$|\Delta I| = 3/2$ Decays of the $\Omega^-$ in Chiral Perturbation Theory

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Abstract

We study the decays $\Omega^- \to \Xi \pi$ using heavy-baryon chiral perturbation theory to quantify the $|\Delta I| = 1/2$ rule in these decay modes. The ratio of $|\Delta I| = 3/2$ to $|\Delta I| = 1/2$ amplitudes is somewhat larger in these decays than it is in other hyperon decays. At leading order there are two operators responsible for the $|\Delta I| = 3/2$ parts of the $\Omega^-$ decays which also contribute at one loop to other hyperon decays. These one-loop contributions are sufficiently large to indicate (albeit not definitely) that the measured ratio $\Gamma(\Omega^- \to \Xi^0\pi^-)/\Gamma(\Omega^- \to \Xi^-\pi^0) \approx 2.7$ may be too large.
1 Introduction

For a purely $|\Delta I| = 1/2$ weak interaction, the ratio of decay rates $\Gamma(\Omega^- \rightarrow \Xi^0\pi^-)/\Gamma(\Omega^- \rightarrow \Xi^-\pi^0)$ would be 2. Instead, this ratio is measured to be approximately 2.7 [1], and it has been claimed in the literature that this could signal a violation of the $|\Delta I| = 1/2$ rule [2].

In this paper we construct the lowest-order chiral Lagrangian that contributes to the $|\Delta I| = 3/2$ non-leptonic decays of the $\Omega^-$ and extract information on the couplings by fitting the observed decay rates. We then compute the one-loop contributions of this Lagrangian to the $|\Delta I| = 3/2$ amplitudes in (octet) hyperon non-leptonic decays. We find that the measured $|\Delta I| = 3/2$ amplitude in $\Omega^-$ decays is sufficiently large to be in conflict with the measured $|\Delta I| = 3/2$ amplitudes in (octet) hyperon non-leptonic decays. This is not a definite conclusion because the combinations of couplings that appear in the two cases are different.

2 Chiral Lagrangian

The chiral Lagrangian that describes the interactions of the lowest-lying mesons and baryons has been discussed extensively in the literature [4, 5, 6]. It is written down in terms of the $3 \times 3$ matrices $\phi$ and $B$ which represent the pseudoscalar-meson and baryon octets, and of the Rarita-Schwinger tensor $T^\mu_{abc}$ which describes the spin-$3/2$ baryon decuplet (we use the notation of Ref. [7]). The octet pseudo-Goldstone bosons enter through the exponential $\Sigma = \exp(i\phi/f)$. The field $T^\mu_{abc}$ satisfies the constraint $\gamma^\mu T^\mu_{abc} = 0$ and is completely symmetric in its SU(3) indices, $a, b, c$ [6]. Its components are (with the Lorentz index suppressed)

$$
T_{111} = \Delta^{++}, \quad T_{112} = \frac{1}{\sqrt{3}} \Delta^+, \quad T_{122} = \frac{1}{\sqrt{3}} \Delta^0, \quad T_{222} = \Delta^-, \quad T_{113} = \frac{1}{\sqrt{3}} \Sigma^{*+}, \quad T_{123} = \frac{1}{\sqrt{6}} \Sigma^{*0}, \quad T_{223} = \frac{1}{\sqrt{3}} \Sigma^{*-}, \\
T_{133} = \frac{1}{\sqrt{3}} \Xi^{*0}, \quad T_{233} = \frac{1}{\sqrt{3}} \Xi^{*-}, \quad T_{333} = \Omega^-.
$$

Under chiral SU(3)$_L \times$ SU(3)$_R$, these fields transform as

$$
\Sigma \rightarrow L\Sigma R^\dagger, \quad B \rightarrow UBU^\dagger, \quad T^\mu_{abc} \rightarrow U_{ad}U_{be}U_{cf}T^\mu_{def},
$$

where $L, R \in$ SU(3)$_{L,R}$ and the matrix $U$ is implicitly defined by the transformation

$$
\xi \equiv e^{i\phi/(2f)} \rightarrow L\xi U^\dagger = U\xi R^\dagger.
$$

In the heavy-baryon formalism [3], the effective Lagrangian is rewritten in terms of velocity-dependent baryon fields, $B_v$ and $T_v^\mu$. The leading-order chiral Lagrangian that describes the strong

\footnotetext{1For the $|\Delta I| = 1/2$ sector, theoretical calculation to one loop has recently been done in Ref. [3].}
interactions of the pseudoscalar-meson and baryon octets as well as the baryon decuplet is given by \[3\] 
\[
\mathcal{L}^w = \frac{1}{4} f^2 \left( \partial^\mu \Sigma^\dagger \partial_\mu \Sigma \right) + T(v \cdot D_B) + 2D \left( B_v S_v^\mu \{ A_\mu , B_v \} \right) + 2F \left( B_v S_v^\mu [ A_\mu , B_v ] \right) - T v \cdot DT_{\nu v} + \Delta m T_{\nu v} T_{\nu v} + C \left( T_{\nu v} A_\mu B_v + B_v A_\mu T_{\nu v} + 2H T_{\nu v} S_v \cdot A T_{\nu v} \right),
\]
where $\Delta m$ denotes the mass difference between the decuplet and octet baryons in the chiral-symmetry limit, $S_v^\mu$ is the velocity-dependent spin operator of Ref. [3], and $A_\mu = \frac{1}{2} ( \xi \partial_\mu \xi^\dagger - \xi^\dagger \partial_\mu \xi )$.

Within the standard model, the $|\Delta S| = 1$, $|\Delta I| = 3/2$ weak transitions are induced by an effective Hamiltonian that transforms as $(27_L, 1_R)$ under chiral rotations and has a unique chiral realization in the baryon-octet sector at leading order in $\chi PT$ [8]. Similarly, at lowest order in $\chi PT$, there is only one operator with the required transformation properties involving two decuplet-baryon fields, and there are no operators that involve one decuplet-baryon and one octet-baryon fields [7].

The leading-order weak chiral Lagrangian is, thus,
\[
\mathcal{L}^w = \beta_{27} T_{ij,kl} \left( \xi B_v \xi^\dagger \right)_{ki} \left( \xi B_v \xi^\dagger \right)_{lj} + \delta_{27} T_{ij,kl} \xi_{kd} \xi_{bi} \xi_{le} \xi_{cj} (T_{\nu v})_{abc} (T_{\nu v})_{ade} + h.c.
\]
(5)

The non-zero elements of $T_{ij,kl}$ that project out the $|\Delta S| = 1$, $|\Delta I| = 3/2$ Lagrangian are $T_{12,13} = T_{13,21} = T_{21,13} = T_{21,31} = \frac{1}{2}$ and $T_{22,23} = T_{23,22} = -\frac{1}{2}$. For purely-mesonic $|\Delta S| = 1$, $|\Delta I| = 3/2$ processes, the lowest-order weak Lagrangian can be written as
\[
\mathcal{L}^w = \frac{G_F}{\sqrt{2}} f_\pi^4 V_{ud} V_{us} g_{27} T_{ij,kl} \left( \partial^\mu \Sigma \Sigma^\dagger \right)_{ki} \left( \partial_\mu \Sigma \Sigma^\dagger \right)_{lj} + h.c.
\]
and the constant $g_{27}$ is measured to be about 0.16 [10].

It is simple to see that the only contribution from these lowest-order Lagrangians to $\Omega^- \rightarrow \Xi \pi$ decays is via kaon poles, of $\mathcal{O}(p)$. The weak Lagrangian in Eq. (5) does not contain any couplings for the $\Omega^-$. This is easy to understand in terms of isospin: since the construction couples two decuplet fields and has $\Delta S = 1$ and $|\Delta I| = 3/2$, it is not possible to involve the $\Omega^-$ which has isospin zero.\(^2\)

Before deriving the desired higher-order Lagrangian, we remark that we only need one that generates the P-wave components of $\Omega^- \rightarrow \Xi \pi$. The reason is that, experimentally, the asymmetry parameter in these decays is small and consistent with zero [1], indicating that they are dominated by a P-wave. We will, therefore, ignore any possible D-wave in our discussion.

To construct the next-order Lagrangian, $\mathcal{O}(p)$, we form all possible 27-plets with one decuplet-baryon field, one octet-baryon field and one pion field (that enters through $A_\mu$). Employing standard

\(^2\)This is the same reason why Eq. (6) cannot contribute to S-wave hyperon decays that involve the $\Lambda$ [8, 9].
techniques.\footnote{See, e.g., Ref. \cite{9}.} we treat the combination $\bar{B}_{ab} A_{cd} T_{efg}$ as a tensor product $(8 \otimes 8) \otimes 10$ and find five different operators that transform as 27-plets, two of which contain couplings that include the $\Omega^-$. Their irreducible representations are

$$I_{ab,cd} = \left( \epsilon_{cef} \epsilon_{dgh} + \epsilon_{def} \epsilon_{cgh} \right) \left( \bar{T}_{aeg} T_{bfh} + \bar{T}_{beg} T_{afh} \right), \quad (7)$$

$$I'_{ab,cd} = \epsilon_{cmn} \left( \bar{T}_{am,do} T_{bno} + \bar{T}_{bm,do} T_{ano} \right) + \epsilon_{dmn} \left( \bar{T}_{am,co} T_{bno} + \bar{T}_{bm,co} T_{ano} \right) - \frac{1}{5} \left( \delta_{ac} O_{bd}^I + \delta_{bc} O_{ad}^I + \delta_{ad} O_{bc}^I + \delta_{bd} O_{ac}^I \right), \quad (8)$$

where

$$\bar{T}_{abc} = \epsilon_{amn} \left( \bar{B}_{bm} A_{cn} + \bar{B}_{cn} A_{bm} \right) + \epsilon_{bmn} \left( \bar{B}_{cm} A_{an} + \bar{B}_{an} A_{cm} \right) + \epsilon_{cmn} \left( \bar{B}_{am} A_{bn} + \bar{B}_{bn} A_{am} \right), \quad (9)$$

$$\bar{T}_{ab,cd} = \bar{B}_{ac} A_{bd} + \bar{B}_{ad} A_{bc} + \bar{B}_{bc} A_{ad} + \bar{B}_{bd} A_{ac} - \frac{1}{5} \left( \delta_{ac} D_{bd} + \delta_{bc} D_{ad} + \delta_{ad} D_{bc} + \delta_{bd} D_{ac} \right) - \frac{1}{6} \left( \delta_{ac} \delta_{bd} + \delta_{ad} \delta_{bc} \right) \bar{S}, \quad (10)$$

$$O_{ab}^I = \epsilon_{bmn} \bar{T}_{am,op} T_{nop}, \quad \bar{S} = \text{Tr} \left( \bar{B} A \right), \quad \bar{D} = \left\{ \bar{B}, A \right\} - \frac{2}{3} \text{Tr} \left( \bar{B} A \right). \quad (11)$$

The tensor $I_{ab,cd}$ satisfies the symmetry relation $I_{ab,cd} = I_{ba,cd} = I_{ab,dc} = I_{ba,dc}$ and the tracelessness condition $I_{ab,cb} = 0$, as does $I'_{ab,cd}$. With these building blocks, the Lagrangian that transforms as $(27_L, 1_R)$ and generates $\Delta S = 1, |\Delta I| = 3/2$ transitions including $\Omega^-$ fields can be written as

$$\mathcal{L}_1^w = T_{ij,kl} \xi_{ka} \xi_{lb} \left( C_{27} I_{ab,cd} + C'_{27} I'_{ab,cd} \right) \xi^i_{cl} \xi^j_{dj}. \quad (12)$$

This Lagrangian contains the terms

$$\mathcal{L}_{\Omega^- B \phi} = \frac{C_{27}}{f} 6 \left( -\sqrt{2} \Sigma_v \partial^\mu K^0 + 2 \Sigma_{\pi} \partial^\mu K^+ - 2 \Xi_{\pi} \partial^\mu \pi^0 + \sqrt{2} \Xi_{\pi} \partial^\mu \pi^+ \right) \Omega^-_{\mu} \Omega^-_{\mu} \right) + \frac{C'_{27}}{f} 2 \left( \sqrt{2} \Sigma_v \partial^\mu K^0 - 2 \Sigma_{\pi} \partial^\mu K^+ - 2 \Xi_{\pi} \partial^\mu \pi^0 + \sqrt{2} \Xi_{\pi} \partial^\mu \pi^+ \right) \Omega^-_{\mu} \Omega^-_{\mu}. \quad (13)$$

From this expression, one can see that the decay modes $\Omega^- \rightarrow \Xi \pi$ measure the combination $3C_{27} + C'_{27}$. Since the decays $\Omega^- \rightarrow \Sigma K$ are kinematically forbidden, and since three body decays of the $\Omega^-$ are poorly measured, it is not possible at present to extract these two constants separately.
3 \( |\Delta I| = 3/2 \) Amplitudes for \( \Omega^- \to \Xi\pi \) Decays

In the heavy-baryon formalism, we can write the amplitudes as

\[
i\mathcal{M}_{\Omega^- \to \Xi\pi} = G_F m^2_\pi \bar{u}_\Xi \mathcal{A}_{\Omega^- \Xi\pi}^{(P)} k_\mu u_\Omega \equiv G_F m^2_\pi \bar{u}_\Xi \frac{\alpha_{\Omega^- \Xi\pi}^{(P)}}{\sqrt{2} f} k_\mu u_\Omega ,
\]

where the \( u \)'s are baryon spinors, \( k \) is the outgoing four-momentum of the pion, and only the dominant P-wave piece is included. The \( |\Delta I| = 3/2 \) amplitudes satisfy the isospin relation

\[
\mathcal{M}_{\Omega^- \to \Xi^-\pi^0} + \sqrt{2} \mathcal{M}_{\Omega^- \to \Xi^0\pi^-} = 0.
\]

Summing over the spin of the \( \Xi \) and averaging over the spin of the \( \Omega^- \), one derives from Eq. (14) the decay width

\[
\Gamma(\Omega^- \to \Xi\pi) = \frac{|k| m_\Xi}{6\pi m_\Omega} \left[ (m_\Omega - m_\Xi)^2 - m^2_\pi \right] |\mathcal{A}_{\Omega^- \Xi\pi}^{(P)}|^2 G^2_F m^4_\pi .
\]

Using the measured decay rates [1] and isospin-multiplet average masses, we obtain the amplitudes

\[
\mathcal{A}_{\Omega^- \Xi^-\pi^0}^{(P)} = (3.31 \pm 0.08) \text{ GeV}^{-1} , \quad \mathcal{A}_{\Omega^- \Xi^0\pi^-}^{(P)} = (5.48 \pm 0.09) \text{ GeV}^{-1} ,
\]

up to an overall sign, where the relative sign between the amplitudes is chosen so that the \( |\Delta I| = 1/2 \) rule is approximately satisfied. Upon defining the \( |\Delta I| = 1/2, 3/2 \) amplitudes

\[
\alpha_1^{(\Omega)} \equiv \frac{1}{\sqrt{3}} \left( \alpha_{\Omega^- \Xi^-}^{(P)} + \sqrt{2} \alpha_{\Omega^- \Xi^0}^{(P)} \right) , \quad \alpha_3^{(\Omega)} \equiv \frac{1}{\sqrt{3}} \left( \sqrt{2} \alpha_{\Omega^- \Xi^-}^{(P)} - \alpha_{\Omega^- \Xi^0}^{(P)} \right) ,
\]

respectively, we can extract the ratio

\[
\frac{\alpha_3^{(\Omega)}}{\alpha_1^{(\Omega)}} = -0.072 \pm 0.013 ,
\]

which is similar to the result of Ref. [10]. This ratio is higher than the corresponding ratios in other hyperon decays [1], which range from 0.03 to 0.06 in magnitude, but not significantly so.

At tree level, the theoretical P-wave amplitudes arise from the diagrams displayed in Figure 1. The contact diagram, Figure 1(a), yields

\[
\alpha_{\Omega^- \Xi^-}^{(P)} = -4\sqrt{2} \left( 3C_{27} + C'_{27} \right) , \quad \alpha_{\Omega^- \Xi^0}^{(P)} = 4 \left( 3C_{27} + C'_{27} \right) ,
\]

whereas the kaon-pole diagram, Figure 1(b), gives

\[
\alpha_{\Omega^- \Xi^-}^{(P)} = -2CV_{ud}V^{*}_{us}g_{27} \frac{f^2_\pi}{m^2_K - m^2_\pi} , \quad \alpha_{\Xi^0\pi^-}^{(P)} = \sqrt{2}CV_{ud}V^{*}_{us}g_{27} \frac{f^2_\pi}{m^2_K - m^2_\pi} .
\]

The value of the constant \( 3C_{27} + C'_{27} \) can be extracted using the expression

\[
\alpha_3^{(\Omega)} = -4\sqrt{3} \left( 3C_{27} + C'_{27} \right) - \sqrt{6} CV_{ud}V^{*}_{us}g_{27} \frac{f^2_\pi}{m^2_K - m^2_\pi} .
\]
Figure 1: Tree-level diagrams for the $|\Delta I| = 3/2$ amplitudes of the P-wave $\Omega^- \to \Xi\pi$ decays. In all figures, a solid dot (hollow square) represents a strong (weak) vertex, and the strong vertices are generated by $L^s$ in Eq. (4). Here the weak vertices come from (a) $L^w_1$ in Eq. (12) and (b) $L^w_\phi$ in Eq. (5).

The kaon-pole term turns out to be small, being less than 10% of the experimental $\alpha_3^{(\Omega)}$, and so it will be neglected. Taking $f = f_\pi \approx 92.4\text{ MeV}$, we then find

$$3C_{27} + C'_{27} = (8.7 \pm 1.6) \times 10^{-3} \ G_F m_\pi^2 .$$

This value is consistent with power counting, being suppressed by approximately a factor of $\Lambda_{\chi_S}\beta_{27}$ with respect to the $\beta_{27}$ found in Ref. [7].

4 Octet-Hyperon Non-leptonic Decays

We now address the question of the size of the contribution of $L^w_1$ in Eq. (12) to octet-hyperon decays at one-loop. There are two terms in the amplitude for the decay $B \to B'\pi$, corresponding to S- and P-wave contributions. In our calculation we refer exclusively to the $|\Delta I| = 3/2$ component of these amplitudes. We follow Refs. [7, 11] to write the amplitude in the form

$$iM_{B \to B'\pi} = G_F m_\pi^2 \bar{a}_{B'} \left( A^{(S)}_{BB'\pi} + 2k \cdot S \ A^{(P)}_{BB'\pi} \right) u_B ,$$

where $k$ is the outgoing four-momentum of the pion. There are four independent amplitudes, and, as discussed in Ref. [6], we choose them to be $\Sigma^+ \to n\pi^+$, $\Sigma^- \to n\pi^-$, $\Lambda \to p\pi^-$ and $\Xi^- \to \Lambda\pi^-$. Contributions of $L^w_1$ to the S- and P-wave decay amplitudes at the one-loop level arise only from the diagrams of Figure 2, and they can be expressed in the form

$$A^{(S)}_{BB'\pi} = \frac{1}{\sqrt{2} f_\pi} \eta^{(S)}_{BB'} \frac{m_K^3}{24\pi f_\pi^2} ,$$

$$A^{(P)}_{BB'\pi} = \frac{1}{\sqrt{2} f_\pi} \left( \eta^{(P)}_{BB'} \frac{m_K^3}{24\pi f_\pi^2} + \beta^{(P)}_{BB'} \frac{m_K^2}{16\pi^2 f_\pi^2} \ln \frac{m_K^2}{\mu^2} \right) .$$

Here, we note that the $|\Delta I| = 3/2$ interaction, Eq. (12), does not contribute at one loop to $K \to \pi\pi$ decays, and so there is no constraint from the kaon sector.
Figure 2: One-loop diagrams contributing to the (a) S-wave and (b) P-wave amplitudes of the $|\Delta I| = 3/2$ non-leptonic decays of the spin-1/2 hyperons, with the weak vertices coming from $\mathcal{L}_w^\gamma$ in Eq. (12). A dashed line denotes an octet-meson field, and a single (double) solid-line denotes an octet-baryon (decuplet-baryon) field.

Implicit in this form is the prescription of Refs. [11, 7] in which only the non-analytic terms are kept. Interestingly, the only non-vanishing contribution to S-wave amplitudes occurs for $\Sigma$ decays and it is finite. Our results are

$$\eta^{(S)}_{\Lambda p} = \eta^{(S)}_{\Xi^- \Lambda} = 0,$$

$$\eta^{(S)}_{\Sigma^+ n} = \frac{16}{45} (6 + \sqrt{3}) \mathcal{C} (5C_{27} - 3C'_{27}), \quad \eta^{(S)}_{\Sigma^- n} = \frac{32}{45} (6 + \sqrt{3}) \mathcal{C} (-5C_{27} + 3C'_{27}),$$

$$\eta^{(P)}_{\Lambda p} = \frac{16\sqrt{2}}{45} (1 + 2\sqrt{3}) \mathcal{C} D \frac{-5C_{27} + 3C'_{27}}{m_{\Sigma} - m_N},$$

$$\eta^{(P)}_{\Xi^- \Lambda} = \frac{8\sqrt{2}}{45} \mathcal{C} D \frac{10(1 + 2\sqrt{3}) C_{27} - (2 + 7\sqrt{3}) C'_{27}}{m_{\Xi} - m_{\Sigma}},$$

$$\eta^{(P)}_{\Sigma^+ n} = \frac{16}{45} (6 + \sqrt{3}) \mathcal{C} (D + 3F) \frac{5C_{27} - 3C'_{27}}{m_{\Sigma} - m_N}, \quad \eta^{(P)}_{\Sigma^- n} = \frac{32}{45} (6 + \sqrt{3}) \mathcal{C} F \frac{-5C_{27} + 3C'_{27}}{m_{\Sigma} - m_N},$$
\[ \beta^\prime_{\Lambda p} = \frac{4}{27\sqrt{6}} C \left[ (54D + 162F + 5H) C_{27} - (90D + 54F + H) C'_{27} \right], \]
\[ \beta^\prime_{\Xi A} = \frac{4}{135\sqrt{6}} C \left[ (270D - 810F - 25H) C_{27} + (54D - 234F - 15H) C'_{27} \right], \]
\[ \beta^\prime_{\Sigma^+ n} = \frac{8}{135} C \left[ (10D - 125H) C_{27} + (-86D + 84F + 55H) C'_{27} \right], \]
\[ \beta^\prime_{\Sigma^- n} = \frac{4}{27} C \left[ (-62D + 54F + 35H) C_{27} + (18D - 18F - 27H) C'_{27} \right]. \]

5 Results and Conclusion

The contributions from Eq. (12) to octet-baryon non-leptonic decay can be summarized numerically in terms of \( C_{27} \) and \( C'_{27} \) as follows:

\[ S_3^{(A)} = S_3^{(\Xi)} = 0, \quad S_3^{(\Sigma)} = -100.6 C_{27} + 60.38 C'_{27}, \]
\[ P_3^{(A)} = 8.089 C_{27} - 4.127 C'_{27}, \quad P_3^{(\Xi)} = -33.62 C_{27} + 11.34 C'_{27}, \]
\[ P_3^{(\Sigma)} = 18.64 C_{27} - 10.42 C'_{27}. \]

Here, we have employed the parameter values \( D = 0.61, \ F = 0.40, \ C = 1.6, \ \text{and} \ H = -1.9, \) obtained in Ref. [12]. The measured rates for \( \Omega^- \rightarrow \Xi \pi \) only determine the combination \( 3C_{27} + C'_{27} \), as indicated in Eq. (22). As an illustration of the effect of these terms on the octet-hyperon non-leptonic decay, we present numerical results in Table 1, where we look at four simple scenarios to satisfy Eq. (22) in terms of only one parameter. For comparison, we show in the same Table the experimental value of the amplitudes as well as the best theoretical fit at \( O(m_s \log m_s) \) obtained in Ref. [7]. The new terms calculated here (with \( \mu = 1 \text{ GeV} \)), induced by \( \mathcal{L}_1^w \) in Eq. (12), are of higher order in \( m_s \) and are therefore expected to be smaller than the best theoretical fit. A quick glance at

| Amplitude | Experiment | Theory Ref. [7] |
|-----------|------------|-----------------|
| \( S_3^{(\Sigma)} \) | -0.107 ± 0.038 | -0.120 |
| \( P_3^{(A)} \) | -0.021 ± 0.025 | -0.023 |
| \( P_3^{(\Xi)} \) | 0.022 ± 0.023 | 0.027 |
| \( P_3^{(\Sigma)} \) | -0.110 ± 0.045 | -0.066 |

Table 1: New \( |\Delta I| = 3/2 \) contributions to S- and P-wave hyperon decay amplitudes compared with experiment and with the best theoretical fit of Ref. [7]. Here \( C_{27} \) and \( C'_{27} \) are given in units of \( 10^{-3} G_F m_s^2 \), and their values are chosen to fit the \( \Omega^- \rightarrow \Xi \pi \) decays.
Table I shows that in some cases the new contributions are much larger. Another way to gauge the size of the new contributions is to compare them with the experimental error in the octet-hyperon decay amplitudes. Since the theory provides a good fit at $O(m_s \log m_s)$, we would like the new contributions (which are of higher order in $m_s$) to be at most at the level of the experimental error. From Table I, we see that in some cases the new contributions are significantly larger than these errors. In a few cases they are significantly larger than the experimental amplitudes. All this indicates to us that the measured $\Omega^- \to \Xi \pi$ decay rates imply a $|\Delta I| = 3/2$ amplitude that may be too large and in contradiction with the $|\Delta I| = 3/2$ amplitudes measured in octet-hyperon non-leptonic decays.

Nevertheless, it is premature to conclude that the measured values for the $\Omega^- \to \Xi \pi$ decay rates must be incorrect because, strictly speaking, none of the contributions to octet-baryon decay amplitudes is proportional to the same combination of parameters measured in $\Omega^- \to \Xi \pi$ decays, $3C_{27} + C'_{27}$. It is possible to construct linear combinations of the four amplitudes $S_3^{(\Sigma)}$, $P_3^{(\Sigma)}$, $P_3^{(\Lambda)}$ and $P_3^{(\Xi)}$ that are proportional to $3C_{27} + C'_{27}$. We find that the most sensitive one is

$$\left( S_3^{(\Sigma)} - 4.2P_3^{(\Xi)} \right)_{\text{Exp}} = -0.2 \pm 0.1,$$

where we have simply combined the errors in quadrature. The contribution from Eq. (12) to this combination is

$$\left( S_3^{(\Sigma)} - 4.2P_3^{(\Xi)} \right)_{\text{Theory,new}} \approx 13 \left( 3C_{27} + C'_{27} \right) \approx 0.1,$$

which falls within the error in the measurement.

Our conclusion is that the current measurement of the rates for $\Omega^- \to \Xi \pi$ implies a $|\Delta I| = 3/2$ amplitude that appears large enough to be in conflict with measurements of $|\Delta I| = 3/2$ amplitudes in octet-baryon non-leptonic decays. However, within current errors and without any additional assumptions about the relative size of $C_{27}$ and $C'_{27}$, the two sets of measurements are not in conflict.

**Acknowledgments** This work was supported in part by DOE under contract number DE-FG02-92ER40730. We thank the theory group at Fermilab for their hospitality while part of this work was done. We also thank Xiao-Gang He, K. B. Luk and Sandip Pakvasa for conversations, and W. Bardeen for interesting discussions on the $|\Delta I| = 1/2$ rule.
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