Particle Physics - Exercises

5. Electroweak Theory 13.01.2011

In the electroweak theory the vector and axialvector couplings g_V and g_A of fermions to the Z boson are

$$g_V = I_3 - 2Q \sin^2 \theta_W$$
$$g_A = I_3 \quad .$$

I_3 is the 3rd component of the weak isospin, Q the electric charge and $\sin^2 \theta_W \simeq 0.23$ the electroweak mixing angle.

1. Calculate the vector and axialvector couplings

- of a Z boson
- of a W boson
- of a photon

to electrons and neutrinos and to up and down quarks. **[6]**

The coupling of a boson to a fermion pair is proportional to $g_V^2+g_A^2$.
It determines the partial decay width or relative decay probability into this decay channel.

2. Calculate the couplings $g_V^2+g_A^2$

- of a Z boson
- of a W boson
- of a photon

to electrons and neutrinos and to up and down quarks. **[6]**

3. Which fraction $R_b = \Gamma(Z,\gamma^* \rightarrow \bar{b}b) / \Gamma(Z,\gamma^* \rightarrow \text{hadrons})$ of all hadronic decays of Z bosons and virtual photons γ^* (at $m_\gamma=m_Z$) goes into $\bar{b}b$ quark pairs? **[4]**

4. The leptonic decay rate of the W boson $\Gamma(W \rightarrow e\, \nu_e) = G_F^m M_W^n / 6\sqrt{2}\pi$ depends on powers of the weak Fermi coupling G_F and the W mass. Determine the powers m and n from the Feynman diagram of the decay and dimensional analysis! **[3]**