

THE STANDARD MODEL LAGRANGIAN
for broken $U(1) \times SU(2) \times SU(3)$

$$\mathcal{L}_{SM} = \mathcal{L}_{Boson} + \mathcal{L}_{Lepton} + \mathcal{L}_{Quark}$$

$$\mathcal{L}_{Boson} =$$

$$\begin{aligned} & - \frac{1}{4} (\partial_\alpha A_\beta - \partial_\beta A_\alpha)^2 - \frac{1}{4} (\partial_\alpha Z_\beta - \partial_\beta Z_\alpha)^2 - \frac{1}{2} (\partial_\alpha W_\beta^- - \partial_\beta W_\alpha^-) (\partial_\alpha W_\beta^+ - \partial_\beta W_\alpha^+) \\ & + ig \left\{ (\partial_\alpha W_\beta^+ - \partial_\beta W_\alpha^+) W_\beta^- - (\partial_\alpha W_\beta^- - \partial_\beta W_\alpha^-) W_\beta^+ \right\} (\cos \vartheta_W Z_\alpha + \sin \vartheta_W A_\alpha) \\ & + ig (W_\alpha^+ W_\beta^- - W_\alpha^- W_\beta^+) \partial_\beta (\cos \vartheta_W Z_\alpha + \sin \vartheta_W A_\alpha) \\ & + g^2 \left\{ W_\beta^+ W_\alpha^- (\cos \vartheta_W Z_\alpha + \sin \vartheta_W A_\alpha) - W_\alpha^+ W_\beta^- (\cos \vartheta_W Z_\beta + \sin \vartheta_W A_\beta) \right\} (\cos \vartheta_W Z_\beta + \sin \vartheta_W A_\beta) \\ & + \frac{1}{2} g^2 W_\beta^- W_\alpha^+ (W_\beta^- W_\alpha^+ - W_\alpha^+ W_\beta^-) - \frac{1}{4} (\partial_\alpha G_\beta^a - \partial_\beta G_\alpha^a + g_s f^{abc} G_\alpha^b G_\beta^c)^2 \\ & + \frac{1}{2} \partial_\alpha \Phi \partial_\alpha \Phi + M_W^2 W_\alpha^- W_\alpha^+ + \frac{1}{2} M_Z^2 Z_\alpha Z_\alpha + \frac{1}{4} g^2 (2\nu\Phi + \Phi^2) W_\alpha^- W_\alpha^+ \\ & + \frac{1}{8} \frac{g^2}{\cos^2 \vartheta_W} (2\nu\Phi + \Phi^2) Z_\alpha Z_\alpha - \frac{1}{2} M_\Phi^2 \Phi^2 - \frac{\sigma}{4} (4\nu\Phi^3 + \Phi^4) \end{aligned}$$

$$\mathcal{L}_{Lepton} = \sum_{3 \text{ generations, } g} i \bar{e}^g \gamma_\alpha \partial e^g + i \bar{\nu}^g \gamma_\alpha \partial \nu^g + e \bar{e}^g \gamma_\alpha e^g A_\alpha$$

$$- \frac{g}{2 \cos \vartheta_W} Z_\alpha \left\{ \bar{\nu}^g \gamma_\alpha \frac{1}{2} (1 - \gamma_5) \nu^g + \bar{e}^g \gamma_\alpha (2 \sin^2 \vartheta_W - \frac{1}{2} (1 - \gamma_5)) e^g \right\}$$

$$- \frac{g}{\sqrt{2}} \left\{ \bar{\nu}^g \gamma_\alpha \frac{1}{2} (1 - \gamma_5) e^g W_\alpha^+ + \bar{e}^g \gamma_\alpha \frac{1}{2} (1 - \gamma_5) \nu^g W_\alpha^- \right\}$$

$$- \left(1 + \frac{\Phi}{\nu} \right) M^g \bar{e}^g e^g$$

$$\mathcal{L}_{Quark} = \sum_g \sum_{3 \text{ colours, } c} i \bar{u}_c^g \gamma_\alpha \partial u_c^g + i \bar{d}_c^g \gamma_\alpha \partial d_c^g - e A_\alpha \left(\frac{2}{3} \bar{u}_c^g \gamma_\alpha u_c^g - \frac{1}{3} \bar{d}_c^g \gamma_\alpha d_c^g \right)$$

$$- g_s \bar{u}_c^g \gamma_\alpha \left(\frac{1}{2} T^a G_\alpha^a \right)_{cd} u_d^g - g_s \bar{d}_c^g \gamma_\alpha \left(\frac{1}{2} T^a G_\alpha^a \right)_{cd} d_d^g$$

$$- \frac{g}{2 \cos \vartheta_W} Z_\alpha \left\{ \bar{u}_c^g \gamma_\alpha \left(\frac{1}{2} (1 + \gamma_5) - \frac{4}{3} \sin^2 \vartheta_W \right) u_c^g + \bar{d}_c^g \gamma_\alpha \left(-\frac{1}{2} (1 + \gamma_5) + \frac{2}{3} \sin^2 \vartheta_W \right) d_c^g \right\}$$

$$- \frac{g}{\sqrt{2}} \left\{ \bar{u}_c^g \gamma_\alpha \frac{1}{2} (1 - \gamma_5) V_{gf} d_c^f W_\alpha^+ + \bar{d}_c^g \gamma_\alpha \frac{1}{2} (1 - \gamma_5) V_{gf}^\dagger u_c^f W_\alpha^- \right\}$$

$$- \left(1 + \frac{\Phi}{\nu} \right) \left\{ M_{up}^g \bar{u}_c^g u_c^g + M_{down}^g \bar{d}_c^g d_c^g \right\}$$

Coded in DERIVE:

Standard Lagrangian 29/11/90

[BOSON3.MTH](#)

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