

## 2/12/08 Lecture outline

- More naturalness successes. Box diagram contribution to  $\delta(M_{K_L^0} - M^{K_S^0})/M_{K_L^0} = G_F^2 f_K^2 \sin^2 \theta_c \Lambda^2$ , comparing with  $7 \times 10^{-15}$ , expect new physics at  $\Lambda \sim 2 GeV$ . This is how the charm quark was first predicted to exist, and indeed  $m_c \sim 1.2 GeV$ . GIM mechanism cancels large  $\sim \Lambda^2$  contribution.

- (Un) naturalness of Higgs mass in Standard Model, and where new physics is expected to restore naturalness. Corrections to Higgs mass from top loop,  $W$  and  $Z$  loop, and Higgs loop. Naturalness suggests new physics at the  $\sim 1 TeV$  scale.

- Quantifying naturalness and amount of tuning,  $\Delta \equiv \max|\partial \ln M_z^2 / \partial \ln a_i|$ .

- SUSY and naturalness. Diagram cancellations.

- Another favorite for BSM physics: GUT unification. Review basics of GUT unification, and the bounds on the mass scale where the new GUT particles ( $SU(5)/SU(3) \times SU(2) \times U(1)_Y$  gauge fields, and Higgs triplets) can appear. Running and coupling constant unification.