is a QCD correction. Corrections to Eq. (26.35) for massive fermions are given in Refs. 10 and 35 and the mass/Yukawa effects in the QCD corrections in Refs. [18,36]. Expressing the widths in terms of $G_F M^3_{W,Z}$ incorporates the bulk of the low-energy radiative corrections [10,35]. The $Z \to f\overline{f}$ widths have an additional QED correction $1 + 3\alpha\, q_f^2/4\pi$. The electroweak corrections are incorporated by replacing $g^{i2}_{V,A}$ by the effective couplings $\overline{g}^{i2}_{V,A}$ defined in Eq. (26.33) of the full *Review*. Hence, the widths are proportional to $1 + \rho_t$, where $\rho_t = 3G_F\, m_t^2/8\,\sqrt{2}\pi^2$. There is additional (negative) quadratic m_t dependence in the $Z \to b\overline{b}$ vertex corrections [37] which causes $\Gamma(b\overline{b})$ to decrease with m_t. The dominant effect is to multiply $\Gamma(b\overline{b})$ by the vertex correction $1 + \delta\rho_{b\overline{b}}$, where $\delta\rho_{b\overline{b}} \sim 10^{-2}(-\frac{1}{2}\frac{m_t^2}{M_Z^2} + \frac{1}{5})$. In practice, the corrections are included in $\overline{g}^{\,b}_{V,A}$.

For 3-fermion families the total widths are predicted to be

$$\Gamma_Z \approx 2.493 \pm 0.004 \text{ GeV} \tag{26.36}$$

$$\Gamma_W \approx 2.09 \pm 0.01 \text{ GeV} \quad . \tag{26.37}$$

The numerical values for the widths assume $M_Z = 91.187 \pm 0.007$ GeV, $M_W = 80.29 \pm 0.11$ GeV, $\alpha_s = 0.120$, and $m_t = 169^{+16}_{-18}$ GeV, where the M_W, α_s, and m_t values are predicted by the global fits for $M_H = 300$ GeV. The uncertainties for Γ_W and Γ_Z are dominated by ΔM_W and Δm_t, respectively. The uncertainty in α_s, ± 0.007, introduces an additional uncertainty of 0.2% in the hadronic widths, corresponding to ± 4 MeV in Γ_Z.

These predictions are to be compared with the experimental results $\Gamma_Z = 2.490 \pm 0.007$ GeV and $\Gamma_W = 2.08 \pm 0.07$ GeV.

26.4. Experimental results

The values of the principal Z-pole observables are listed in Table 26.3, along with the Standard Model predictions for $M_Z = 91.187 \pm 0.007$, $m_t = 169^{+16}_{-18}$ GeV (for $M_H = 300$ GeV), 60 GeV $< M_H < 1$ TeV, and $\alpha_s = 0.120 \pm 0.007$. The values and predictions of M_W, M_W/M_Z, the Q_W for cesium [30,31], and recent results from deep inelastic and $\nu_e e$ scattering are also listed. The agreement is generally excellent, although $\Gamma_b = \Gamma(b\overline{b})/\Gamma(\text{had})$ is $\sim 1.8\sigma$ above the Standard Model prediction, and the left-right A^0_{LR} is 2σ above the Standard Model prediction. There is also an experimental difference of $\sim 2\sigma$ between the SLD value of $A^0_e = A^0_{LR}$ and the LEP value $A^0_{\ell\text{LEP}} \sim 0.1434 \pm 0.0073$ obtained from $A^{(0,\ell)}_{FB}$, $A^0_e(P_\tau)$, $A^0_\tau(P_\tau)$ assuming lepton family universality. The observables in Table 26.3 (including correlations on the LEP observables), as well as all low-energy neutral-current data [9], are used in the global fits described