

19/01/2018

THE FUNDAMENTAL INTERACTIONS

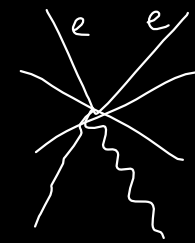
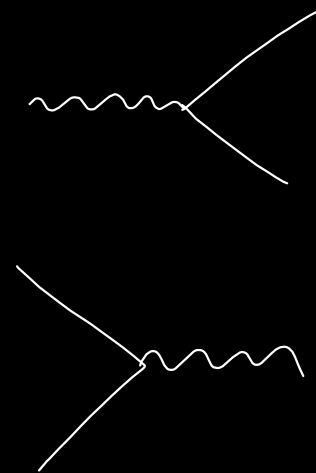
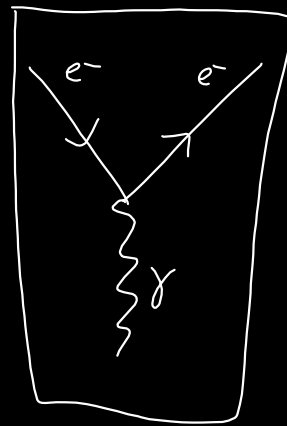
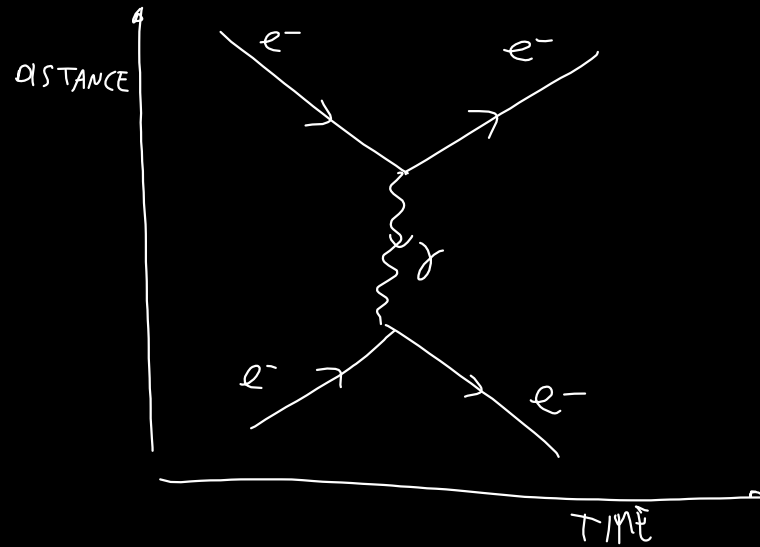
1) ~~GRAVITY~~

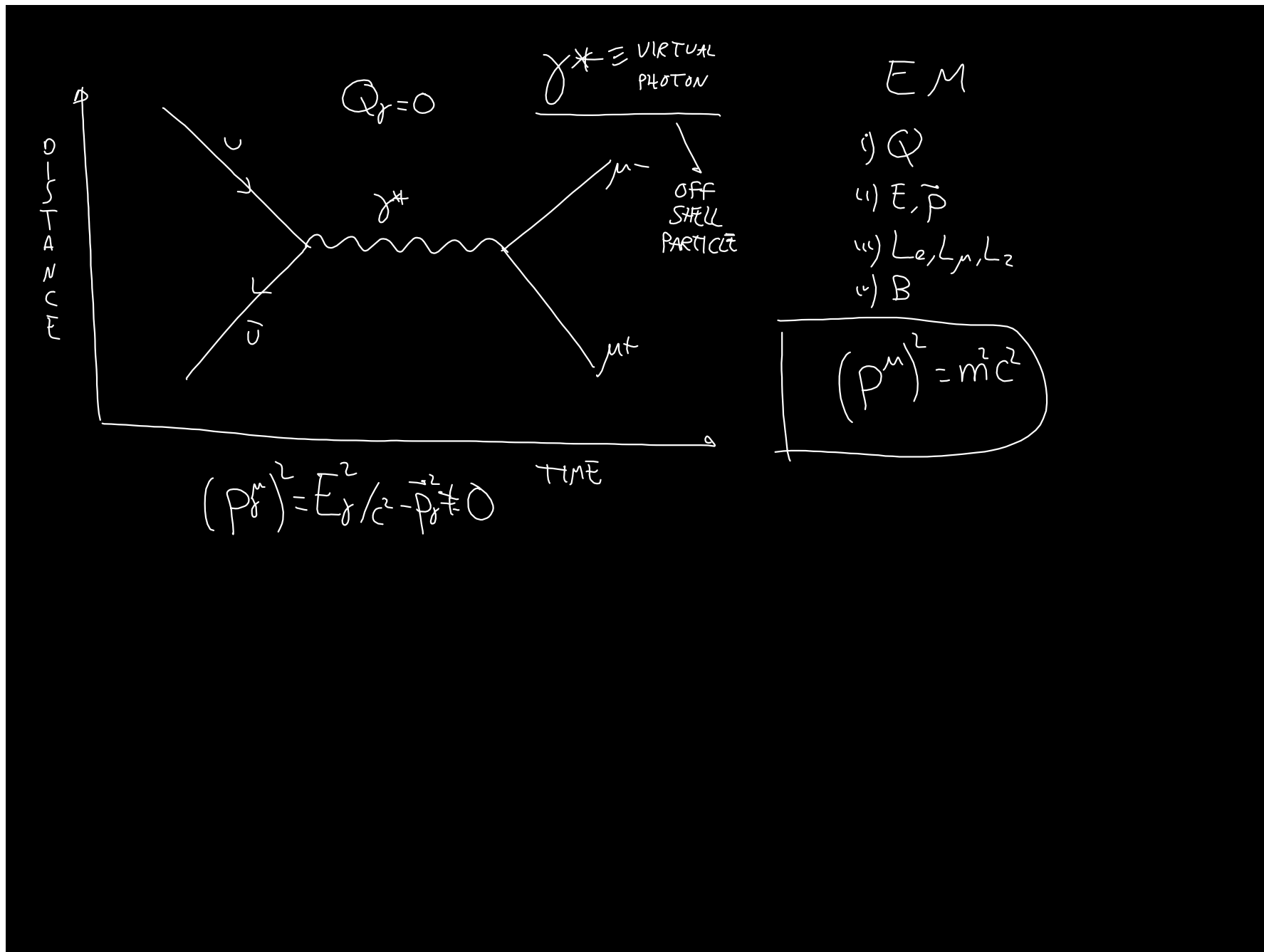
$$F_G \sim 10^{-39} F_E$$

2) ELECTROMAGNETISM

$$\left. \begin{array}{l} Q < 0 \\ Q > 0 \end{array} \right\}$$

FEYNMAN DIAGRAMS

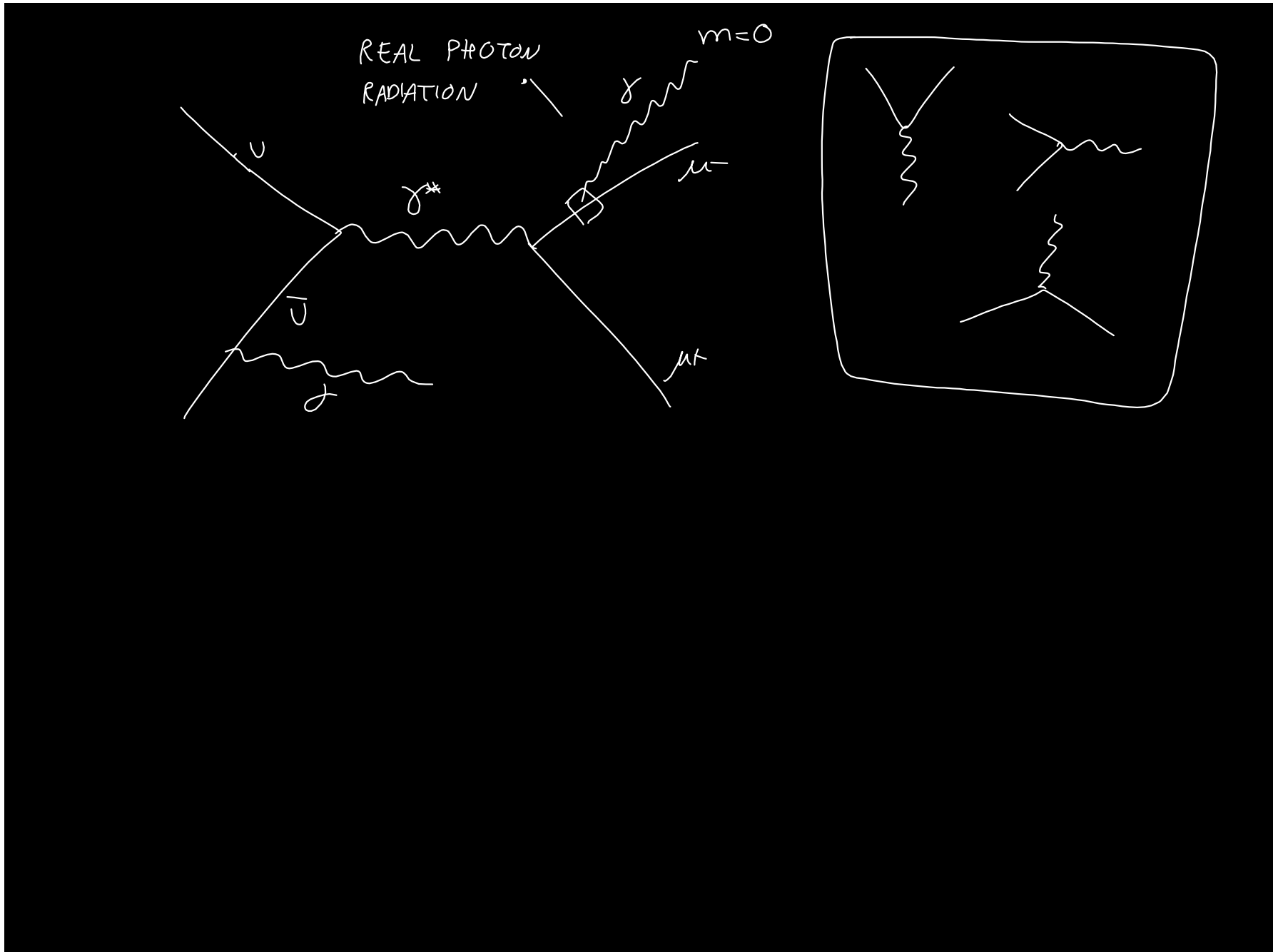




HEISENBERG UNCERTAINTY

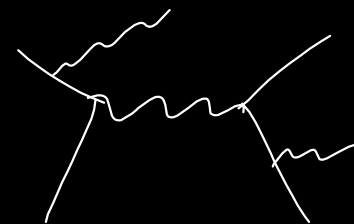
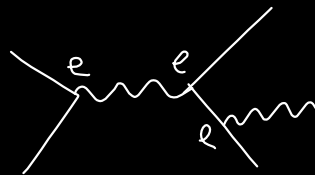
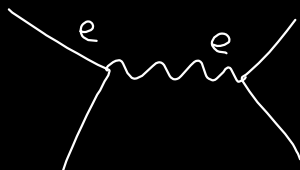
$$\underline{\Delta E} \times \Delta t \geq \frac{\hbar}{2}$$

- (i) REAL PARTICLES
ON-SHELL $(p^m)^2 = m^2$
- (ii) VIRTUAL PARTICLES
OFF-SHELL $(p^m)^2 \neq m^2$



PERTURBATIVE EXPANSION

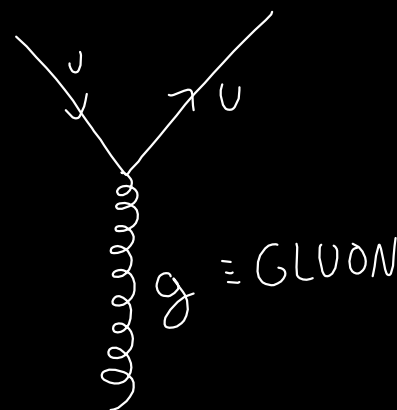
$$A = e^2 A_0 + e^3 A_1 + e^4 A_2$$



STRONG FORCE

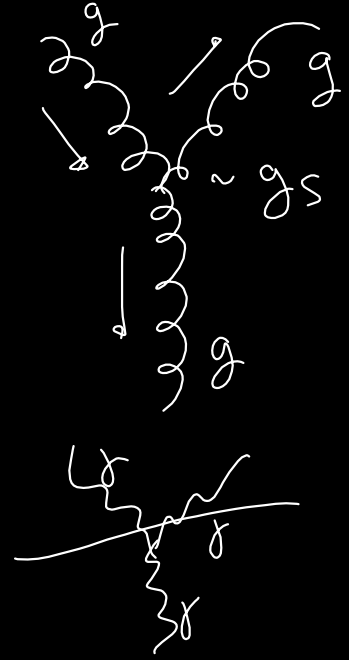
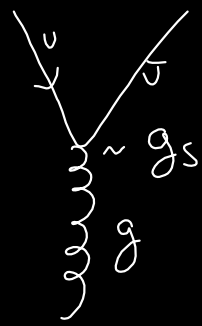
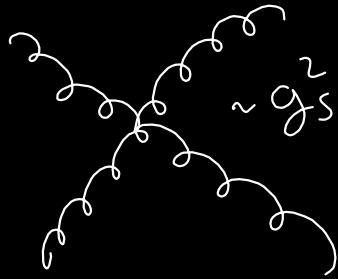
$$\text{EM} \begin{cases} Q > 0 \\ 0 > 0 \end{cases}$$

$$\text{STRONG} \begin{cases} Q_{\text{BLUE}} > 0, < 0 \\ Q_{\text{RED}} > 0, < 0 \\ Q_{\text{GREEN}} > 0, < 0 \end{cases}$$



EM $Q_\gamma = 0$

STRONG $Q_g \neq 0$



~~$e \sim 1.9 \times 10^{-19} C$~~

$e(Q)$

STRONG
INTERAC
TION



$g_s(Q)$

$e(Q=0)$

EM

$e(Q)$

STRONG
FORCE

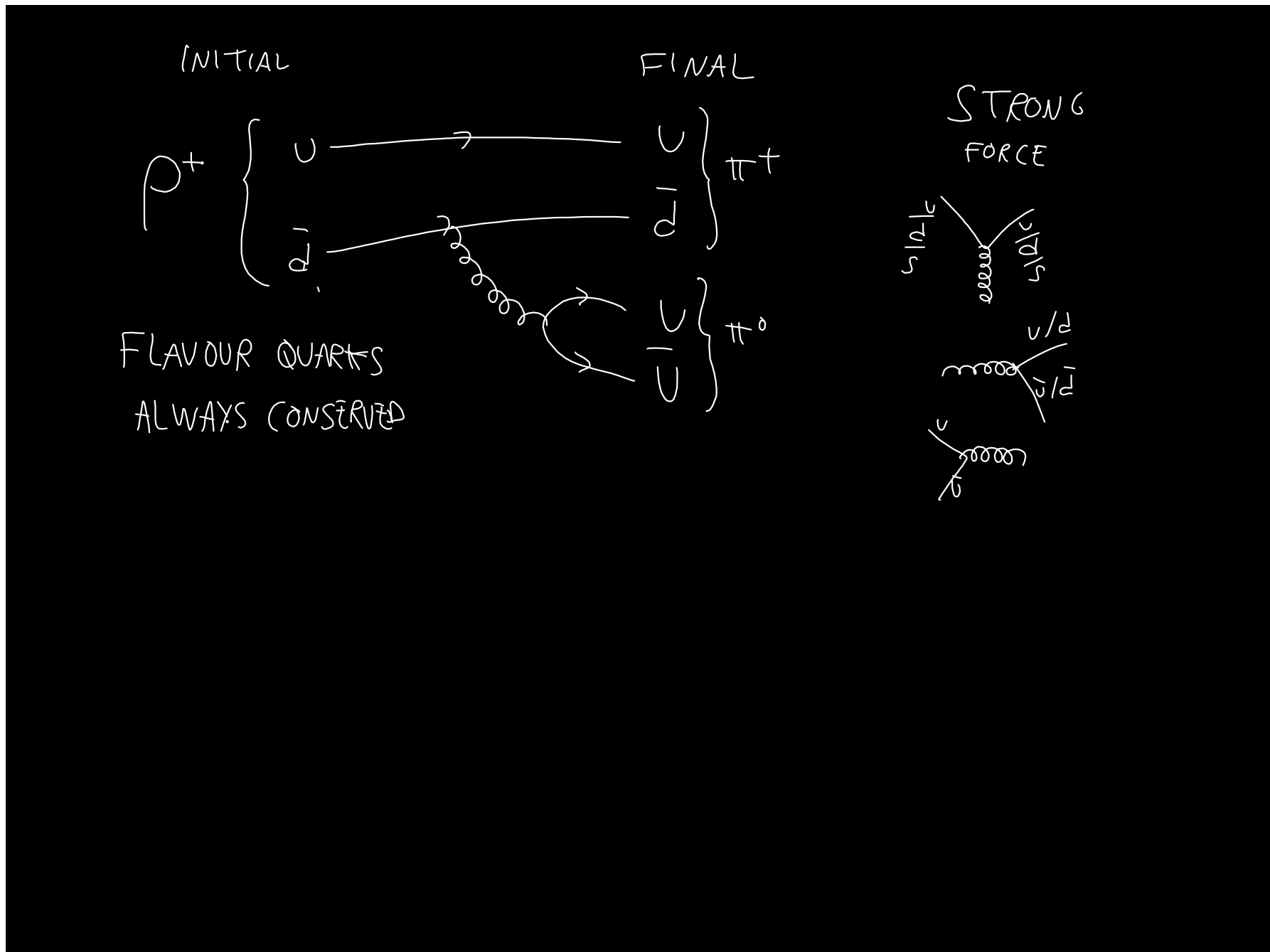
ENERGY
COLLISIONS

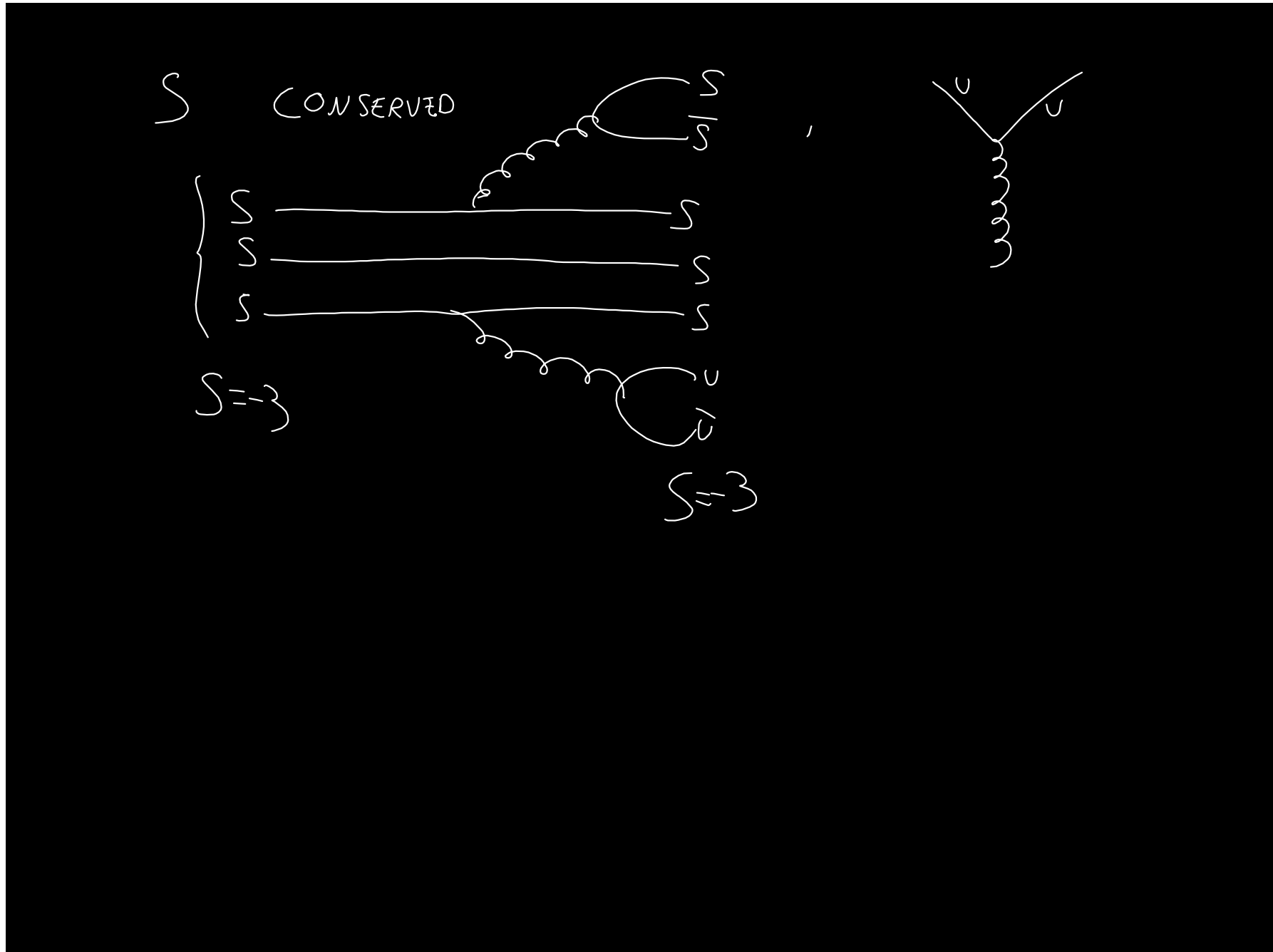
$$\rho^+ \longrightarrow \pi^+ + \pi^0$$

QUARK COMPOSITION

$$\rho^+ = (u \bar{d}) \quad \pi^+ = (u \bar{d}) \quad \pi^0 = \frac{1}{\sqrt{2}} \left(\begin{array}{c} u \bar{u} \\ d \bar{d} \end{array} \right)$$

$$(u \bar{d}) \longrightarrow (u \bar{d}) + (u \bar{u})$$





CONSERVED QUANTITIES

(SAME EM)

i) E, \vec{p}

ii) Q_e

iii) Q_{color}

iv) L_x, L_y, L_z

v) B

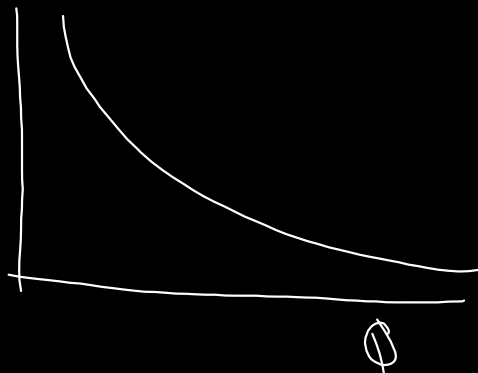
vi) S, C, γ

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$$P_{\delta}^{\wedge} = (E_{\delta/C}, \vec{P}_{\delta})$$

$$E_{\delta/C} = |\vec{P}_{\delta}|$$

$$|\vec{P}_{\delta}| = \sqrt{P_x^2 + P_y^2 + P_z^2}$$



$$|P_{\delta}^{\wedge}| = \sqrt{(E_{\delta/C})^2 - (\vec{P}_{\delta})^2} = 0 \Rightarrow m_{\delta}$$

WEAK INTERACTION

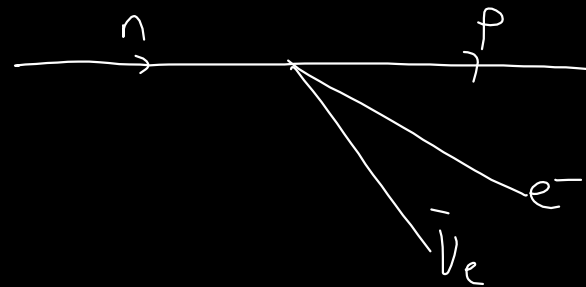
β -DECAY



$$Z \rightarrow Z+1$$

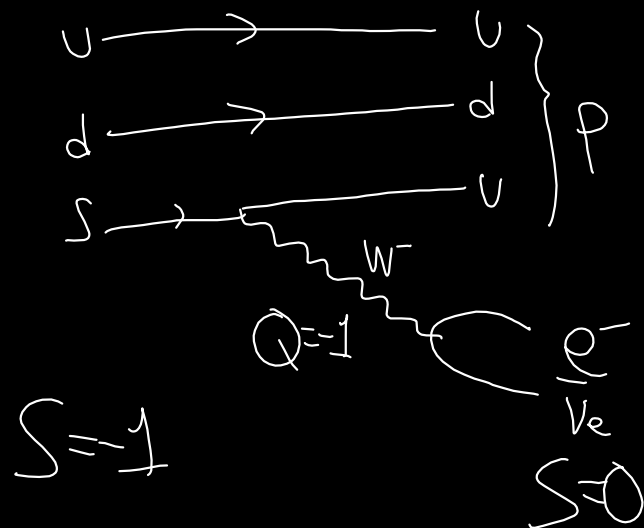
$$A \rightarrow A$$

$\nu_e, \nu_\mu, \nu_\tau \rightarrow$ CHARGED ONLY
VIA WEAK FORCE



$$n \rightarrow p + e^- + \bar{\nu}_e$$

$$(udd) \rightarrow (uud) + e^- + \bar{\nu}_e$$



W BOSON

WEAK FORCE

CAN CHANGE

QUARK FLAVOR

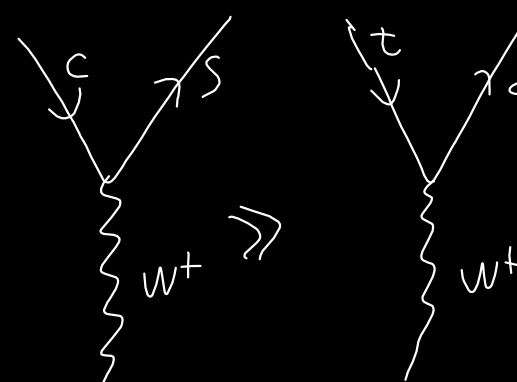
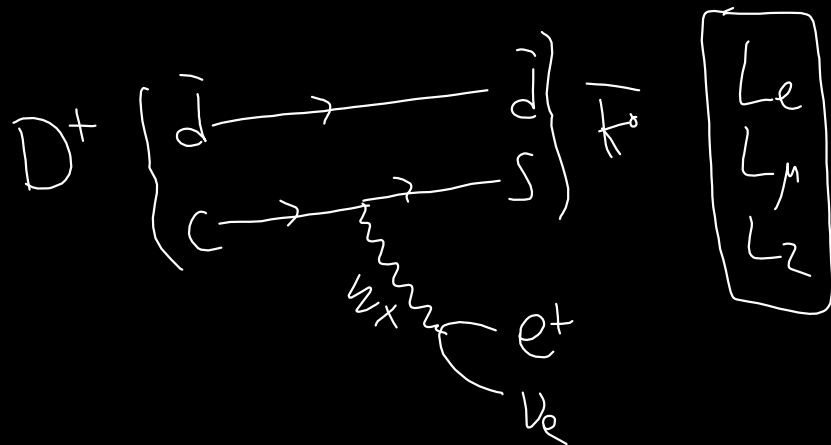
S, C, b

≠ CONSERVED

WEAK INT.

$$D^+ \rightarrow \bar{K}^0 + e^+ + \nu_e$$

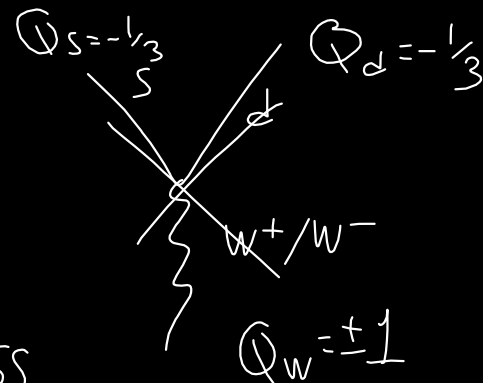
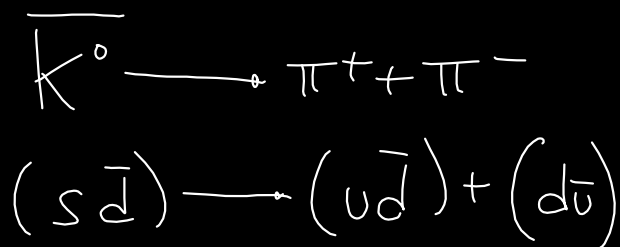
$$(c \bar{d}) \rightarrow (s \bar{d}) + e^+ + \nu_e$$



γ AND W^\pm

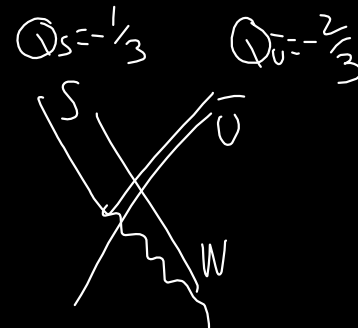
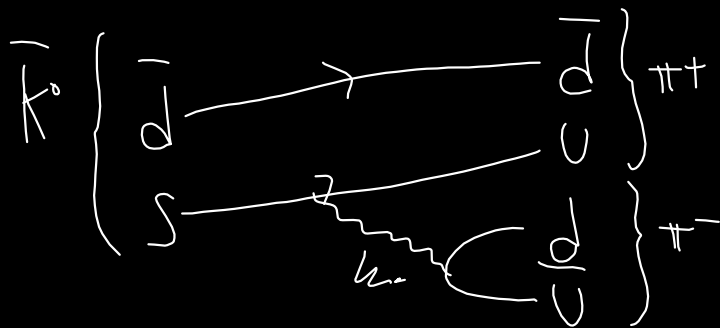
1) $Q_\gamma = 0$ $Q_{W^\pm} = \pm 1$

2) $m_\gamma = 0$ $m_W \sim 80 \text{ mp}$

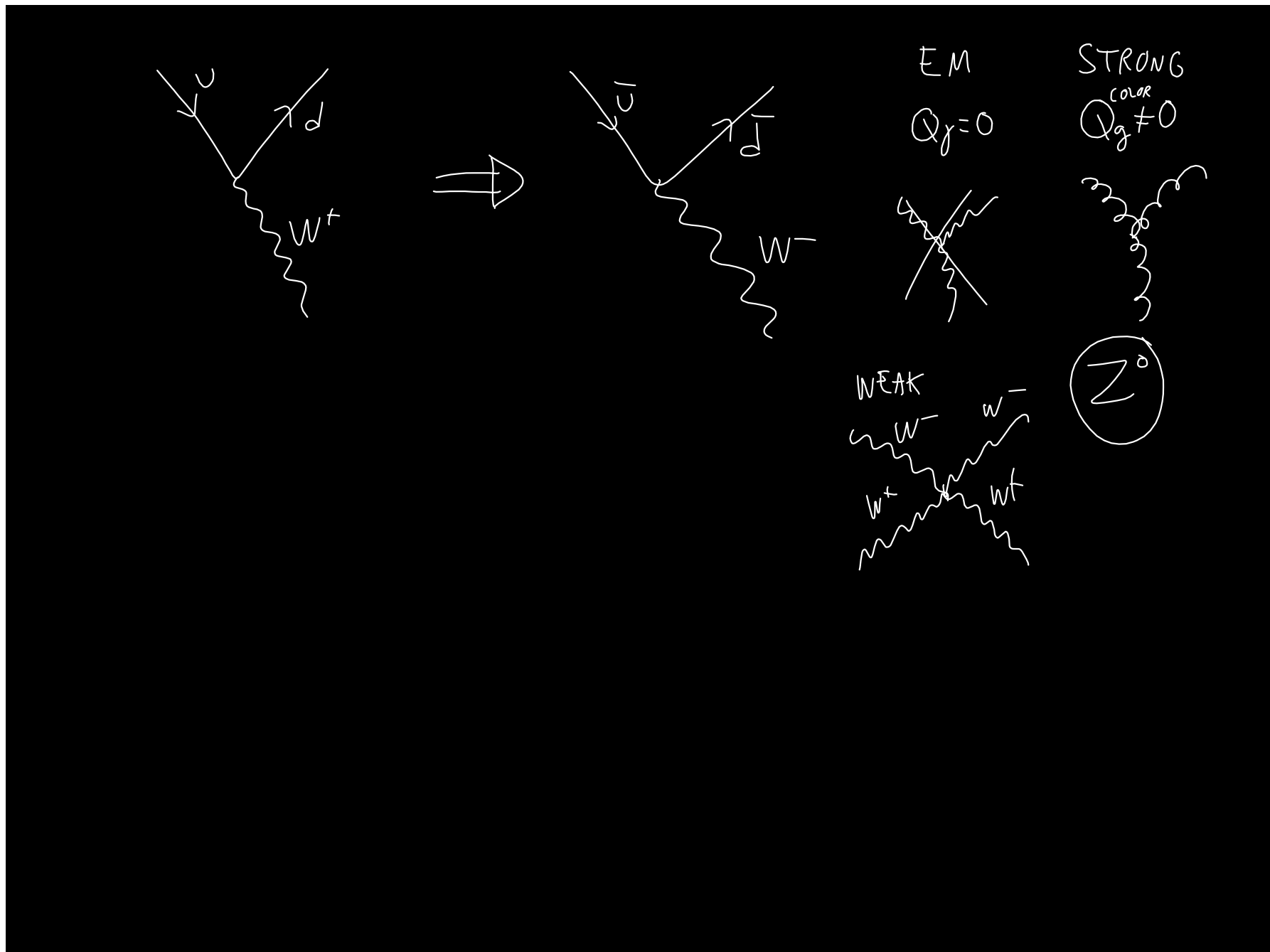


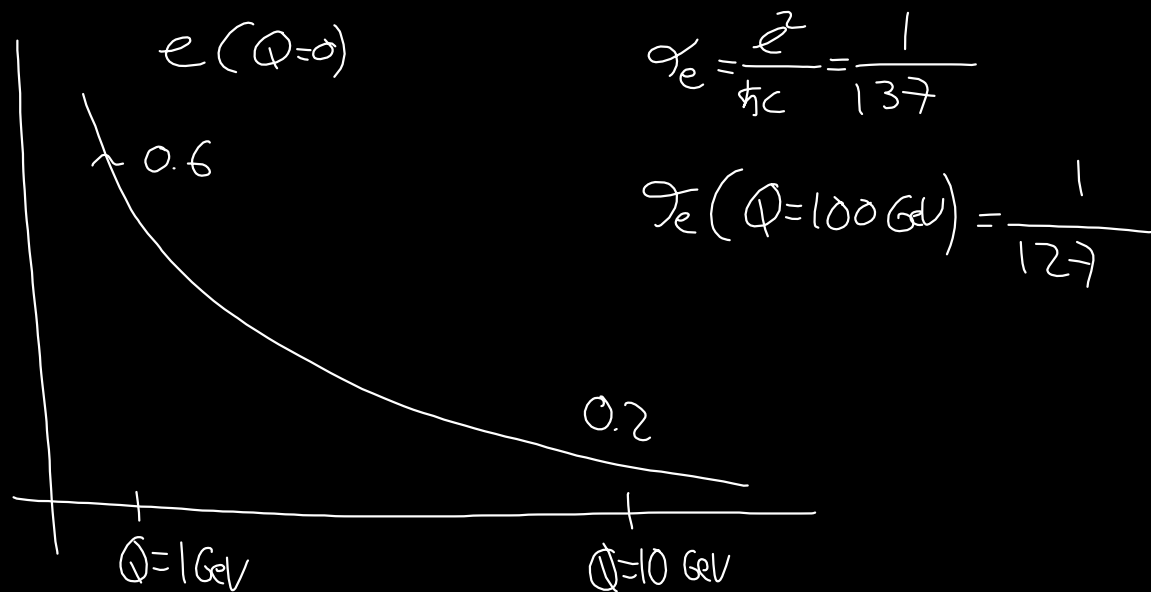
$S = -1$

$S = 0 \Rightarrow$ WEAK PROCESS



$Q_s = Q_{\bar{u}} + Q_W$
 $-1/3 = -2/3 + (-1)$





$$\Phi_y = 0 \quad (\text{ELECTRIC})$$

$$\Phi_y^{\text{COLOR}} = 0$$

$$\Phi_g = 0 \quad (\text{ELECTRIC})$$

$$\Phi_g^{\text{COLOR}} \neq 0$$

