Exercises Particle Physics 2 #2

Exercise 5:

The charged current interaction.

Start with the Lagrangian that follows from weak isospin gauge invariance and show that a re-definition of the fields:

$$W_\mu^\pm = \frac{b_\mu^1 \mp i b_\mu^2}{\sqrt{2}}$$

leads to:

$$\mathcal{L}_{CC} = -W_\mu^+ J^{+\mu} - W_\mu^- J^{-\mu}$$

with

$$J^{+\mu} = \frac{g}{\sqrt{2}} \bar{\psi} \gamma^\mu \tau^+ \psi \quad ; \quad J^{-\mu} = \frac{g}{\sqrt{2}} \bar{\psi} \gamma^\mu \tau^- \psi$$

and

$$\tau^+ = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix} \quad ; \quad \tau^- = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

Exercise 6:

Show explicitly that the vector current can be decomposed as:

$$\bar{\psi} \gamma^\mu \psi \; = \; \bar{\psi}_L \gamma^\mu \psi_L \; + \; \bar{\psi}_R \gamma^\mu \psi_R$$

making use of the projection operators:

$$\frac{1}{2}(1 - \gamma^5) \quad \text{and} \quad \frac{1}{2}(1 + \gamma^5)$$

Exercise 7:

(a) Compare the Fermi 4-point interaction model (see previous semester) with the gauge theory model to show that the following relation holds:

$$\frac{G_F}{\sqrt{2}} = \frac{g^2}{8 M_W^2}$$

(b) i: How many free coupling constant-parameters are there in the electroweak standard model for the strength of the interactions. List them. (Remember the structure of the charge current as we studied in the last lecture the previous semester.)

ii: For some of the constants alternative choices are possible. Which are the most useful?

ii: How many free parameters does the standard model contain in total. List them.