Physics Beyond the Standard Model

Exercise Sheet 8

Exercise 1: MSSM higgs masses

Consider the following MSSM higgs potential:

$$\begin{aligned} V &= m_1^2 H_1^{\dagger i} H_1^i + m_2^2 H_2^{\dagger i} H_2^i - B\mu(\epsilon_{ij} H_1^i H_2^j + h.c.) \\ &\quad + \frac{g^2+g'^2}{8}[H_1^{\dagger i} H_1^i - H_2^{\dagger i} H_2^i]^2 + \frac{g^2}{2}|H_1^{\dagger i} H_2^i|^2 + \frac{\epsilon}{2v^2 \sin^2\beta}[H_2^{\dagger i} H_2^i]^2 \end{aligned}$$

with

$$\begin{aligned} H_1^1 &= \frac{1}{\sqrt{2}}[v_1 + H^0 \cos\alpha - h^0 \sin\alpha + iA^0 \sin\beta - iG^0 \cos\beta] \\ H_1^2 &= H^- \sin\beta - G^- \cos\beta \\ H_2^1 &= H^+ \cos\beta + G^+ \sin\beta \\ H_2^2 &= \frac{1}{\sqrt{2}}[v_2 + H^0 \sin\alpha + h^0 \cos\alpha + iA^0 \cos\beta + iG^0 \sin\beta] \end{aligned}$$

and parameters

$$\begin{aligned} v_1 &= v\cos\beta \\ v_2 &= v\sin\beta \\ M_Z^2 &= \frac{g^2+g'^2}{4}v^2 \\ M_W^2 &= \frac{g^2}{4}v^2 \end{aligned}$$

The leading contribution of the radiative corrections can be incorporated using the universal parameter

$$\epsilon = \frac{3G_F}{\sqrt{2}\pi^2}\frac{m_t^4}{\sin^2\beta}\log\frac{M_{\tilde{t}_1}M_{\tilde{t}_2}}{m_t^2}.$$

Calculate all MSSM higgs masses from the potential and show that the mass of the lightest scalar Higgs boson is constrained. Express $m_{1,2}$ through $v_{1,2}$ as well as μB through M_A respecting the constraint that the potential is minimised at the vev.