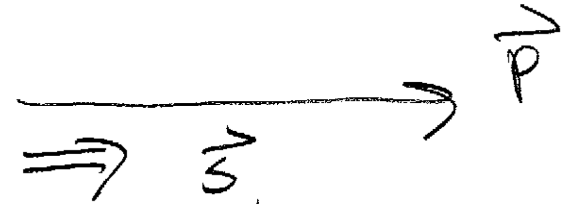
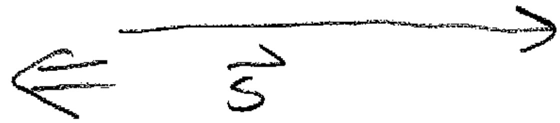
Basic Idea : only { left handed electron neutrino
{ right handed positron anti-neutrino

Participate in ~~weak~~ charged weak interaction

[Handedness only strictly correct in massless limit

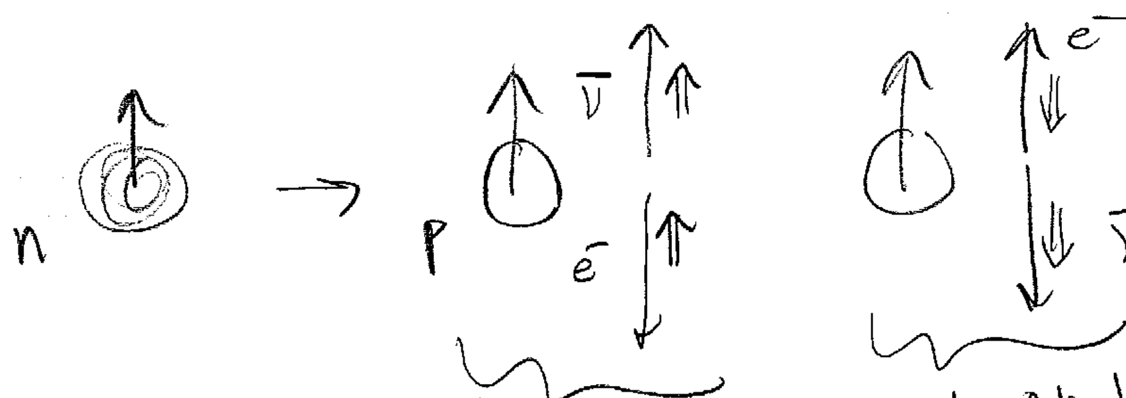


"Right Handed" .. if massless, cannot reverse direction of $\vec{p}$



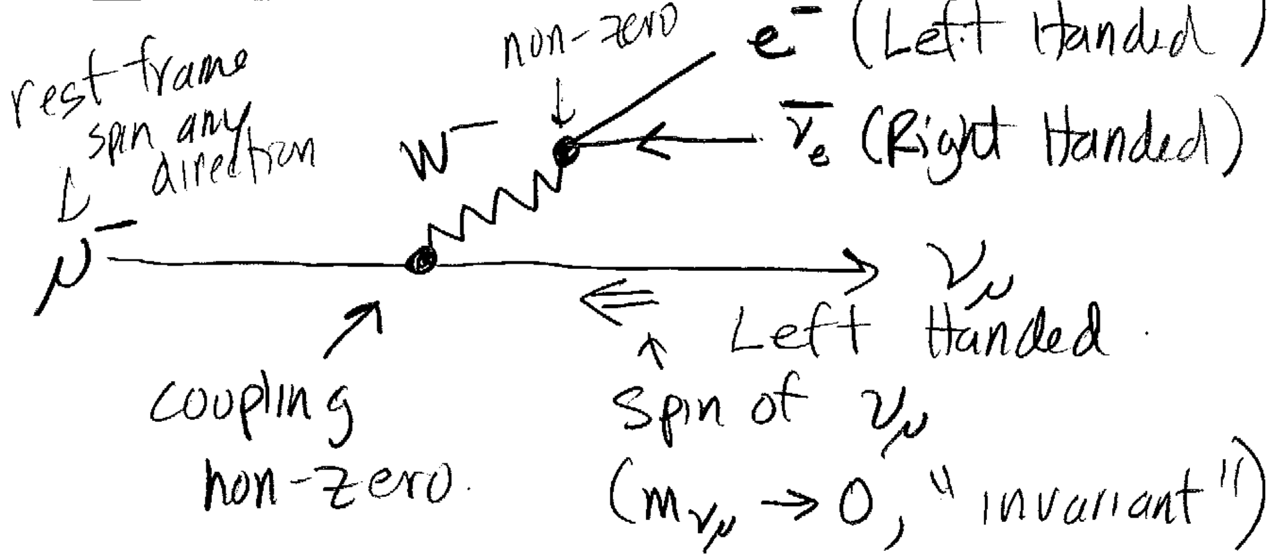
Massive : can be generalized]

Idea then (limit of $m_\nu \to 0$, $m_e \to 0$)



angular 3^{rd} component OK   not OK!

Heart of the Matter : Generalized

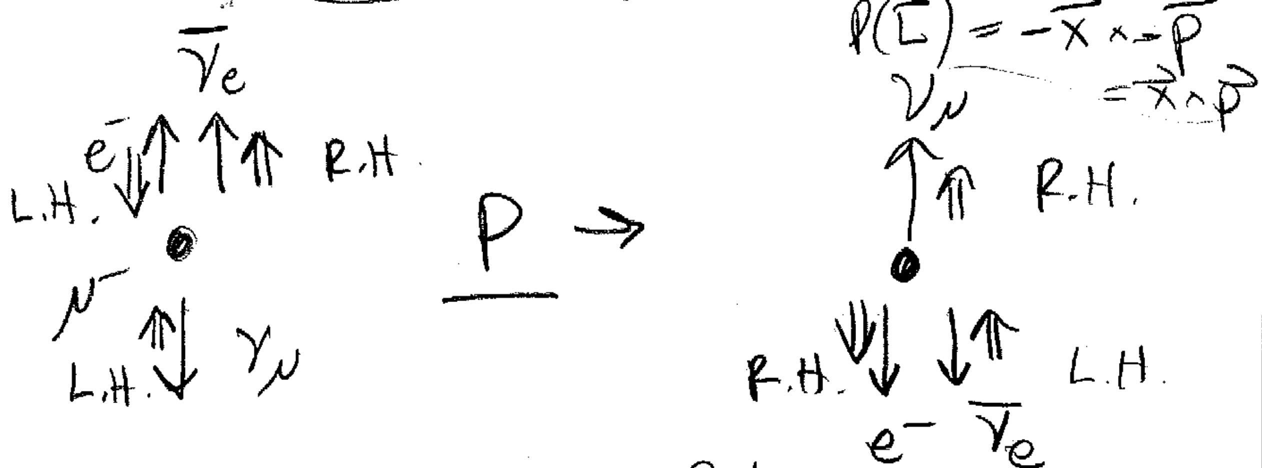


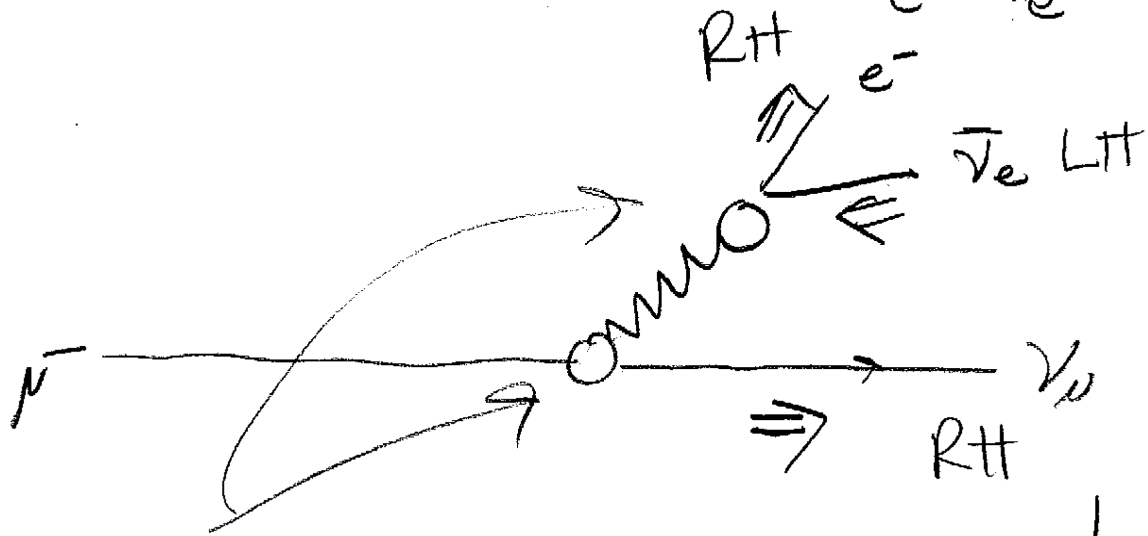
Parity Does Not Flip Spin Direction

Does Flip $\vec{p}$

$\vec{L} = \vec{x} \times \vec{p}$

$P(\vec{L}) = -\vec{x} \times -\vec{p} = \vec{x} \times \vec{p}$





COUPLINGS ALL ZERO!

Comment about neutrinos

$$i\hbar \frac{d}{dt} \begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix} = \underbrace{\begin{pmatrix} H_{ee} & H_{e\mu} \\ H_{\mu e} & H_{\mu\mu} \end{pmatrix}}\begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}$$

actually coefficients

$H_{ee} \propto m_{\nu_e} c^2$ (rest frame).

$H_{\mu\mu} \propto m_{\nu_\mu} c^2$

$\underbrace{\text{Maybe actually } 0,}$!

$H_{e\mu} \neq 0$!

consider

$$\underset{\sim}{H} = \begin{pmatrix} 0 & H_{e\mu} \\ H_{\mu e} & 0 \end{pmatrix} \propto H_{e\mu}\, \underset{\sim}{\sigma_x}$$

eigenvectors: $\begin{pmatrix} 1/\sqrt{2} \\ \pm 1/\sqrt{2} \end{pmatrix}$ $(\nu_1 + \nu_2)$

eigenvalues: $\underbrace{\pm H_{e\mu}}$

– mass ?, not allowed.

$\Rightarrow \begin{pmatrix} 0 & H \\ H & H \end{pmatrix}$ OK.

Discovered: $\tau - \theta$ puzzle.

(θ^+) $K^+ \to \pi^+ \pi^0$ $\quad P =$

? $\quad (-1)(-1)\left((-1)^{L=0}\right) \quad = +1$

(τ^+) $K^+ \to \pi^+ \pi^+ \pi^-$

$(-1)(-1)(-1) \quad -1$

Both happened! Lots of stories

$\underset{\sim}{C} \to$ Charge Conjugation.

takes matter $\Leftrightarrow$ antimatter.

$\underset{\sim}{C}|n\gamma\rangle = (-1)^n |n\gamma\rangle$] !!

$\underset{\sim}{C}|p\rangle = |\bar{p}\rangle$ $\quad p$ not an eigenstate

$\underset{\sim}{C}|\pi^0\rangle = \underbrace{\pm 1 |\pi^0\rangle}$

mesons, $(-1)^{l+s}$

angular $\quad$ spin

π^0: $l=0$, $s=0$

$\underset{\sim}{C}|\pi^0\rangle = |\pi^0\rangle$

ρ^0: $l=0$, $S=1$ $\quad C=-1$

Big deal: (E+M, Strong) respects $\underset{\sim}{C}$

$$[\underset{\sim}{H}_{em}, \underset{\sim}{C}] = 0$$

$$\underbrace{\pi^0}_{C=+1} \to \underbrace{\gamma\gamma}_{C=+1} \quad \text{or} \quad \underbrace{\gamma\gamma\gamma}_{C=-1}$$

$$\boxed{\pi^0 \to \gamma\gamma}$$

$\rho^0 \to 3\gamma$ yes

$\rho^0 \to \pi^0 \gamma$ yes

$\quad\ \ +1 \ -1$

$\boxed{\underset{\sim}{C}\underset{\sim}{P}}$ $\quad \underset{\sim}{C}|\nu_L\rangle = \underbrace{|\bar{\nu}_L\rangle}$

note $[\underset{\sim}{C}, \underset{\sim}{P}] = 0$ $\quad \underset{\sim}{C}|\bar{\nu}_R\rangle = |\nu_R\rangle$ do not particpate

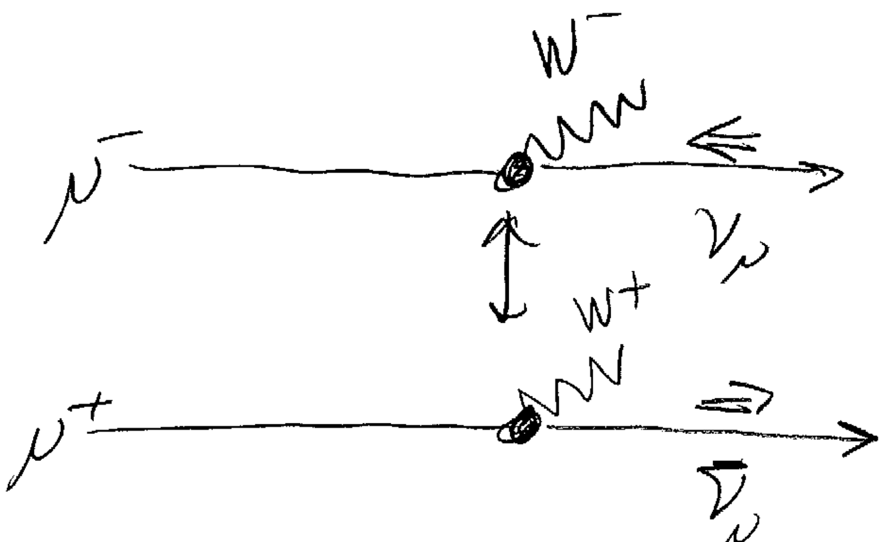
but $\underset{\sim}{C}\underset{\sim}{P}|\nu_L\rangle = \underset{\sim}{C}|\nu_R\rangle = |\bar{\nu}_R\rangle$

aha!

Idea: $[\underset{\sim}{H}_w, \underset{\sim}{P}] \neq 0 \neq [\underset{\sim}{H}_w, \underset{\sim}{C}]$

Maybe $[\underset{\sim}{H}_w, \underset{\sim}{C}\underset{\sim}{P}] = 0$

Idea:



Same strength? LANDAU ≈ 1959

$K^0 - \bar{K}^0$ System

made with Λ

$K^0 \rightarrow (\bar{s}\, d)$

$\bar{K}^0 \rightarrow (s\, \bar{d})$

(ack!)

$P = -1$ $\quad$ $P = +1$ $(L = 0)$

Dominant Decay: $K^0 \rightarrow \pi^+ \pi^-$