

Hyperon non-leptonic decays, the $|\Delta I| = 1/2$ rule, and *a priori* mixed hadrons

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The $|\Delta I| = 1/2$ rule in non-leptonic decays of hyperons can be naturally understood by postulating *a priori* mixed physical hadrons, along with the isospin invariance of the responsible transition operator. It is shown that this operator can be identified with the strong interaction Yukawa Hamiltonian. The experimental amplitudes are well reproduced.

Keywords: Hadrons; non-leptonic; decays

La regla $|\Delta I| = 1/2$ en los decaimientos no leptónicos de hiperones puede entenderse en forma natural postulando mezclas *a priori* en los hadrones físicos, junto con la invariancia de isoespín del operador responsable de la transición. Se muestra que este operador puede identificarse con el hamiltoniano de Yukawa de la interacción fuerte. Las amplitudes experimentales se reproducen en forma satisfactoria.

Descriptores: Hadrones; no leptónicos; decaimientos

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1. Introduction

The possibility that strong-flavor and parity violating pieces in the mass operator of hadrons exist does not violate any known fundamental principle of physics. If they do exist they would lead to non-perturbative *a priori* mixings of flavor and parity eigenstates in physical (mass eigenstates) hadrons. Then, two paths for weak decays of hadrons to occur would be open: the ordinary one mediated by W_μ^\pm (Z_μ) and a new one via the strong-flavor and parity conserving interaction hamiltonians. The enhancement phenomenon observed in non-leptonic decays of hyperons (NLDH) could then be attributed to this new mechanism. However, for this to be the case it will be necessary that *a priori* mixings produce the well established predictions of the $|\Delta I| = 1/2$ rule [1, 2].

In this paper we shall (i) motivate the existence of *a priori* mixings, (ii) develop practical applications of such mixings via an ansatz which takes guidance in some model, (iii) show that indeed the predictions of the $|\Delta I| = 1/2$ in NLDH are obtained in this approach, and (iv) give a brief account of the comparison of the amplitudes obtained with their experimental values.

For motivation we shall use the model of Ref. 3, in which the electroweak sector is doubled along with the fermion and

higgs content. The gauge group is $SU_3^C \otimes SU_2 \otimes U_1 \otimes S\hat{U}_2 \otimes \hat{U}_1$, there will be ordinary quarks q and hatted (mirror) quarks \hat{q} and two doublet higgses ϕ and $\hat{\phi}$. The latter will generate the mass matrix of the q 's and \hat{q} 's, correspondingly. After appropriate rotations the q 's and \hat{q} 's are assigned diagonal masses and strong-flavors. (See the diagonal terms in the matrix below.) At this point we go beyond Ref. 3: we assume the q 's and \hat{q} 's to have opposite parities and that bisinglet and bidoublet higgses exist. The diagonal mass matrix becomes (the calculation is straightforward; the indices naught, s , and p mean flavor, positive parity, and, negative parity eigenstates, respectively, and we limit the discussion to d and s quarks; the u , c , b , and t quarks can be treated analogously)

$$(\bar{d}_{0s} \ \bar{s}_{0s} \ \bar{d}_{0p} \ \bar{s}_{0p}) \begin{pmatrix} m_{0d} & 0 & \Delta_{11} & \Delta_{12} \\ 0 & m_{0s} & \Delta_{21} & \Delta_{22} \\ \Delta_{11}^* & \Delta_{21}^* & \hat{m}_{0d} & 0 \\ \Delta_{12}^* & \Delta_{22}^* & 0 & \hat{m}_{0s} \end{pmatrix} \begin{pmatrix} d_{0s} \\ s_{0s} \\ d_{0p} \\ s_{0p} \end{pmatrix} \quad (1)$$

A final rotation leads to the *a priori* mixed physical (mass eigenstate) quarks, namely $d_{ph} = d_{0s} + \sigma s_{0s} + \delta s_{0p} + \dots$, $s_{ph} = s_{0s} - \sigma d_{0s} + \delta' d_{0p} + \dots$, $\bar{d}_{ph} = \bar{d}_{0p} + \sigma \bar{s}_{0p} - \delta \bar{s}_{0s} + \dots$, $\bar{s}_{ph} = \bar{s}_{0p} - \sigma \bar{d}_{0p} - \delta' \bar{d}_{0s} + \dots$, and similar expressions for

\hat{q}_{ph} , etc. Since necessarily $\hat{m}_{0d}, \hat{m}_{0s}, \hat{m}_{0s} - \hat{m}_{0d} \gg m_{0d}, m_{0s}, \Delta_{ij}$, the angles in the last rotation can be kept to first order. There are six angles, three for $\Delta S = 0$ and three for $|\Delta S| = 1$ mixings. The latter we have called $\sigma, \delta,$ and δ' . The dots stand for other mixings which will not be relevant in what follows. The above model shows how non-perturbative *a priori* mixings can arise. An extended and more detailed discussion of the above approach is presented in Refs. 4.

For practical applications of the above ideas one faces the problem of our current inability to compute well with QCD. In order to proceed, one has no remedy but to develop an ansatz. This latter will be based on the above model and it will consist of two steps: (a) take the above mixings and (b) replace them in the non-relativistic quark model (NRQM) wave functions. This ansatz will yield *a priori* mixings at the hadron level. We get at the meson level $K_{ph}^+ = K_{0p}^+ - \sigma\pi_{0p}^+ - \delta'\pi_{0s}^+ + \dots, K_{ph}^0 = K_{0p}^0 + \sigma\pi_{0p}^0/\sqrt{2} + \delta'\pi_{0s}^0/\sqrt{2} + \dots, \pi_{ph}^+ = \pi_{0p}^+ + \sigma K_{0p}^+ - \delta K_{0s}^+ + \dots, \pi_{ph}^0 = \pi_{0p}^0 - \sigma(K_{0p}^0 + \bar{K}_{0p}^0)/\sqrt{2} + \delta(K_{0s}^0 - \bar{K}_{0s}^0)/\sqrt{2} + \dots, \pi_{ph}^- = \pi_{0p}^- + \sigma K_{0p}^- + \delta K_{0s}^- + \dots, \bar{K}_{ph}^0 = \bar{K}_{0p}^0 + \sigma\pi_{0p}^0/\sqrt{2} - \delta'\pi_{0s}^0/\sqrt{2} + \dots,$ and $K_{ph}^- = K_{0p}^- - \sigma\pi_{0p}^- + \delta'\pi_{0s}^- + \dots$. At the baryon level we get $p_{ph} = p_{0s} - \sigma\Sigma_{0s}^+ - \delta\Sigma_{0p}^+ + \dots, n_{ph} = n_{0s} + \sigma(\Sigma_{0s}^0/\sqrt{2} + \sqrt{3/2}\Lambda_{0s}) + \delta(\Sigma_{0p}^0/\sqrt{2} + \sqrt{3/2}\Lambda_{0p}) + \dots, \Sigma_{ph}^+ = \Sigma_{0s}^+ + \sigma p_{0s} - \delta'p_{0p} + \dots, \Sigma_{ph}^0 = \Sigma_{0s}^0 + \sigma(\Xi_{0s}^0 - n_{0s})/\sqrt{2} + \delta\Xi_{0p}^0/\sqrt{2} + \delta'n_{0p}/\sqrt{2} + \dots, \Sigma_{ph}^- = \Sigma_{0s}^- + \sigma\Xi_{0s}^- + \delta\Xi_{0p}^- + \dots, \Lambda_{ph} = \Lambda_{0s} + \sigma\sqrt{3/2}(\Xi_{0s}^0 - n_{0s}) + \delta\sqrt{3/2}\Xi_{0p}^0 + \delta'\sqrt{3/2}n_{0p} + \dots, \Xi_{ph}^0 = \Xi_{0s}^0 - \sigma(\Sigma_{0s}^0/\sqrt{2} + \sqrt{3/2}\Lambda_{0s}) + \delta'(\Sigma_{0p}^0/\sqrt{2} + \sqrt{3/2}\Lambda_{0p}) + \dots,$ and $\Xi_{ph}^- = \Xi_{0s}^- - \sigma\Sigma_{0s}^- + \delta'\Sigma_{0p}^- + \dots$. Our phase conventions are those of Ref. 5. Notice that the physical mesons are CP-eigenstates, *e.g.*, $CPK_{ph}^+ = -K_{ph}^-$, etc., because we have assumed CP-invariance.

The *a priori* mixed hadrons will lead to NLDH via the parity and flavor conserving strong interaction (Yukawa) hamiltonian H_Y . The transition amplitudes will be given by the matrix elements $\langle B_{ph} M_{ph} | H_Y | A_{ph} \rangle$, where A_{ph} and B_{ph} are the initial and final hyperons and M_{ph} is the emitted meson. Using the above mixings these amplitudes will have the form $\bar{u}_B(A - B\gamma_5)u_A$, where u_A and u_B are four-component Dirac spinors and the amplitudes A and B correspond to the parity violating and the parity conserving amplitudes of the W_μ^\pm mediated NLDH, although with *a priori* mixings these amplitudes are both actually parity and flavor conserving. As a first approximation we shall neglect isospin violations, *i.e.*, we shall assume that H_Y is an SU_2 scalar. However, we shall not neglect SU_3 breaking. One obtains for A and B the results:

$$\begin{aligned} A_1 &= \delta' \sqrt{3} g_{p,p\pi^0}^{p,sp} + \delta (g_{\Lambda,pK^-}^{s,ss} - g_{\Lambda,\Sigma^+\pi^-}^{s,pp}), \\ A_2 &= -[\delta' \sqrt{3} g_{p,p\pi^0}^{p,sp} + \delta (g_{\Lambda,pK^-}^{s,ss} - g_{\Lambda,\Sigma^+\pi^-}^{s,pp})]/\sqrt{2} \\ A_3 &= \delta (\sqrt{2} g_{\Sigma^0,pK^-}^{s,ss} + \sqrt{3/2} g_{\Sigma^+\Lambda\pi^+}^{s,pp} + g_{\Sigma^+\Sigma^+\pi^0}^{s,pp}/\sqrt{2}), \\ A_4 &= -\delta' \sqrt{2} g_{p,p\pi^0}^{p,sp} + \delta (\sqrt{3/2} g_{\Sigma^+\Lambda\pi^+}^{s,pp} - g_{\Sigma^+\Sigma^+\pi^0}^{s,pp}/\sqrt{2}), \quad (2) \\ A_5 &= -\delta' g_{p,p\pi^0}^{p,sp} - \delta (g_{\Sigma^0,pK^-}^{s,ss} + g_{\Sigma^+\Sigma^+\pi^0}^{s,pp}), \\ A_6 &= \delta' g_{\Sigma^+\Lambda\pi^+}^{p,sp} + \delta (g_{\Xi^-\Lambda K^-}^{s,ss} + \sqrt{3} g_{\Xi^0\Xi^0\pi^0}^{s,pp}), \\ A_7 &= [\delta' g_{\Sigma^+\Lambda\pi^+}^{p,sp} + \delta (g_{\Xi^-\Lambda K^-}^{s,ss} + \sqrt{3} g_{\Xi^0\Xi^0\pi^0}^{s,pp})]/\sqrt{2}, \end{aligned}$$

and

$$\begin{aligned} B_1 &= \sigma (-\sqrt{3} g_{p,p\pi^0} + g_{\Lambda,pK^-} - g_{\Lambda,\Sigma^+\pi^-}), \\ B_2 &= -\sigma (-\sqrt{3} g_{p,p\pi^0} + g_{\Lambda,pK^-} - g_{\Lambda,\Sigma^+\pi^-})/\sqrt{2}, \\ B_3 &= \sigma (\sqrt{2} g_{\Sigma^0,pK^-} + \sqrt{3/2} g_{\Sigma^+\Lambda\pi^+} + g_{\Sigma^+\Sigma^+\pi^0}/\sqrt{2}), \\ B_4 &= \sigma (\sqrt{2} g_{p,p\pi^0} + \sqrt{3/2} g_{\Sigma^+\Lambda\pi^+} - g_{\Sigma^+\Sigma^+\pi^0}/\sqrt{2}), \quad (3) \\ B_5 &= \sigma (g_{p,p\pi^0} - g_{\Sigma^0,pK^-} - g_{\Sigma^+\Sigma^+\pi^0}), \\ B_6 &= \sigma (-g_{\Sigma^+\Lambda\pi^+} + g_{\Xi^-\Lambda K^-} + \sqrt{3} g_{\Xi^0\Xi^0\pi^0}), \\ B_7 &= \sigma (-g_{\Sigma^+\Lambda\pi^+} + g_{\Xi^-\Lambda K^-} + \sqrt{3} g_{\Xi^0\Xi^0\pi^0})/\sqrt{2}. \end{aligned}$$

The subindices 1, ..., 7 correspond to $\Lambda \rightarrow p\pi^-, \Lambda \rightarrow n\pi^0, \Sigma^- \rightarrow n\pi^-, \Sigma^+ \rightarrow n\pi^+, \Sigma^+ \rightarrow p\pi^0, \Xi^- \rightarrow \Lambda\pi^-,$ and $\Xi^0 \rightarrow \Lambda\pi^0$, respectively. The g -constants in these equations are Yukawa coupling constants (YCC) defined by the matrix elements of H_Y between flavor and parity eigenstates, for example, by $\langle B_{0s} M_{0p} | H_Y | A_{0p} \rangle = g_{A,BM}^{p,sp}$. We have omitted the upper indices in the g 's of the B amplitudes because the states involved carry the normal intrinsic parities of hadrons. In Eqs. (3) we have used the SU_2 relations $g_{p,p\pi^0} = -g_{n,n\pi^0} = g_{p,n\pi^+}/\sqrt{2} = g_{n,p\pi^-}/\sqrt{2}, g_{\Sigma^+\Lambda\pi^+} = g_{\Sigma^0\Lambda\pi^0} = g_{\Sigma^-\Lambda\pi^-}, g_{\Lambda,\Sigma^+\pi^-} = g_{\Lambda,\Sigma^0\pi^0}, g_{\Sigma^+\Sigma^+\pi^0} = -g_{\Sigma^+\Sigma^0\pi^+} = g_{\Sigma^-\Sigma^0\pi^-}, g_{\Sigma^0,pK^-} = g_{\Sigma^-\Lambda K^-}/\sqrt{2} = g_{\Sigma^+\Lambda K^0}/\sqrt{2}, g_{\Lambda,pK^-} = g_{\Lambda,nK^0}, g_{\Xi^0\Xi^0\pi^0} = g_{\Xi^-\Xi^0\pi^-}/\sqrt{2}, g_{\Xi^-\Lambda K^-} = -g_{\Xi^0\Lambda K^0},$ and $g_{\Lambda,\Lambda\pi^0} = 0$. Similar relations are valid within each set of upper indices, *e.g.*, $g_{p,p\pi^0}^{p,sp} = -g_{n,n\pi^0}^{p,sp}$, etc.; the reason for this is, as we discussed in Refs. 4, mirror hadrons may be expected to have the same strong-flavor assignments as ordinary hadrons. Thus, for example, $\pi_{0s}^+, \pi_{0s}^0,$ and π_{0s}^- form an isospin triplet, although a different one from the ordinary $\pi_{0p}^+, \pi_{0p}^0,$ and π_{0p}^- isospin triplet. These latter relations have been used in Eqs. (2).

Predictions for the A amplitudes, along with the accompanying predictions for the B amplitudes, obtained by assuming that the magnitudes of the YCC of Eqs. (2) match their corresponding counterparts in Eqs. (3). The values of the YCC are listed in Ref. 9. All amplitudes are given in units of 10^{-7} .

Decay	B_{exp}	2		
		B_{th}	A_{th}	
$\Lambda \rightarrow p\pi^-$	-22.09 ± 0.44	-22.36	-3.231 ± 0.020	-3.263
$\Lambda \rightarrow n\pi^0$	15.89 ± 1.01	15.81	2.374 ± 0.027	2.308
$\Sigma^- \rightarrow n\pi^-$	1.43 ± 0.17	1.35	-4.269 ± 0.014	-4.264
$\Sigma^+ \rightarrow n\pi^+$	-42.17 ± 0.18	-42.10	-0.140 ± 0.027	-0.153
$\Sigma^+ \rightarrow p\pi^0$	$-26.86 \pm_{1.36}^{1.10}$	-30.72	$3.247 \pm_{0.116}^{0.089}$	2.907
$\Xi^- \rightarrow \Lambda\pi^-$	-17.47 ± 0.50	-17.28	4.497 ± 0.020	4.521
$\Xi^0 \rightarrow \Lambda\pi^0$	-12.29 ± 0.70	-12.22	3.431 ± 0.055	3.197

From the above results one readily obtains the equalities:

$$A_2 = -A_1/\sqrt{2}, \quad A_5 = (A_4 - A_3)/\sqrt{2},$$

$$A_7 = A_6/\sqrt{2}, \quad (4)$$

$$B_2 = -B_1/\sqrt{2}, \quad B_5 = (B_4 - B_3)/\sqrt{2},$$

$$B_7 = B_6/\sqrt{2}. \quad (5)$$

These are the predictions of the $|\Delta I| = 1/2$ rule. That is, *a priori* mixings in hadrons as introduced above lead to the predictions of the $|\Delta I| = 1/2$ rule, but notice that they do not lead to the $|\Delta I| = 1/2$ rule itself. This rule originally refers to the isospin covariance properties of the effective non-leptonic interaction hamiltonian to be sandwiched between strong-flavor and parity eigenstates. The $I = 1/2$ part of this hamiltonian is enhanced over the $I = 3/2$ part. In contrast, in the case of *a priori* mixings H_Y has been assumed to be isospin invariant, *i.e.*, in this case the rule should be called a $\Delta I = 0$ rule.

It must be stressed that the results (4) and (5) are very general: (i) the predictions of the $|\Delta I| = 1/2$ rule are obtained simultaneously for the A and B amplitudes, (ii) they are independent of the mixing angles σ , δ , and δ' , and (iii) they are also independent of particular values of the YCC. They will be violated by isospin breaking corrections. So, they should be quite accurate, as is experimentally the case.

Although *a priori* mixings do not violate any fundamental principle, the reader may wonder if they do not violate some important theorem, specifically the Feinberg-Kabir-Weinberg theorem [6]. They do not. This theorem is useful for defining conserved quantum numbers after rotations that diagonalize the kinetic and mass terms of particles. It presupposes on mass-shell particles and interactions that can be diagonalized simultaneously with those terms. This last is sometimes not clearly stated, but it is an obvious requirement. Quarks inside hadrons are off mass-shell; so the theorem cannot eliminate the non-diagonal d - s terms which lead to non-diagonal terms

in hadrons. It has not yet been proved for hadrons, but one can speculate: what if it had? Hadrons are on mass-shell, but they show many more interactions than quarks, albeit, effective ones. The Yukawa interaction cannot be diagonalized along with the kinetic and mass terms, as can be seen through the YCC of the amplitudes above. Therefore, this theorem would not apply to the last rotation leading to *a priori* mixings in hadrons. Another example is weak radiative decays, it is interesting because it is a mixed one. The charge form factors can be diagonalized while anomalous magnetic ones cannot. The theorem would apply to the former but not to the latter.

The reader may wonder where specifically the predictions of the $|\Delta I| = 1/2$ came from. They can be traced down to the coefficients of σ , δ , and δ' in the mixed hadrons, $1/\sqrt{2}$, $\sqrt{3}/2$, etc., and the latter in turn came from reconstructing the NRQM wave function. In this respect, there is an important comment we wish to make. The factorization of these coefficients and the angles from the NRQM wave functions should be preserved by QCD, because QCD did not intervene at all in their fixing and it treats all quarks on an equal footing. In other words, the effect of forming compound hadrons by setting the quarks in motion and in interaction with one another will go into rendering the NRQM wave functions into realistic strong-flavor and parity eigenstate wave functions, but should not break the above factorization. One may expect Eqs. (4) and (5) to remain correct after QCD fully operates. The important question is whether one has results that are valid beyond the particular models one has taken for guidance. This argument supports the affirmative answer.

A detailed comparison with all the experimental data available in these decays requires more space and will be presented separately [7]. Nevertheless, we shall briefly mention a few very important results. First, the experimental B amplitudes [8] (displayed in Table I) are reproduced within a few percent by accepting that the YCC are given by the ones observed in strong interactions [9], an assumption which cannot be avoided in this approach. The best pre-

dictions for these amplitudes are $B_1 = 22.11 \times 10^{-7}$, $B_2 = -15.63 \times 10^{-7}$, $B_3 = 1.39 \times 10^{-7}$, $B_4 = -42.03 \times 10^{-7}$, $B_5 = -30.67 \times 10^{-7}$, $B_6 = 17.45 \times 10^{-7}$, and $B_7 = 12.34 \times 10^{-7}$. The only unknown parameter σ is determined at $(3.9 \pm 1.3) \times 10^{-6}$. Second, although the A amplitudes involve new YCC, an important prediction is already made in Eqs. (2). Once the signs of the B amplitudes are fixed, one is free to fix the signs of four A amplitudes—say, $A_1 > 0$, $A_3 < 0$, $A_4 < 0$, $A_6 < 0$ —to match the signs of the corresponding experimental α asymmetries, namely, $\alpha_1 > 0$, $\alpha_3 < 0$, $\alpha_4 > 0$, $\alpha_6 < 0$ [8]. Then the signs of $A_2 < 0$, $A_5 > 0$, and $A_7 < 0$ are fixed by Eqs. (2) and the fact that $|A_4| \ll |A_3|$. In turn the signs of the corresponding α 's are fixed. These three signs agree with the experimentally observed ones, namely, $\alpha_2 > 0$, $\alpha_5 < 0$, $\alpha_7 < 0$.

The above predictions are quite general because only assumptions already implied in the ansatz for the application of *a priori* mixings have been used. A detailed comparison of the A amplitudes with experiment is limited by our current inability to compute well with QCD. However, one may try simple and argumentable new assumptions to make predictions for such amplitudes. Since QCD has been assumed to be common to both ordinary and mirror quarks, it is not unreasonable to expect that the magnitudes of the YCC in the A amplitudes have the same magnitudes as their corresponding counterparts in the ordinary YCC of the B amplitudes. The relative signs may differ, however. Introducing this assumption we obtain the predictions for the A amplitudes displayed in Table I. The predictions for the B amplitudes must also be redone, because determining the A amplitudes alone may introduce small variations in the YCC that affect importantly the B amplitudes, *i.e.*, both the A and B amplitudes must be simultaneously determined, the B 's act then as extra constraints on the determination of the A 's. The new predictions for the B 's are also displayed in Table I. In obtaining Table I we have actually used the experimental decay rates Γ and α and γ asymmetries, but we only display the experimental and theoretical amplitudes.

The predictions for the A 's agree very well with experiment to within a few percent, while the predictions for the B 's remain as before. The *a priori* mixing angles are determined to be $\delta = (0.22 \pm 0.04) \times 10^{-6}$, $\delta' = (0.25 \pm 0.04) \times 10^{-6}$, and $\sigma = (4.6 \pm 0.8) \times 10^{-6}$. This last value of σ is consistent with the previous one. The more detailed analysis of the comparison of the A 's and B 's with experiment is presented in Ref. 7.

The above results, especially those of Eqs. (4) and (5) and the determination of the amplitudes, satisfy some of the most important requirements that *a priori* mixings must meet in order to be taken seriously as an alternative to describe the enhancement phenomenon observed in non-leptonic decays of hadrons. This means then that another source of flavor and parity violation may exist, other than that of W_μ^\pm and Z_μ . It is worthwhile to point out that the calculation of decays and reactions through the W/Z exchange mechanisms is obtained in the present scheme in the usual way. The weak hamiltonian is, so to speak, sandwiched between *a priori* mixed hadrons; to lowest order only the parity and flavor eigenstates survive, the mixed eigenstates contribute negligible corrections. Thus, beta and semileptonic decay remain practically unchanged, while nonleptonic kaon decays, hypernuclear decays, and others in which the enhancement phenomenon could be present should be recalculated.

Before closing, we wish to discuss what may be expected for the W/Z contributions to NLDH if the *a priori* mixing scheme is indeed valid. The problem we must face with the W/Z contributions is, again, our current inability to compute well with QCD at low energies. This leaves the scale of such contributions essentially undetermined. When one assumes that they are the only contributions available, that scale is fixed or fitted to saturate the experimental data. If, on the contrary, one assumes that it is the *a priori* mixings that dominate, one should then expect the W/Z contributions to be much smaller, a few percent of what has been assumed in the past. In other words, the $|\Delta I| = 1/2$ part of the W/Z contributions would not be enhanced and would remain at the same level of a few percent as the $|\Delta I| = 3/2$ part, which is the level generally accepted for this part.

Looking at the results of Table I, one may see that there is indeed room for contributions of a few percent that would improve further the agreement between theoretical predictions and experimental data, especially in the A -amplitude sector which has very small error bars. The way to proceed would be to add the W/Z contributions to the amplitudes of Eqs. (2) and (3) with an overall scale factor left as a free parameter and, next, to fix it along with σ , δ and δ' by comparison with the data. This would then give the relative scale between *a priori* mixing and W/Z contributions. It would also indicate the level between new physics due to mirror matter and physics due to ordinary matter. This is an interesting question which should be pursued in the future.

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