Standart Model

- Kontravaryant vektör: $x^{\mu} = (t, x, y, z)$

$$p^{\mu} = (E, p_x, p_y, p_z)$$

- Kovaryant vektör: $x_{\mu} = (t, -x, -y, -z)$

$$p_{\mu} = (E, -p_x, -p_y, -p_z)$$

- Fermiyon dalga fonkisyonu: $\psi(\vec{x}, t) = u(p)e^{-ipx}$
- Vektör bozon dalga fonksiyonu: $A^{\mu}(\vec{x}, t) = \varepsilon^{\mu}(p)e^{-ipx}$
- Skaler bozon dalga fonksiyonu: $\phi(\vec{x}, t) = 1e^{-ipx}$
- Dirac Denklemi: $(i\gamma^{\mu}\partial_{\mu} - m)\psi = 0$
- Klein-Gordon Denklemi: $(\partial^{\mu}\partial_{\mu} + m^2)\psi = 0$

Standart Model

- *Ayar Grubu*:

$$SU(3)_C \times SU(2)_L \times U(1)_Y \Rightarrow SU(3)_C \times U(1)_{em}$$

- Güçlü etkileşme: $SU(3)_C,\quad 8\,\mathrm{Gluon:G^a},\ 1-8,\ \mathrm{kuplaj\ sabiti:g_s} = g_3$
- Zayıf etkileşme: $SU(2)_L$, 3 tane ayar bozonu: $W^{\pm} = (W^1 \mp iW^2)/\sqrt{2}$,
  kuplaj sabiti: $\mathrm{g} = \mathrm{g}_2$
- Hiperyük etkileşme: $U(1)_Y$, 1 tane ayar bozonu: B, kuplaj sabiti: $\mathrm{g}' = \mathrm{g}_1$

$$\alpha_i = \frac{g_i^2}{4\pi} \quad i = 1,2,3.$$

Standart Model

- Elektro-Zayıf Birleşme (karışım): $SU(2)_L \times U(1)_Y$

$$A^0 = \cos\theta_W B + \sin\theta_W W^3$$

$$Z^0 = -\sin\theta_W B + \cos\theta_W W^3$$

$$e = \cos\theta_W g_1 = \sin\theta_W g_2,$$

$$\sin^2\theta_W = \frac{g'^2}{g'^2 + g^2},$$

$$\alpha_{em} = \frac{e^2}{4\pi},$$

$$Q = \frac{Y}{2} + I_3$$

Standart Model

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Fermiyonlar	I^W	I_3^W	Y	Q
$\begin{pmatrix} \nu_e \\ e \end{pmatrix}_L \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}_L \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}_L$	$\frac{1}{2}$	$\begin{pmatrix} 1/2 \\ -1/2 \end{pmatrix}$	-1	$\begin{pmatrix} 0 \\ -1 \end{pmatrix}$
e_R, μ_R, τ_R	0	0	-2	-1
$\begin{pmatrix} u \\ d \end{pmatrix}_L \begin{pmatrix} c \\ s \end{pmatrix}_L \begin{pmatrix} t \\ b \end{pmatrix}_L$	$\frac{1}{2}$	$\begin{pmatrix} 1/2 \\ -1/2 \end{pmatrix}$	$\frac{1}{3}$	$\begin{pmatrix} 2/3 \\ -1/3 \end{pmatrix}$
u_R, c_R, t_R	0	0	$\frac{4}{3}$	$+\frac{2}{3}$
d_R, s_R, b_R	0	0	$-\frac{2}{3}$	$-\frac{1}{3}$

Standart Model

- Standart Model Lagranjiyeni:

$$L = \sum_f \overline{\psi}_f \gamma^\mu i D_\mu \psi_f - \frac{1}{4} B_{\mu\nu} B^{\mu\nu} - \frac{1}{4} W^i_{\mu\nu} W^{i\mu\nu} - \frac{1}{4} G^a_{\mu\nu} G^{a\mu\nu}$$

$$+ (D_\mu \phi)^\dagger (D_\mu \phi) - \mu^2 \phi^\dagger \phi - \lambda (\phi^\dagger \phi)^2$$

$$- \frac{\sqrt{2}\mu^2}{\lambda} \sum_{f,f'} \mathrm{M}_{ff'} (\overline{\psi}_{Lf} \phi \psi_{Rf'} + \overline{\psi}_{Rf'} \phi^\dagger \psi_{Lf})$$

$$D_\mu = \partial_\mu + ig' \frac{Y}{2} B_\mu + ig \frac{\tau^i}{2} W^i_\mu + ig_s \frac{\lambda^a}{2} G^a_\mu ,$$

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu + g f^{abc} A^b_\mu A^c_\nu$$

$$f^{abc} = 0 \rightarrow U(1)$$

Standart Model

- Lagranjiyenin Higgs kısmı:

$$L_H = (D_\mu \phi)^\dagger (D_\mu \phi) - V$$

$$V = \mu^2 \phi^\dagger \phi - \lambda (\phi^\dagger \phi)^2$$

$$\phi^\dagger \phi = -\frac{\mu^2}{2\lambda} = \frac{\mathrm{v}^2}{2}$$

$$\phi^\dagger \phi = \begin{pmatrix} \phi^\dagger \\ \phi^0 \end{pmatrix} \Rightarrow \frac{1}{\sqrt{2}} \begin{pmatrix} (\phi_1 + i\phi_2) \\ (\mathrm{v} + \mathrm{h} + \mathrm{i}\phi_3) \end{pmatrix}$$

$$M_W = \frac{\mathrm{gv}}{2} \qquad M_h = \sqrt{2\lambda}\,\mathrm{v}$$

$$M_Z = \frac{\mathrm{v}\sqrt{\mathrm{g}^2 + g'^2}}{2}$$

Standart Model

$$L_H = \frac{1}{2}(\partial_\mu H)^2 + \mu^2 H^2 + \frac{g^2 v^2}{4} W^{+\mu} W_\mu^- + \frac{g^2 v^2}{8\cos^2\theta_W} Z_\mu Z\mu$$

$$+ etkilesme\ terimleri$$