2/7/08 Lecture outline

• More on naturalness, and effective field theory.

• Model with massless fermion coupled to heavy scalar. Low energy matching below scale where the scalar is integrated out. Tree level and loop contributions to 4-fermion interaction. Especially note that the fermion stays massless – protected by chiral symmetry.

• Model with light fermion coupled to heavy scalar. Integrate out massive scalar, note matching contributions to the light fermion mass, from matching at the scale of the heavy scalar. Note that loop corrections to the fermion mass is **multiplicative**. Ensured by the chiral symmetry, treating the breaking fermion mass parameter as a spurion.

• Contrast with situation where there is a light scalar coupled to a heavy fermion. Now, matching across the scale of the heavy fermion mass, there is an **additive** loop contribution to the scalar mass. Naively quadratic divergent. Of course, this is regulated and treated via renormalization. But even the renormalized, observable, scalar mass gets an additive correction $\sim M^2_{heavy}$ across the threshold where the heavy fermion is integrated out.

• Past successes of naturalness arguments. Electron mass, and problem of large $\Delta E_{coulomb}$, cancelled by positron. The electromagnetic loop correction to $M^2_{\pi^+} - M^2_{\pi^0}$, $\delta(M^2_{\pi^+} - M^2_{\pi^0}) \sim \alpha\Lambda^2/4\pi$, comparing to actual value naturalness suggests new physics at $\Lambda \sim 800\ MeV$; indeed ρ shows up there.