SM Exercises 8

In this exercise we are going to calculate the decays of the Higgs boson. To that end we will consider the Higgs mass, m_h, as a free parameter of the Standard Model that can take any value between 50 GeV and 500 GeV.

1. (30%) Compute the decay width of the Higgs boson into a lepton pair ($h \to \ell\bar{\ell}$) as a function of m_h and m_ℓ. Obtain also the decay width into a quark pair ($h \to q\bar{q}$) as a function of m_h and m_q. Identify the four most relevant fermion final states into which the Higgs boson can decay.

2. (30%) Compute the decay width of the Higgs into W and Z pairs ($h \to W^+W^-$, $h \to ZZ$). Notice that since the latter contains two identical particles in the final state, its phase space should be divided by two to avoid double-counting. Again, express the result in terms of m_h and M_W or M_Z.

3. (20%) Use the above six final states (four fermions and two gauge bosons) to compute the total decay width of the higgs boson. Plot this decay width as a function of m_h (use a log scale if convenient). Plot also the different branching ratios as a function of m_h. Compare your figures with those that can be found in the literature (books, internet, etc.) for the same quantities. What are the main differences you notice?

4. (20%) The Higgs boson was recently discovered with a mass of about 125 GeV. According to your results, what is the decay width of the Higgs boson and what are its branching ratios? What decay modes were actually used to discover the Higgs at the LHC? Explain why they do not coincide with the dominant decay modes you found.