SM Exercises 7

To be handed in on 03.06.13

1. (45%) What are the possible 2-body final states into which the W boson can decay? Estimate all the branching ratios (without calculating any decay width, just from the form of the Lagrangian and the quantum numbers of the different particles) taking into account that $M_W \gg m_f$, where m_f is the mass of any Standard Model fermion but the top quark. In this exercise you can neglect the mixing in the quark sector. Compute the decay rate for the process $W^- \to e^- \bar{\nu}_e$. Use the previous result to obtain the total decay width of the W boson. Compare it with the observed value.

2. (45%) Compute the decay width of the Z^0 into e^+e^- (since $M_Z \gg m_e$, you can neglect the electron mass). Estimate all the decay branching ratios of the Z^0 boson and use them to obtain its total decay width. Compare it with the observed value.

3. (10%) Suppose a fourth family exists, with a complete set of particles including a fourth neutrino ν_4 of mass similar to the other neutrinos, and gauge interactions identical to those of the other families. What would the decay width for $Z \to \nu_4 \bar{\nu}_4$ be? What about the decay width for $W^\pm \to L_4^\pm \nu_4$ where L_4 is the charged lepton of the family? Would such a fourth family be compatible with current data?