PHY 5669: Quantum Field Theory B, Spring 2015

April 17^{th}, 2015

Final Exam

(due April 30^{th}, 2015)

The Lagrangian of the Standard Model (SM) is made of several parts that are discussed in Secs. 87-89 of Srednicki's book. Make sure you understand the form of all components of the Standard Model Lagrangian, write the Feynman rules for propagators and interaction vertices, and use them in working through this exam. Please show full work.

1. The interaction Lagrangian between the Standard Model Higgs boson and the electroweak gauge bosons is given in Eq. (87.27) of Srednicki's book. In the case of a SM Higgs ($M_H \approx 125$ GeV), $M_H < 2M_W$ and $M_H < 2M_Z$, but in Fig. 1 you can see that $\mathrm{Br}(H \to WW)$ and $\mathrm{Br}(H \to ZZ)$ are given also for $M_H \approx 125$ GeV and lower. What do they correspond to? Explain how you could calculate the corresponding rates.

2. The interaction Lagrangian between the Standard Model Higgs boson and quarks the electroweak gauge bosons is given in Eqs. (89.8) and (89.9) of Srednicki's book. Calculate the rate for $H \to Q\bar{Q}$ where Q is a generic quark (notice that this result would hold for massive leptons as well).

3. The Higgs boson can also decay into gluons ($H \to gg$). This cannot happen at tree level (there is no such vertex in the SM Lagrangian), but can be induced at the one-loop level. Can you see how? Calculate the corresponding rate. You can leave your result in a form that depends on a Feynman-parameter integral.

4. At the one-loop level, the Higgs boson can also decay into two photons ($H \to \gamma\gamma$) and a photon and a Z boson ($H \to \gamma Z$). How can this happen? Calculate the corresponding rates. You can leave your result in a form that depends on one or more Feynman-parameter integrals.

5. In Fig. 1 you can see plotted the theoretical predictions for the SM Higgs-boson branching ratios (l.h.s.) and total width (r.h.s.). Remember that $\mathrm{Br}(H \to XX) = \Gamma(H \to XX)/\Gamma_{\mathrm{tot}}$ where Γ_{tot} is the sum of all the rates. How do your results compare to the numbers that you can extract from the plots? Assuming that your results are correct (you can cross check with the literature), they will probably not perfectly agree with the plot on the l.h.s. Can you tell what could cause such difference?

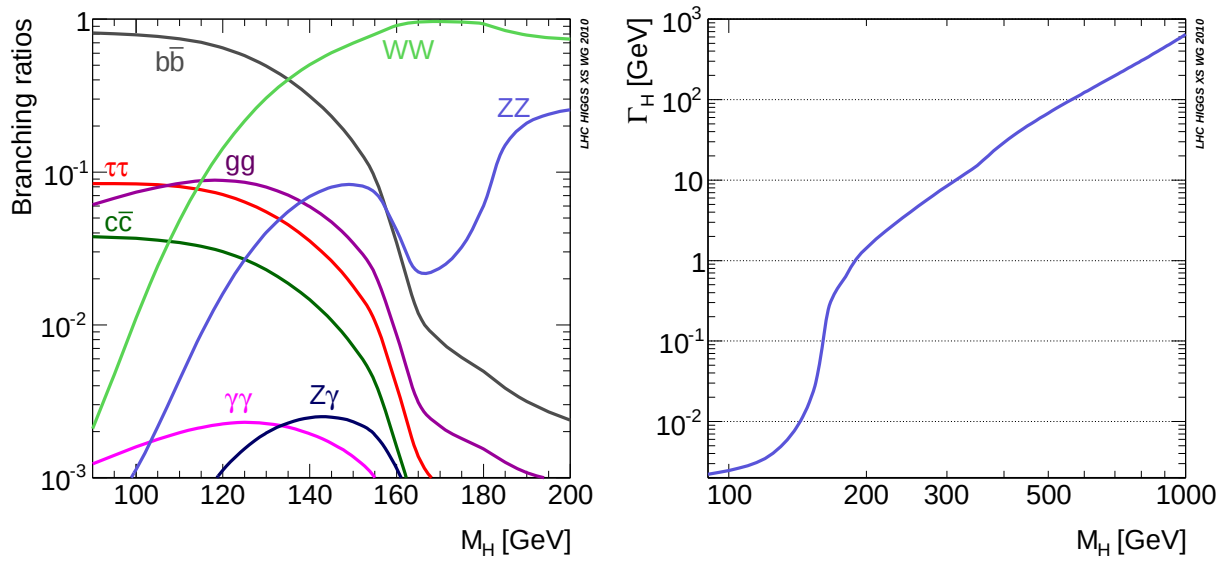

Figure 1: **L.H.S.**: Branching ratios of the SM Higgs boson as a function of its mass. **R.H.S.**: width of the SM Higgs boson as a function of its mass.