5/31/17 Lecture 16 outline / summary

• Next topic: evidence for $SU(3)_C$.

• Recall the $j = 3/2$ baryons, they were completely symmetric in spin and $SU(3)_F$. But quarks are fermions and the complete wavefunction should be fully antisymmetric. $SU(3)_C$ fixes this: the baryons are made up of 3 quarks, each in the 3 of $SU(3)_C$, combined into a color neutral object using $\epsilon_{c_1 c_2 c_3}$. More on the $SU(3)$ multiplication rules.

• More evidence: $e^+e^- \to \gamma \to q\bar{q} \to$ jets. Compute tree-level amplitude and motivate $\sigma = (\pi/3)(Q\alpha/E)^2$ and hence $R = \sigma(e^+e^- \to \text{jets})/\sigma(e^+e^- \to \mu^+\mu^-) = N_c \sum Q_i^2$. Experimentalists measure this, and thereby show that $N_c = 3$.

• More about $\mathcal{L}_{QCD}$ and $U(1)_{QED}$ vs $SU(3)_C$ gauge invariance. $\mathcal{L} \supset \bar{\psi}(i\not{D} - m)\psi$, with $D_\mu = \partial_\mu + iqA_\mu + igT^a A_\mu^a$.

• $F_{\mu\nu} = [D_\mu, D_\nu]/(-ig) = \partial_\mu A_\nu - \partial_\nu A_\mu - ig[A_\mu, A_\nu]$, in the adjoint representation of the gauge group.

• $\mathcal{L} \supset -\frac{1}{4} Tr F_{\mu\nu} F^{\mu\nu} \supset -g f^{abc} \partial_\mu A_\nu^a F^{\mu b} A^{\nu c} - (g^2/4) f^{abc} f^{ade} A_\mu^b A_\nu^c A^{\mu d} A^{\nu e}$.

• QCD Feynman rules.

• Asymptotic freedom and QCD.