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What if $\phi_4 = v$?

$$\phi = \begin{pmatrix} 0 \\ iv \end{pmatrix} \frac{1}{\sqrt{2}}$$

$U(1)_Y \rightarrow$

$$\boxed{e^{i\alpha \frac{g'}{2} Y}} \psi$$

$$\partial_\mu \rightarrow \partial_\mu - \cancel{(\partial_\mu \alpha)}$$

$$\frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix} = e^{-i\pi/2} \begin{pmatrix} 0 \\ iv \end{pmatrix} \frac{1}{\sqrt{2}}$$

$$\alpha \frac{g'}{2} = -\frac{\pi}{2}$$

$$\underbrace{-\lambda_e \bar{\ell}_L \phi e_R}$$

$$-\lambda_e (\bar{\nu}_L \quad \bar{e}_L)\begin{pmatrix}\varphi^+ \\ \varphi^0\end{pmatrix} e_R$$

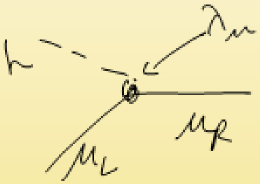
$$\xrightarrow{\text{EWSB}} -\lambda_e (\bar{\nu}_L \quad \bar{e}_L)\begin{pmatrix}0 \\ v + h(x)\end{pmatrix} e_R$$

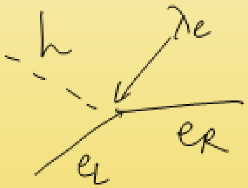
$$-\underbrace{\lambda_e v}\,\bar{e}_L e_R - \lambda_e \bar{e}_L h e_R$$

$m_e = \lambda_e v$

$m_\mu = \lambda_\mu v$

$\phi^\dagger \phi \phi^\dagger \phi$





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$$-\lambda_\nu \bar{l}_L \Phi^c \nu_R$$

$$-\lambda_\nu (\bar{\nu}_L \quad \bar{e}_L) \begin{pmatrix} v \\ 0 \end{pmatrix} \nu_R \quad + \; h.c$$

$$-(\lambda_\nu v)\, \bar{\nu}_L \nu_R$$

$$\boxed{\text{vev}}$$

$$v = 246 \text{ GeV}$$

$$\lambda_e \frac{v}{\sqrt{2}} = 0.5 \text{ MeV}$$

$$\lambda_e \longrightarrow \frac{\sqrt{2}}{500{,}000} \rightarrow \overset{0.3}{\cancel{0.9}} \times 10^{-6}$$

$$\lambda_t \longrightarrow \frac{175 \text{ GeV} \times \sqrt{2}}{246 \text{ GeV}} \sim 1$$

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$m_\nu = 1\ eV$

$\hookrightarrow \lambda_\nu \sim \frac{1\ eV \cdot \sqrt{2}}{246\ GeV}$

$\sim 10^{-11}$

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helicity

$\underline{\bar{\sigma} \cdot \hat{p}}$

$$\begin{pmatrix} \sigma \cdot \hat{p} & \\ & \sigma \cdot \hat{p} \end{pmatrix}$$

$\uparrow$

$\Sigma \cdot \hat{p}$

chirality

$\underline{\underline{\gamma^5}}$

~~left:~~ $\gamma^5 \psi = -\psi$

$$\gamma^5 e_L = -e_L$$

$$\gamma^5 \left(\frac{1-\gamma^5}{2} \right) e = \frac{\gamma^5 - 1}{2} e$$

$$= -e_L$$

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$$(C\gamma^0)\gamma^{\mu *}(-i\partial_\mu - gA_\mu \cancel{\mp m})\psi^* = 0$$

$$\boxed{-(C\gamma^0)\gamma^{\mu *} = \gamma^\mu (C\gamma^0)}$$

ignore this

$$\gamma^\mu (C\gamma^0)(i\partial_\mu + gA_\mu \cancel{\mp m})\psi^* = 0$$

$$\gamma^\mu (i\partial_\mu + gA_\mu \cancel{\mp m}) \cancel{\psi^* = 0} (C\gamma^0)\psi^*_i = 0$$

$$\gamma^\mu (i\partial_\mu + gA_\mu)\psi^c = 0$$

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$$- m_R \overline{\nu_R^c} \nu_R$$

$$\boxed{\nu_R^c = (\nu_R)^c}$$

$$\neq (\nu^c)_R$$

$$\overline{\nu_R^c} \cdot \nu_R = \left(\overline{\nu_R} \nu_R^c \right)^\dagger$$

$$\cancel{\nu_R^c = C\gamma^0 \nu_R^*}$$

$$\mathcal{L}$$

$$\hookrightarrow -\frac{1}{2} m_R \overline{\nu_R^c} \nu_R - \frac{1}{2} m_R \overline{\nu_R} \nu_R^c$$

$$-\frac{1}{2} m_R \overline{\nu_R^c} \nu_R + h.c$$

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$$-\frac{1}{2} m_R \underbrace{\bar{\nu}\,\nu}$$

$$\left(\bar{\nu}_R + \overline{\nu_R^c}\right)\left(\nu_R + \nu_R^c\right)$$

$$\cancel{\bar{\nu}_R \nu_R} + \overline{\nu_R^c}\,\nu_R + \bar{\nu}_R \nu_R^c + \cancel{\overline{\nu_R^c}\,\nu_R^c}$$