Lecture 19/20

Three-flavour quark model

Three light quarks: u, d, s

- mass differences $\ll$ hadron masses
- $\rightarrow$ group in supermultiplets with same J^P, similar masses but different charges and hypercharges (or strangeness)
- examples

  0^- meson nonet: (K^0, K^+), (π^-, π^0, π^+), η, η', $(K^-, \overline{K}^0)$

  $\frac{1}{2}^+$ baryon octet: (n, p), $(\Sigma^-, \Sigma^0, \Sigma^+)$, Λ, (Ξ^-, Ξ^+)

  $\frac{3}{2}^+$ baryon decuplet: $(\Delta^-, \Delta^0, \Delta^+, \Delta^{++})$, $(\Sigma^{*-}, \Sigma^{*0}, \Sigma^+)$,
  $\qquad\qquad\qquad (\Xi^{*-}, \Xi^{*0})$, Ω^-
- weight diagram: plot $Y = B + S$ against I_3; each row composed of isospin multiplets; different rows have different strangeness

Masses given approximately by

$$M = [N(q) + N(\overline{q})]M_q + [N(s) + N(\overline{s})]\Delta M_s + \frac{\mathcal{E}_{ss}}{\hbar^2}\langle \widehat{\mathbf{S}}_1 \cdot \widehat{\mathbf{S}}_2 \rangle$$

- where $M_q \simeq 350$ MeV (constituent quark mass)
- $\delta M_s \simeq 150$ MeV (extra mass of s quark)
- $\mathcal{E}_{ss} \simeq 170$ MeV (colour magnetic spin-spin interaction)

Except π: much lighter than expected (140 MeV not ~ 600 MeV)

Heavy quarks

Masses of c, b quarks $\gg$ typical momenta in hadrons $\sim \hbar/(1\,\text{fm})$

- nonrelativistic
- $Q\overline{Q}$ mesons bound by Coulomb-like potential: "quarkonia"

t quark never forms hadrons

- lifetime $\tau \sim 10^{-25}$ s (weak decay!)
- $<$ time for signal to cross a hadron ~ 1 fm$/c$