COMENZAMOS DE UN MODELO $SU(2)_1 \times SU(2)_2$ EL CUAL SE ROMPE A $SU(2)_L$ A TRAVÉS DE UN MECANISMO TIPO SIGMA NO LINEAL.

$$SU(2)_1 \times SU(2)_2 \xrightarrow{\Sigma \text{ CAMPO ESCALAR}} SU(2)_L$$

- TENEMOS 2 CAMPOS DE GAUGE A_1 + A_2 ESCRITOS EN LA REPRESENTACIÓN ADJUNTA
- 3 CAMPOS ESCALARES ϕ_1, ϕ_2, Σ

LOS CAMPOS TRANSFORMAN DE LA SIGUIENTE MANERA BAJO LA SIMETRÍA QUIRAL "$SU(2)_1 \times SU(2)_2$".

$$\phi_1 \to U_1 \phi_1 \qquad U_1 = e^{i\vec{\beta}_1 \cdot \vec{\tau}/2}$$

$$\phi_2 \to U_2 \phi_2 \qquad U_2 = e^{i\vec{\beta}_2 \cdot \vec{\tau}/2}$$

$$A_1 \to U_1 A_1 U_1^+ - \frac{i}{g_1}(\partial_\mu U_1) U_1^+$$

$$A_2 \to U_2 A_2 U_2^+ - \frac{i}{g_2}(\partial_\mu U_2) U_2^+$$

$$\Sigma \to U_1 \Sigma U_2^+$$

$$\mathcal{L}_{GAUGE} = -\frac{1}{4} A^1_{\mu\nu} A^{1\mu\nu} - \frac{1}{4} A^2_{\mu\nu} A^{2\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$$

$$\mathcal{L}_{ESCALAR} = -\frac{1}{2}\left(D_\mu \phi_1^+ D^\mu \phi_1\right) - \frac{1}{2}\left(D_\mu \phi_2^+ D^\mu \phi_2\right) - v^2 \mathrm{Tr}\left[D_\mu U^+ D^\mu U\right]$$
$$- \mu^2 \mathrm{Tr}[U^+ U] - \lambda \mathrm{Tr}[U^+ U U^+ U]$$

CON $\boxed{\Sigma = v U}$

$$\left.\begin{aligned} D_\mu \phi_1 &= \partial_\mu \phi_1 + \frac{i}{2} g_1 A_{1\mu} \phi_1 + \frac{i}{2} Y B_\mu \phi_1 \\ D_\mu \phi_2 &= \partial_\mu \phi_2 + \frac{i}{2} g_2 A_{2\mu} \phi_2 + \frac{i}{2} Y B_\mu \phi_1 \\ D_\mu \Sigma &= \partial_\mu \Sigma + \frac{i}{2} g_1 A_{1\mu} \Sigma + \frac{i}{2} g_2 \Sigma A_{2\mu} \end{aligned}\right\} \text{DERIVADAS COVARIANTES}$$

EN EL GAUGE UNITARIO $\langle U \rangle = \mathbb{1}$

$$D_\mu \Sigma \longrightarrow \cancel{\partial_\mu \mathbb{1}}^{\,0} + \frac{i}{2} g_1 A_1 \mathbb{1} + \frac{i}{2} g_2 \mathbb{1} A_2$$

$$v^2 \mathrm{Tr}\left[(D_\mu \Sigma)^+ (D^\mu \Sigma)\right] =$$

$$v^2 \mathrm{Tr}\left[\left(-\frac{i}{2} g_1 A_1 + \frac{i}{2} g_2 A_2\right)\left(\frac{i}{2} g_1 A_1 - \frac{i}{2} g_2 A_2\right)\right]$$

$$-\left(\frac{i}{2}\right)^2 v^2 \mathrm{Tr}\left[\left(g_1 A_1 - g_2 A_2\right)\left(g_1 A_1 - g_2 A_2\right)\right]$$

$$\frac{v^2}{4} \mathrm{Tr}\left[g_1 A_1 - g_2 A_2\right]^2$$ TERMINO DE MEZCLA.

LOS TERMINOS $\frac{\mu^2}{2} v^2 - \frac{\lambda}{4}(v^4)$ NO CONTRIBUYEN CON LA DINÁMICA

$$\boxed{\frac{M^2}{\cancel{\ }} \mathrm{Tr}\left[g_1 A_1 - g_2 A_2\right]^2_{ij}}$$

$$W_\mu = g_w \sum_i \frac{A_i}{g_i} = g_w\left(\frac{A_1}{g_1} + \frac{A_2}{g_2}\right) \quad \Big/ \quad \boxed{g_w^{-2} = g_1^{-2} + g_2^{-2}}$$

$$V_\mu = \sum_j v_{ij} A_j$$ v_{ij} = AUTOVECTORES ORTOGONALES A W_μ

$$\frac{1}{g_w^2} = \frac{1}{g_1^2} + \frac{1}{g_2^2} = \frac{g_2^2 + g_1^2}{g_1^2 g_2^2} \Rightarrow \boxed{g_w = \frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}}}$$

$$W_\mu = \frac{g_1 g_2}{\sqrt{g_1^2 + g_2^2}}\left(\frac{A_1}{g_1} + \frac{A_2}{g_2}\right)$$

$$= A_1 \underbrace{\frac{g_2}{\sqrt{g_1^2 + g_2^2}}}_{\cos\theta} + \underbrace{\frac{g_1}{\sqrt{g_1^2 + g_2^2}}}_{\mathrm{sen}\,\theta} A_2 \quad \therefore \quad \boxed{W_\mu = A_1 \cos\theta + A_2\, \mathrm{sen}\,\theta}$$

EL AUTOESTADO ORTOGONAL A W_μ ES

$$V_\mu = -A_1 \operatorname{sen}\theta + A_2 \cos\theta .$$

$$W_\mu \cdot V_\mu = -\operatorname{sen}\theta\cos\theta \cancel{A_1^2}^{1} + \cancel{A_2^2}^{1} \operatorname{sen}\theta\cos\theta . = 0$$

$$\begin{bmatrix} A_1 \\ A_2 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\operatorname{sen}\theta \\ \operatorname{sen}\theta & \cos\theta \end{bmatrix} \begin{bmatrix} W_\mu \\ V_\mu \end{bmatrix}$$

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$\ast$

$W_\mu \cdot \rightarrow$ CAMPO DE GAUGE QUE TRANSFORMA BAJO EL GRUPO $SU(2)_L$

$$W_\mu \rightarrow U_L W_\mu U_L^\dagger - \frac{i}{g_W}(\partial_\mu U_L)U_L^\dagger$$

$V_\mu \rightarrow$ CAMPO DE MATERIA EN LA REP. ADJUNTA.

$$V_\mu \rightarrow U_L W_\mu U_L^\dagger \qquad U_L \rightarrow e^{i\vec{\beta}_L \cdot \vec{\tau}/2}.$$

$$D_\mu \phi_1 = \partial_\mu \phi_1 + \frac{i}{2} g_1 (\cos\theta W_\mu - \operatorname{sen}\theta V_\mu) + \frac{i}{2} Y B_\mu \phi_1$$

$$D_\mu \phi_2 = \partial_\mu \phi_2 + \frac{i}{2} g_2 (\operatorname{sen}\theta W_\mu + \cos\theta V_\mu) + \frac{i}{2} Y B_\mu \phi_2$$

$$D_\mu \phi_1 = \partial_\mu \phi_1 + \frac{i}{2}\left(\frac{g_1 g_2}{\sqrt{}} W_\mu - \frac{g_1^2}{\sqrt{}} V_\mu\right) + \frac{i}{2} B_\mu Y \phi_1$$

$$\boxed{D_\mu \phi_1 = \partial_\mu \phi_1 + \frac{i}{2} g_W W_\mu - \frac{i}{2} g_W \frac{g_1}{g_2} V_\mu + \frac{i}{2} B_\mu Y \phi_1}$$

SI $g_2 \gg g_1$ ESTE ACOPLAMIENTO ES DÉBIL.

$$\boxed{D_\mu \phi_2 = \partial_\mu \phi_2 + \frac{i}{2} g_W W_\mu + g_W \frac{g_2}{g_1} V_\mu + \frac{i}{2} Y B_\mu \phi_1}$$

ACOPLAMIENTO FUERTE.

TERMINO

$$\frac{M^2}{4} \mathrm{Tr}\left[g_1 A_1 - g_2 A_2\right]^2$$

$$\frac{x}{\sqrt{x}} = x^1 x^{-1/2} = x^{1/2}$$

$$= g_1 A_1 - g_2 A_2$$

$$= g_1 (W_\mu \cos\theta - V_\mu \operatorname{sen}\theta) - g_2 (+W_\mu \operatorname{sen}\theta + V_\mu \cos\theta)$$

$$= g_1 \cos\theta\, W_\mu - g_1 \operatorname{sen}\theta\, V_\mu - g_2 \operatorname{sen}\theta\, W_\mu - g_2 \cos\theta\, V_\mu$$

$$= \left(\cancel{\frac{g_1 g_2}{\sqrt{\ }} - \frac{g_2 g_1}{\sqrt{\ }}}^{\,0}\right) W_\mu - \left(\frac{g_1^2}{\sqrt{\ }} + \frac{g_2^2}{\sqrt{\ }}\right) V_\mu$$

$$= -\left(\frac{g_1^2 + g_2^2}{\sqrt{g_1^2 + g_2^2}} V_\mu\right) = -\sqrt{g_1^2 + g_2^2}\, V_\mu = -\frac{g_1 g_2}{g_w} V_\mu$$

$$\boxed{\frac{M^2}{4} \mathrm{Tr}\left[\frac{g_1 g_2}{g_w} V_\mu\right]^2}$$

SOLO V_μ TIENE UN TERMINO EXPLICITO DE MASA.

LA MATRIZ DE MASA QUEDA. (SOLO ϕ_1 ADQUIERE VEV).

$$D_\mu \phi_1 = \partial_\mu \phi_1 + \frac{i}{2} g_w W_\mu \phi_1 - g_w \frac{g_1}{g_2} V_\mu \phi_1 + \frac{i}{2} Y B_\mu \phi_1 g_Y$$

$$W_\mu = \begin{bmatrix} W_\mu^3 & \sqrt{2} W_\mu^+ \\ \sqrt{2} W_\mu^- & +W_\mu^3 \end{bmatrix} \qquad V_\mu = \begin{bmatrix} V_\mu^3 & \sqrt{2} V_\mu^+ \\ \sqrt{2} V_\mu^- & -V_\mu^3 \end{bmatrix}$$

M_{NEUTRA} / BASE W_μ^3, V_μ^3, B_μ

$$\underbrace{\begin{bmatrix} \frac{g_w^2 v^2}{4} & -\frac{g_1 g_w^2 v^2}{4 g_2} & -\frac{g_w v^2}{4} g_Y \\ -\frac{g_1 g_w^2 v^2}{4 g_2} & \frac{g_1^2 g_w^2 v^2}{4 g_2^2} & \frac{g_1 g_w g_Y v^2}{4 g_2} \\ -\frac{g_w v^2}{4} g_Y & \frac{g_1 g_w g_Y v^2}{4 g_2} & \frac{g_Y^2 v^2}{4} \end{bmatrix}}_{\text{DERIV. COVARIANTE}} + \underbrace{\begin{bmatrix} 0 & 0 & 0 \\ 0 & \left(\frac{g_1 g_2}{g_w}\right)^2 \frac{M^2}{4} & 0 \\ 0 & 0 & 0 \end{bmatrix}}_{\text{TRAZA.}}$$