Lecture 17/18

Three generations

Three copies of fermions that constitute ordinary matter

- six flavours of quark (in three colours), six flavours of lepton
- plus 12 antifermions

						Q
u	up	c	charm	t	top	$+\frac{2}{3}$
d	down	s	strange	b	bottom	$-\frac{1}{3}$
ν_e		ν_μ		ν_τ		0
e^-		μ^-		τ^-		-1

Each generation satisfies anomaly cancellation condition

$$\sum_f Q_f = 3\left(+\tfrac{2}{3}\right) + 3\left(-\tfrac{1}{3}\right) + (-1) + 0 = 0$$

Flavour numbers

Net number of quarks of each flavour q: $N_q = N(q) - N(\overline{q})$

- conserved by strong and EM interactions
- baryon number: $B = \frac{1}{3}\sum_q N_q$
- 3rd component of isospin: $I_3 = \frac{1}{2}(N_u - N_d)$
- strangeness: $S = -N_s$
- charm: $C = N_c$
- "bottomness": $\widetilde{B} = -N_b$
- "topness": $T = N_t$

  hypercharge: $Y = B + S + C + \widetilde{B} + T$

EM charge of hadron: $Q = I_3 + \frac{1}{2}\left(B + S + C + \widetilde{B} + T\right) = I_3 + \frac{1}{2}Y$

Lepton flavour numbers

- conserved by EM interaction, by weak on normal length scales
- $L_l = N(l^-) - N(l^+) + N(\nu_l) - N(\overline{\nu}_l)$, for $l = e, \mu, \tau$

Flavour mixing

W bosons couple to weak isospin doublets

$$\begin{pmatrix} u \\ d' \end{pmatrix} \quad \begin{pmatrix} c \\ s' \end{pmatrix} \quad \begin{pmatrix} t \\ b' \end{pmatrix} \quad \begin{pmatrix} \nu_e \\ e^- \end{pmatrix} \quad \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix} \quad \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}$$

Weak eigenstates d', s', b' are mixtures of mass eigenstates d, s, b

- otherwise s, b could not decay
- $d - s$ mixing largest

$$\begin{aligned} d &\simeq d' \cos\theta_C - s' \sin\theta_C \\ s &\simeq d' \sin\theta_C + s' \cos\theta_C \end{aligned}$$

  Cabbibo angle: $\theta_C \simeq 13^\circ$
- decays of strange particles suppressed by factor of $\sin^2\theta_C \simeq 0.05$