

IL PROCESSO $e^+e^- \rightarrow \mu^+\mu^-$ IN APPROSSIMAZIONE DI BORN NEL MODELLO STANDARD

MARIO CIACCO
MATRICOLA 835681

ABSTRACT

I INTRODUZIONE

$$|\mathcal{M}|^2 = |\mathcal{M}_1 + \mathcal{M}_2 + \mathcal{M}_3 + \mathcal{M}_4|^2 \quad (1)$$

II L'INTERAZIONE CON IL CAMPO SCALARE

$$\mathcal{L}_s = (D_\mu \Phi)^\dagger D^\mu \Phi + \frac{\lambda}{4!} (|\Phi|^2 + F^2)^2, \quad \lambda > 0 \quad (2)$$

$$\Phi = \begin{pmatrix} 0 \\ F \end{pmatrix} + \begin{pmatrix} \phi_1 \\ \phi_2 \end{pmatrix} = \begin{pmatrix} 0 \\ F \end{pmatrix} + \frac{1}{\sqrt{2}} \begin{pmatrix} \sqrt{2}\phi_1 \\ H + i\phi^0 \end{pmatrix} \quad (3)$$

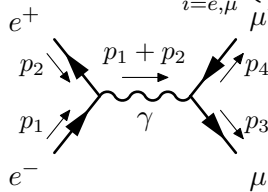
$$\mathcal{L}_{sf} = \sum_{i=e,\mu} y_i \bar{\psi}_{i,L} \Phi \psi_{i,R} + h.c. \quad (4)$$

$$y_j = \frac{1}{\sqrt{2}} g \frac{m_j}{M_W} \quad (5)$$

$$\begin{aligned} \mathcal{L}_{sf} &\Rightarrow \frac{y_j}{\sqrt{2}} (\bar{\nu}_j \quad \bar{\ell}_j) \begin{pmatrix} 1+\gamma^5 \\ 2 \end{pmatrix} \begin{pmatrix} - \\ \sqrt{2}F + H + i\phi^0 \end{pmatrix} \begin{pmatrix} 1+\gamma^5 \\ 2 \end{pmatrix} \ell_j + h.c. \\ &= y_j \bar{\ell}_j F \ell_j + \frac{y_j}{\sqrt{2}} \bar{\ell}_j H \ell_j + i \frac{y_j}{\sqrt{2}} \bar{\ell}_j \gamma^5 \phi^0 \ell_j \end{aligned} \quad (6)$$

$$\frac{m_\mu}{M_W} \simeq 10^{-3} \quad (7)$$

III LA SEZIONE D'URTO DIFFERENZIALE

$$\mathcal{L}_{nc} = \sum_{i=e,\mu} \left\{ \frac{g}{4 \cos \theta_W} \bar{\ell}_i \gamma^\mu (4 \sin^2 \theta_W - 1 + \gamma^5) \ell_i Z_\mu - e \bar{\ell}_i \gamma^\mu \ell_i A_\mu \right\} \quad (8)$$


$$\Rightarrow \mathcal{M}_1 = (-ie)^2 \bar{v}(p_1) \gamma^\mu u(p_2) \frac{-ig_{\mu\nu}}{(p_1 + p_2)^2} \bar{u}(p_3) \gamma^\nu v(p_4)$$

$$\begin{aligned} \frac{1}{4} \sum_{Spin} |\mathcal{M}_1|^2 &= \frac{1}{4} e^4 \frac{1}{(p_1 + p_2)^2} \text{tr}\{(\not{p}_2 + m_e) \gamma^\nu (\not{p}_1 - m_e) \gamma^\mu\} \\ &\quad \times \text{tr}\{(\not{p}_4 - m_\mu) \gamma_\nu (\not{p}_3 + m_\mu) \gamma_\mu\} \end{aligned} \quad (9)$$

$$\frac{1}{4} \sum_{Spin} |\mathcal{M}_1|^2 = \frac{2e^4}{s^2} \{(u - m_e^2 - m_\mu^2)^2 + (t - m_e^2 - m_\mu^2)^2 + 2(m_e^2 + m_\mu^2)s\} \quad (10)$$

$$\Rightarrow \mathcal{M}_2 = \left(\frac{ig}{4c}\right)^2 \bar{v}(p_1)\gamma^\mu(V+\gamma^5)u(p_2) \frac{-ig_{\mu\nu}}{(p_1+p_2)^2 - M_Z^2} \bar{u}(p_3)\gamma^\nu(V+\gamma^5)v(p_4)$$

$$\begin{aligned} \frac{1}{4} \sum_{Spin} |\mathcal{M}_2|^2 &= 2 \left(\frac{g}{4c}\right)^4 \frac{1}{(s - M_Z^2)^2} \{ [(V^2 + 1)^2 + 4V^2](u - m_e^2 - m_\mu^2)^2 \\ &\quad + [(V^2 + 1)^2 - 4V^2](t - m_e^2 - m_\mu^2)^2 \\ &\quad + 2(V^4 - 1)[(m_\mu^2 + m_e^2)s - 4m_\mu^2 m_e^2] \\ &\quad + 8m_\mu^2 m_e^2 (V^2 - 1)^2 \} \end{aligned} \quad (11)$$

$$\begin{aligned} \frac{1}{4} \sum_{Spin} \mathcal{M}_1 \mathcal{M}_2^\dagger &= 2e^2 \left(\frac{g}{4c}\right)^2 \frac{1}{s(s - M_Z^2)} \{ (V^2 + 1)(u - m_e^2 - m_\mu^2)^2 \\ &\quad + (V^2 - 1)(t - m_e^2 - m_\mu^2)^2 \\ &\quad + 2V^2(m_e^2 + m_\mu^2)s \} \end{aligned} \quad (12)$$

$$\begin{aligned} \frac{d\sigma}{dt} &= (2\pi)^{4-6} \cdot F \cdot \int dPS_{2 \rightarrow 2} \cdot \frac{1}{4} \sum_{Spin} |\mathcal{M}|^2 \\ &= \frac{1}{(2\pi)^2} \cdot \frac{1}{2\sqrt{s(s - 4m_e^2)}} \cdot \frac{\pi}{2\sqrt{s(s - 4m_\mu^2)}} \cdot \frac{1}{4} \sum_{Spin} \{ |\mathcal{M}_1|^2 + |\mathcal{M}_2|^2 + 2\mathcal{M}_1 \mathcal{M}_2^\dagger \} \end{aligned} \quad (13)$$

IV L'AMPIEZZA DEL DIAGRAMMA CON LINEA INTERNA DI HIGGS

$$\Rightarrow \mathcal{M}_H = \left(\frac{ig}{2}\right)^2 \frac{m_e m_\mu}{M_W^2} \bar{v}(p_1)u(p_2) \frac{-i}{(p_1+p_2)^2 - M_H^2} \bar{u}(p_3)v(p_4)$$

$$\begin{aligned} \frac{1}{4} \sum_{Spin} |\mathcal{M}_H|^2 &= \left(\frac{ig}{2}\right)^4 \left(\frac{m_e m_\mu}{M_W^2}\right)^2 \frac{1}{(s - M_H^2)^2} \{ (s - 2m_e^2)(s - 2m_\mu^2) \\ &\quad - 2(m_e^2 + m_\mu^2)s + 8m_e^2 m_\mu^2 \} \end{aligned} \quad (14)$$

Riferimenti bibliografici

- [1] George Sterman. *An Introduction to Quantum Field Theory*. Cambridge University Press, 1993.
- [2] Martinus Veltman. *Diagrammatica: The Path to Feynman Diagrams*. Cambridge University Press, 1994.
- [3] *PDG: Particle Listings*. http://pdg.lbl.gov/2019/listings/contents_listings.html. [ultima consultazione 11/04/2020].