662, Homework III, (1 problem, GRADED)

Problem 1

The Higgs boson can decay into two photons. One of the diagrams producing such transition is shown in the figure.

a) Compute the decay width as a function of the mass of the Higgs, the mass and charge of the fermion running in the loop and the Fermi decay constant G_F. Consider the diagram in the figure and also the one with p_1, p_2 interchanged. Assume $m_H < 2m_f$.

b) Compute the numerical value of the width when the fermion is a top quark (remember the color factor of 3) and compare with the decay width of Higgs into $b\bar{b}$.

Problem 1b

(Optional)

a) Discuss helicity properties of the fermion running in the loop and what does that imply for the amplitude as a function of the fermion mass.

b) Determine a low energy effective vertex that produces this transition and the implications of gauge invariance for the momentum dependence of the diagram.

c) Can you use **a)** and **b)** to argue that the diagram is finite?

d) Discuss the difference between the cases $m_H < 2m_f$ and $m_H > 2m_f$. Compare the decay width in the cases of bottom and top quark running in the loop.

Vertices

$$V_1 = q\bar{\psi}\gamma^\mu\psi A_\mu \tag{0.1}$$
$$V_2 = g\bar{\psi}\psi\phi_H \tag{0.2}$$

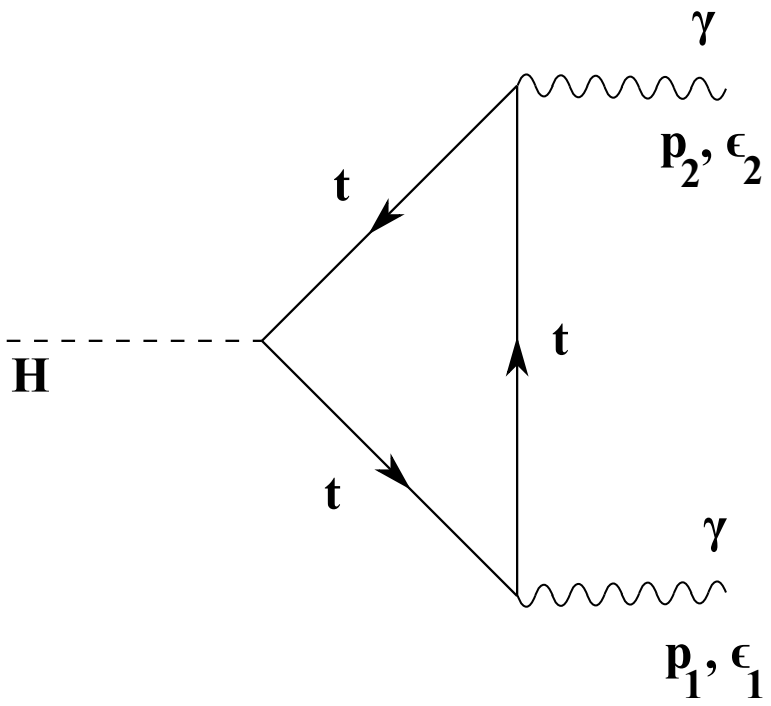

Figure 1: Diagram contributing to $H_0 \to \gamma + \gamma$.

Data

$$g = -\frac{m_f}{v}, \quad \frac{1}{v^2} = \sqrt{2}G_F \tag{0.3}$$

For the top quark: $m_t = 173GeV$, $q = +\frac{2}{3}e$.

Also: $m_H = 125GeV$ and $G_F = 1.166\,10^{-5}GeV^{-2}$.

Finally:

$$\Gamma_{i\to f} = \frac{(2\pi)^4}{2m_i}\prod_{f=1}^{N_f}\int \frac{d^3p_f}{(2\pi)^3}\frac{1}{2\omega_f}\delta^{(4)}(P_f - P_i)|\mathcal{M}_{fi}|^2 \tag{0.4}$$