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**THE ISOLINES OF
ELECTROWEAK RADIATIVE CORRECTIONS AND
THE CONFIDENCE LEVELS FOR THE MASSES OF
THE TOP AND HIGGS**

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ABSTRACT

The most sensitive "gluon-free" electroweak corrections are compared with corresponding experimental data; the results of this comparison are combined to find the confidence levels of bounds on the top and the higgs masses.

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CERN-TH.6849/93
March 1993

The measurements of the W mass [1],[2] and the LEP measurements of the Z -mass and leptonic Z -couplings give [3]–[5]:

$$(m_W/m_Z)^{exp} = 0.8797(29) \quad (1)$$

$$(g_A')^{exp} = -0.4999(9) \quad (2)$$

$$(g_V'/g_A') = 1 - 4 \sin^2 \theta_{eff} = 0.0728(28). \quad (3)$$

These numbers allow the extraction of experimental values of three theoretical functions : V_m , V_A , and V_R , where m , A , and R refer to m_W/m_Z , g_A , and the ratio g_V/g_A , respectively:

$$V_m^{exp} = [0.8797(29) - c]32\pi(c^2 - s^2)s^2/3\bar{\alpha}c = 1.78 \pm 1.78 \quad (4)$$

$$V_A^{exp} = [+0.4999(9) - 0.5]64\pi s^2/3\bar{\alpha} = -0.15 \pm 1.38 \quad (5)$$

$$V_R^{exp} = [0.0728(28) - (1 - 4s^2)]4\pi(c^2 - s^2)/3\bar{\alpha} = -0.73 \pm 0.81, \quad (6)$$

where $\bar{\alpha} = \alpha(m_Z) = 1/128.87(12)$, $s \equiv \sin \theta$, $c \equiv \cos \theta$, $4s^2c^2 = 4\pi\bar{\alpha}/\sqrt{2}G_\mu m_Z^2$, and hence $s^2 = 0.2312(3)$, $(1 - 4s^2) = 0.0753(12)$, $c = 0.8768(19)$.

The one-loop explicit analytical expressions of V_m , V_A , V_R as functions of the top and higgs masses, m_t and m_H , as well as their corresponding graphs and numerical tables, were presented in ref. [6] and with gluonic corrections in ref. [7].

In this paper we first compare isolines of the functions V_m , V_A and V_R projected on the m_t , m_H plane (Fig. 1). An isoline on such a map corresponds to a given value of V . The mean experimental values of V 's are shown by solid lines. Lower 1σ isolines for V_m and V_R and upper 1σ for V_A are shown in Fig. 1 by dashed lines.

As is evident from Fig. 1 the mean isoline of V_A "prefers" surprisingly low values of m_t . In fact this isoline is situated mainly in the region of m_t excluded by CDF and D0 data (to the left of the vertical dashed line at $m_t = 108$ GeV) [8].

For the higgs masses larger than their lower experimental LEP bound, the isolines of different V 's cross under such small angles that it is practically impossible to extract a single value of m_H , where they cross. Note that isolines V_A , V_m , V_R tend to cross at very low values of m_H , which are excluded by LEP data (below the horizontal dashed line at $m_H = 60$ GeV; the horizontal dashed line at $m_H = 700$ GeV indicates the upper theoretical bound for an elementary higgs).

Our second aim is to determine the confidence level of various values of m_t and m_H using the isolines of χ^2 . The errors in g_V/g_A and g_A are not absolutely independent. But the correlation is so tiny that one can neglect this subtlety and consider the whole set of experimental inputs(1)–(3) as statistically independent. Therefore

$$\chi^2(m_t, m_H) = \sum \left(\frac{V_i(m_t, m_H) - \bar{V}_i}{\sigma_i} \right)^2 \quad (7)$$

where $i = m, A, R$; $\bar{V}_i$ is the central experimental value of V_i , and σ_i is its 1σ uncertainty as given by Eqs. (1)–(6).

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The isolines of χ^2 are presented in Fig. 2. Solid lines correspond to expressions for V_i from Ref. [7], which take into account gluonic corrections. (They have been calculated by us only for values of m_t larger than 90 GeV). Dashed isolines correspond to purely electroweak expressions for V_i 's from Ref. [6]. We use them in order to demonstrate the role of gluonic corrections.

The results of Fig. 2 are in qualitative agreement with previous χ^2 fits [9]–[15] of electroweak data. The main difference between our analysis and those of refs. [9]–[15] is that instead of relying on a global computer fit of all electroweak data we use only the subset of the most accurate and “gluon-free” experimental data and easily trace the importance of a possible change of each of them.

In particular, the minimum of χ^2 at $m_h \simeq 10$ GeV in Fig. 2 is connected with the low crossing of V_m, V_A, V_R mentioned above. It is evident from Fig. 1 that, in order to get a higher crossing, the mean value of V_A , and hence of the leptonic width of the Z boson, Γ_Z , has to increase if the data on g_V/g_A are correct and if there is no New Physics.

The increased experimental accuracy of g_V/g_A calls for two final remarks.

First, the Born approximation based on $\bar{\alpha}$, which is the natural coupling constant for electroweak processes (see Ref. [16]), continues to describe experimental data with remarkable accuracy. The electroweak radiative corrections have not been, in fact, observed experimentally. They turned out to be small as a result of cancellation between two large contributions: one from the top, the other from the rest of the virtual particles (see Ref. [6], Figs. 1, 3 and 5). It looks like a “top conspiracy”.

The second remark refers to the uncertainty ± 0.0012 of $1-4s^2$, which is determined by the uncertainty of $\bar{\alpha}$ [see definitions after Eq. (6)]. The experimental uncertainty in $1-4\sin^2\theta_{eff}$ is getting closer and closer to that in $1-4s^2$ so that the latter may become the bottleneck in further precision tests of electroweak corrections. As values of $\bar{\alpha}$ and α are connected by a dispersion relation, the uncertainty in $\bar{\alpha}$ is determined by the uncertainty in the hadronic contribution to the dispersion integral. Therefore precision measurements of the cross-section $e^+e^- \rightarrow$ hadrons at low energies are becoming mandatory (see the remark by J. Haissinski after the talk by L. Rolandi [1]).

Acknowledgements

We are grateful to K.A. Ter-Martirosyan for encouraging discussions. We are also grateful for interesting discussions of this paper and of new experimental data to G. Altarelli, R. Barbieri, D. Bardini, C. De Clercq, E. Lisi, A. Olchevski and M. Pepe Altarelli. One of us (L.O.) is grateful to the CERN Theory Division for warm hospitality.

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FIGURE CAPTIONS

Fig. 1 - Isolines of V_m, V_A, V_R on the plane m_t, m_H . Mean experimental values are shown by solid lines. The upper (for V_A) and lower (for V_m, V_R) 1σ - limits are shown by dashed lines.

Fig. 2 - Isolines for χ^2 . Numbers indicate the values of $\Delta\chi^2 = \chi^2 - \chi^2_{min}$.

Fig. 2

Fig. 1