Standard Model of Particle Physics

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Problem Sheet 9

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Problem 1: Higgs decays

1.) Compute the partial Higgs width $\Gamma(H \to W^+W^-)$ and $\Gamma(H \to Z^0Z^0)$ at tree-level. Use the two-body decay formula

$$\mathrm{d}\Gamma(H \to VV) = \frac{1}{32\pi^2}|\mathcal{M}|^2 \frac{(m_H^2 - 2m_V^2)^{1/2}}{2m_H^2}\mathrm{d}\Omega\,,$$

where $V = W, Z$ and $\mathcal{M}$ denotes the amplitude.

2.) Compute the tree-level partial Higgs width $\Gamma(H \to f\bar{f})$, where f denotes an arbitrary massive fermion, coupled via a Standard Model-like Yukawa interaction to H.

3.) We define the *branching ratio*

$$\mathrm{BR}(W^+W^-) = \frac{\Gamma(H \to W^+W^-)}{\Gamma(H \to W^+W^-) + \Gamma(H \to Z^0Z^0) + \Gamma(H \to f\bar{f})}\,,$$

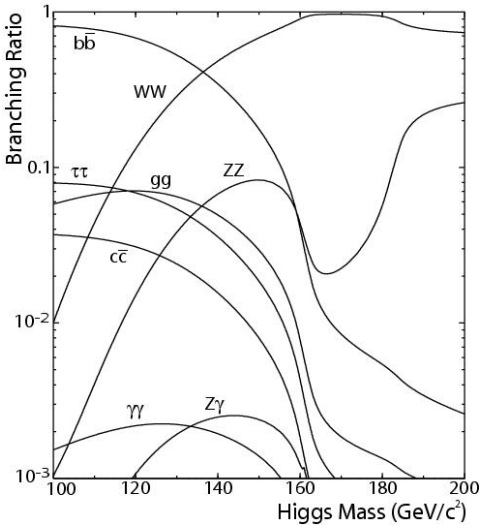

Figure 1: *Higgs branching ratios in the Standard Model.*

i.e. the partial width divided by the total width in that particular model, and analogously $\mathrm{BR}(Z^0Z^0)$ and $\mathrm{BR}(f\bar{f})$. These branching ratios can be measured at colliders such as the LHC. With reference to Fig. 1, which displays the results for the SM, discuss their qualitative behaviour as a function of m_H keeping m_f, m_Z, and m_W fixed.

4.) Compute $\mathrm{BR}(W^+W^-)/\mathrm{BR}(f\bar{f})$ and $\mathrm{BR}(W^+W^-)/\mathrm{BR}(Z^0Z^0)$ for $m_W = m_Z = m_f \equiv \tilde{m}$, and discuss their behaviour for $m_H \gg \tilde{m}$. Why do these ratios behave the way they do?

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