5/24/17 Lecture 15 outline / summary

• Last time:

• Illustrate the $\mathbf{3}$, $\overline{\mathbf{3}}$, and $\mathbf{3}\times\mathbf{3} = \overline{\mathbf{3}}+\mathbf{6}$ via their weights in the (T_3, T_8) plane. Continue to discus $SU(3)$ representations, 1, 3, $\overline{3}$, 8, 6, 10 and various tensor products.

• Application: approximate $SU(3)_F$ global symmetry for the (u, d, s) quarks. Mesons and baryons, spectrum and numbers. Plot their T_3 and T_8 weights. Note $Y = T_8(2/\sqrt{3}) = B + S$ and $Q_{elec} = T_3 + Y/2$.

• The spectrum of mesons and baryons. The $j = 0$ mesons (the pions and their cousins) in the 8. The $j = 1$ mesons in the 8. The $j = 1/2$ baryons (proton, neutron, and cousins) in the 8. The $j = 3/2$ baryons in the 10, with the Ω^- at $S = -3$ (3 strange quarks), predicted by Gell Mann before it was discovered, and he correctly predicted its mass and magnetic moment.

• 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 $\epsilon_{c_1c_2c_3}$. 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.