neutrino is

$$-\frac{e}{2\sqrt{2}\sin\theta_W}\left[W_\mu^-\,\overline{e}\,\gamma^\mu(1-\gamma^5)\nu + W_\mu^+\,\overline{\nu}\,\gamma^\mu\,(1-\gamma^5)e\right]\ . \qquad (26.4)$$

For momenta small compared to M_W, this term gives rise to the effective four-fermion interaction with the Fermi constant given (at tree level, *i.e.*, lowest order in perturbation theory) by $G_F/\sqrt{2} = g^2/8M_W^2$. CP violation is incorporated in the Standard Model by a single observable phase in V_{ij}. The third term in $\mathscr{L}_F$ describes electromagnetic interactions (QED), and the last is the weak neutral-current interaction.

In Eq. (26.1), m_i is the mass of the i^{th} fermion ψ_i. For the quarks these are the current masses. For the light quarks, a typical estimate [3] gives $m_u \approx 5.6 \pm 1.1$ MeV, $m_d \approx 9.9 \pm 1.1$ MeV, $m_s \approx 199 \pm 33$ MeV, and $m_c \approx 1.35 \pm 0.05$ GeV (these are running masses evaluated at 1 GeV). For the heavier quarks $m_b \approx 4.7$ GeV (the "pole" mass), and $m_t > 131$ GeV [4]. (The CDF Collaboration has reported [5] evidence for top events with $m_t = 174 \pm 16$ GeV.) See "The Note on Quark Masses" in the Full Listings for more information.

H is the physical neutral Higgs scalar which is the only remaining part of ϕ after spontaneous symmetry breaking. The Yukawa coupling of H to ψ_i, which is flavor diagonal in the minimal model, is $gm_i/2M_W$. The H mass is not predicted by the model. Experimental limits are given in the Higgs section. In nonminimal models there are additional charged and neutral scalar Higgs particles [6].

26.1. Renormalization and radiative corrections

The Standard Model has three parameters (not counting M_H and the fermion masses and mixings). A particularly useful set is:

(a) The fine structure constant $\alpha = 1/137.036$, determined from the quantum Hall effect. In most electroweak-renormalization schemes, it is convenient to define a running α dependent on the energy scale of the process, with $\alpha^{-1} \sim 137$ appropriate at low energy. At energies of order M_Z, $\alpha^{-1} \sim 128$. For example, in the modified minimal subtraction ($\overline{\rm MS}$) scheme, one has $\widehat{\alpha}(M_Z)^{-1} = 127.9 \pm 0.1$ [7], with the uncertainty due to the low-energy hadronic contribution to vacuum polarization.

(b) The Fermi constant, $G_F = 1.16639(2) \times 10^{-5}$ GeV^{-2}, determined from the muon lifetime formula [8]:

$$\tau_\mu^{-1} = \frac{G_F^2 m_\mu^5}{192\pi^3}\, F\left(\frac{m_e^2}{m_\mu^2}\right)\left(1+\frac{3}{5}\frac{m_\mu^2}{M_W^2}\right)$$
$$\times\left[1+\frac{\alpha(m_\mu)}{2\pi}\left(\frac{25}{4}-\pi^2\right)\right]\ , \qquad (26.5a)$$