Top quark.

(i) Top quark is the heaviest particle discovered so far.

SM is $SU(3)_C \times SU(2)_L \times U(1)_Y$.

Under $SU(2)_L$;

$$\begin{pmatrix} u \\ d \end{pmatrix}, \begin{pmatrix} c \\ s \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix}.$$

top is the third generation quark.

→ discovered at Tevatron in 1992.

→ Tevatron: a $p\bar{p}$ collider.

→ proposed by KM in late 80's.

→ to explain CPV in K-$\bar{K}^0$ system.

→ its mass.

$$\mathcal{L} = \bar{u}_L \phi u_R Y_t.$$

$$\Rightarrow \frac{1}{\sqrt{2}} Y_t \cdot \bar{u}(h+v) u.$$

$$\Rightarrow m_t = \frac{Y_t v}{\sqrt{2}}.$$

with $v = 246$ GeV;

$$Y_t \approx 1.$$

$\Rightarrow$ related to EWSB & Higgs physics.

$$V_{CKM} = \begin{pmatrix} V_{ud} & & \\ & V_{cs} & \\ & & V_{tb} \end{pmatrix}$$

Since $t \to bW$ almost 100%.

$\Rightarrow V_{tb} = 1$.

gauge coupling :

With W : $tbW : \frac{g}{\sqrt{2}} \gamma^\mu P_L V_{tb}$.

P_L is chirality Projection operator.

for a dirac spinor. $u = \begin{pmatrix} u_R \\ u_L \end{pmatrix}$

$P_L = \frac{1-\gamma_5}{2}$; $\gamma_5 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$

so $P_L = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$

$\Rightarrow P_L u = u_L$.

$\Rightarrow P_L$ projects out left-component of u.

Polarizations : denote the $\frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} = P_t$.

For parity conserving interactions,

$P_t = 0$.

γ_5 breaks parity. Thus presence of γ_5 in coup. leads to P_t

→ Top is massive.

→ $m_t \approx 173.2 \pm 0.9$ GeV by CMS.

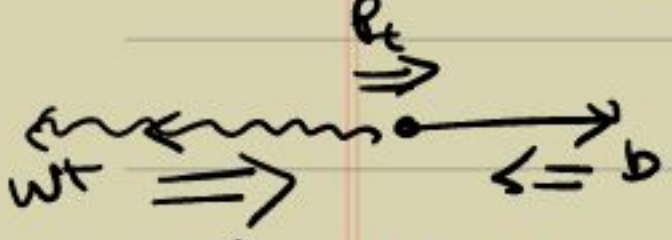
→ $\Gamma = 1.76$ GeV $\Rightarrow$ $\tau_t = 5 \times 10^{-25}$ s.

→ $\Lambda_{QCD} = 100$ MeV. $= 3 \times 10^{-24}$ s.

→ Thus decays before hadronization.

→ ⇒ Polarization is transferred to decay products.

conservation of angular momentum



left-handed

longitudinal.

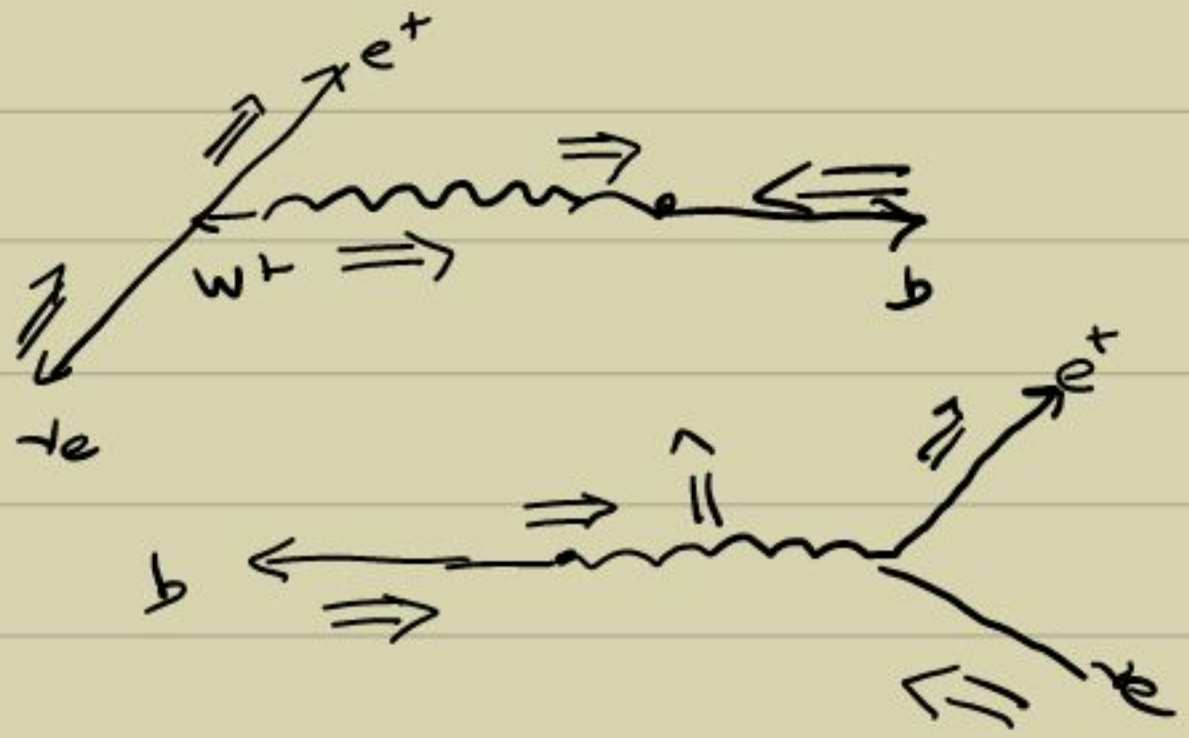
⇒ Top polarization is related to W- polarization,

⇒ e^+ must be right handed & thus follows.

top-spin direction.

⇒ In top-rest frame.

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta'} = (1+\cos\theta)$$



For example, γ & g coupling does not have ξ and thus leads to zero polarization of top.

Top production channels:

At tevatron: $q\bar{q} \to t\bar{t}$ via, γ, Z, g

At LHC : $gg \to t\bar{t}$

single top: (i) t-channel

(ii) s-channel

(iii) tW-channel.

Significance:

(a) determines V_{tb} in production so far only in decay. cannot

(b) weak interactions.

(c) increased sensitivity to tbW vertex.

(d) tW has only Wtb new physics.

Wtb vertex: at tree level, only at loop level

$$\mathcal{L} = \frac{g}{\sqrt{2}} \left[-f_{1L} \gamma^\mu P_L + f_{1R} \gamma^\mu P_R + \frac{i \sigma^{\mu\nu} q_\nu}{m_W} f_{2L} P_L \right.$$

$$\left. + \frac{i \sigma^{\mu\nu}}{m_W} q_\nu f_{2R} P_R \right].$$

f_{2L} contributes to $B \to s\gamma$ & hence quite constrained by it. On the other hand f_{2R} is helicity suppressed.