PHY612; QFT Problem Set 5: *Electroweak vector boson decays II*

Due Wed. 8 Mar 2006 at the beginning of class.
n.b. Use natural units $\hbar = c = 1$ in all problems unless explicitly specified otherwise.

1. W and Z total widths

In class we derived a formula for the partial width of a vector boson to a massless $f_1\bar{f}_2$ mode given a vertex of $ig_0\gamma_\mu(a + b\gamma_5)$, which was

$$\Gamma(V \to f_1\bar{f}_2) = \frac{1}{12\pi}\, g_0^2\, (a^2 + b^2)\, M_V. \tag{1}$$

a) (*2 pts*) Using this width formula, what do you predict for the branching fraction of the W to hadrons, and how well does this compare to experiment? (2004 PDG) Don't forget about color!

b) (*4 pts*) Again using this formula, sum over all allowed quark and lepton modes and give a numerical prediction for the W total width, in [GeV]. Compare your result to experiment.

c) (*4 pts*) Repeat the exercise in part b) for the Z^0.

2. Counting generations

(*10 pts*)

n.b. This may be the most important result in HEP in recent years.

According to the 2004 PDG, 20.00(6)% of Z^0 decays are "invisible". Making the obvious assumption about the dominant final states involved, and further assuming that each generation has an essentially massless neutrino, use the ratio of this branching fraction to the 3.363(4)% branching fraction for $Z^0 \to e^+e^-$ to calculate the number of generations N (with error bars).