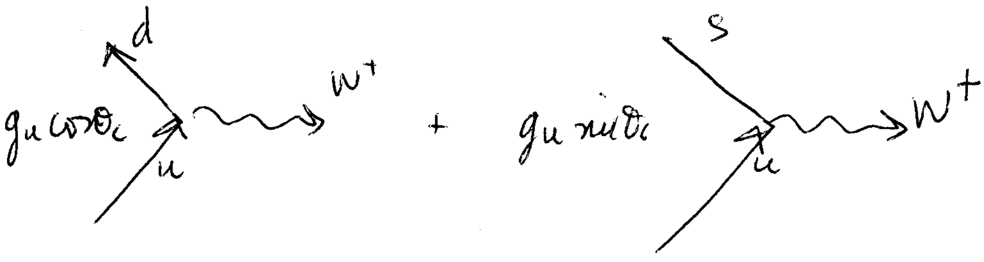


Cabibbo introdusse l'idea di "quark mixing"

$d' = d\cos\theta_c + s\sin\theta_c$ $\qquad$ $s' = -d\sin\theta_c + s\cos\theta_c$

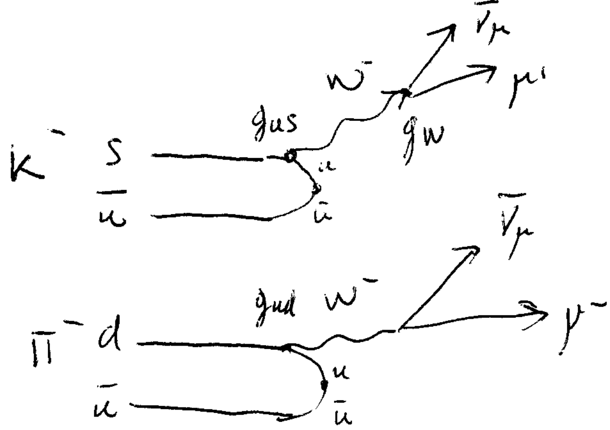






ecc.

$g_{ud} = g_u\cos\theta_c$ $\qquad$ $g_{us} = g_u\sin\theta_c$



$$\frac{\text{prob}\,(K^- \to \mu^- \bar{\nu}_\mu)}{\text{prob}\,(\pi^- \to \mu^- \bar{\nu}_\mu)} \propto \frac{\dfrac{g_{us}^2\, g_W^2}{(M_W c^2)^2}}{\dfrac{g_{ud}^2\, g_W^2}{(M_W c^2)^2}} = \frac{g_{us}^2}{g_{ud}^2} = tg^2\,\theta_C$$

$$tg\,\theta_C = 0.226 \pm .002$$

$$\frac{\text{Prob}\,(n \to p + e^- + \bar{\nu}_e)}{\text{Prob}\,(\mu^- \to \nu_\mu\, e^-\, \bar{\nu}_e)} \propto \frac{g_{ud}^2\, g_W^2}{g_W^2\, g_W^2} = \frac{g_{ud}^2}{g_W^2} = \frac{g_u^2}{g_W^2} \cos^2\theta_C$$

si trova $\dfrac{g_u^2}{g_W^2} \simeq 1$

così nel decadimento di adroni con charm

$$\frac{g_c^2}{g_W^2} \simeq 1$$

$$\begin{pmatrix} u \\ d' \end{pmatrix} \quad \begin{pmatrix} c \\ s' \end{pmatrix} \quad \begin{pmatrix} t \\ b' \end{pmatrix}$$

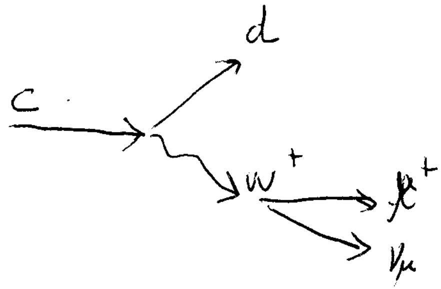
$d' = \alpha d + \beta s + \gamma b$

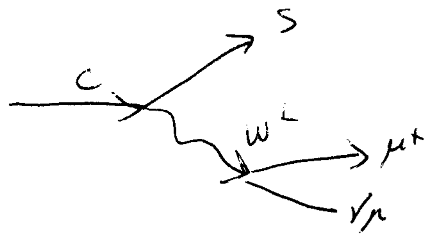
$s' = \ldots\ldots\ldots\ldots$

$$\begin{pmatrix} \alpha & \beta & \gamma \\ \vdots & \vdots & \vdots \end{pmatrix}$$

Cabibbo–Kobayashi–Maskawa

test decadimento di adroni con charm



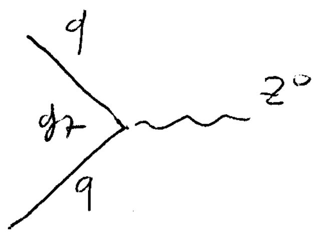


$$\text{prob} \propto \frac{g_c^2 \sin^2\theta_c \, g_W^2}{M_W^2} \qquad \text{prob} \propto \frac{g_c^2 \cos^2\theta_c \, g_W^2}{M_W^2}$$

$$\frac{\text{prob}(c \to d)}{\text{prob}(c \to s)} = tg^2\theta_c \simeq \frac{1}{20}$$

gli adroni con charm decadono + volentieri in adroni strani

correnti neutre



$$g_Z = g_W \, tg\,\theta_W$$

$$\sin^2\theta_W \simeq .227 \pm .014$$

$$M_Z c^2 = 89 \pm 2 \text{ GeV}$$

Esercizi

1) $$\frac{\Gamma(\Sigma^+ \to n + e^+ + \nu_e)}{\Gamma(\Sigma^- \to n + e^- + \bar{\nu}_e)} \ll 1$$

2) Quale decadimento è permesso? (al 1° ordine)

- $K^+ \to \pi^+ + \pi^+ + e^- + \bar{\nu}_e$
- $\Xi^0 \to \Sigma^- + e^+ + \nu_e$
- $K^- \to \pi^+ + \pi^- + e^- + \bar{\nu}_e$
- $\Xi^0 \to p + \pi^- + \pi^0$

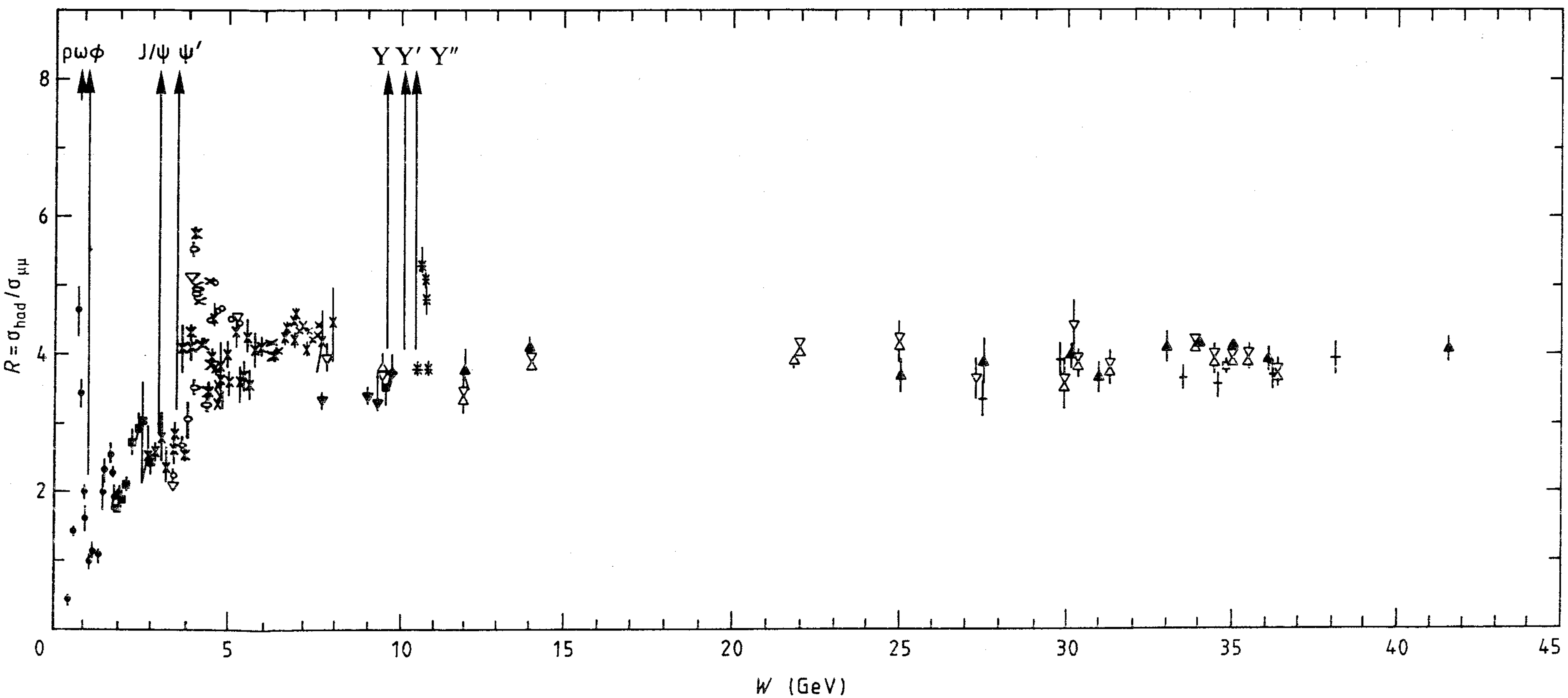


Figure 7.17 The ratio R (see equation (7.89)) (courtesy R Cashmore).