Strong Isospin Mixing Effects on the Extraction of $\Delta I = \frac{3}{2}$ Non-Leptonic Hyperon Decay Amplitudes

ADP-95-4/T171

Kim Maltman

Department of Mathematics and Statistics, York University, 4700 Keele St.,
North York, Ontario, CANADA M3J 1P3

and

Department of Physics and Mathematical Physics, University of Adelaide
Adelaide, South Australia 5005, Australia

ABSTRACT

The existence of isospin admixtures in the physical $\Lambda, \pi^o$ complicates the extraction of $\Delta I = \frac{1}{2}$ non-leptonic hyperon decay amplitudes from experimental data, allowing contributions associated with large $\Delta I = \frac{1}{2}$ amplitudes to appear in the (nominally) $\Delta I = \frac{3}{2}$ amplitudes obtained ignoring these admixtures. We show how to correct for this effect to leading order in $(m_d - m_u)$ and extract the true $\Delta I = \frac{3}{2}$ amplitudes. The resulting corrections are modest ($< 25\%$) for s-waves, but extremely large, $\simeq 100\%$ and $\simeq 400\%$ for $\Lambda$ and $\Xi$ p-waves, respectively.
In a recent paper¹, Karl has demonstrated that the existence of $\Lambda^o - \Sigma^o$ mixing produces small but non-trivial corrections to $g_V, g_A$ in hyperon semi-leptonic decays. Here we investigate a analogous effects which alters the extraction of $\Delta I = \frac{3}{2}$ non-leptonic hyperon decay amplitudes from experimental data.

Recall that the physical $\Lambda$ and $\pi^o$ are admixtures of the pure $I = 0, 1$ isospin states $\Lambda^o$, $\Sigma^o$ and $\pi_8, \pi_3$, respectively (we use throughout the notation $\Lambda, \pi^o, \eta$ for the physical, mixed-isospin states, and $\Lambda^o, \Sigma^o, \pi_3, \pi_8$ for the pure isospin states). Since the isospin impurities are small, $O(10^{-2})$, we may write

$$\Lambda = \Lambda^o + \theta_b \Sigma^o$$

$$\pi^o = \pi_3 + \theta_m \pi_8 \ .$$

To leading order in the current quark masses, adopting the phase conventions of Ref. 2, one has³,⁴

$$\theta_m = -\theta_b = \frac{\sqrt{3}}{4} \left[ \frac{(m_d - m_u)}{m_s - (m_u + m_d)/2} \right] .$$

Following Ref. 1, all numbers quoted below will be based on the value $\theta_m \simeq 0.015$.

It is immediately obvious that the isospin admixtures in Eqn. (1) invalidate the usual procedure for extracting $\Delta I = \frac{3}{2}$ contributions to amplitudes from experimental data. To illustrate, consider the case of $\Lambda$ decay. The physical (s- or p-wave) amplitudes are given, in terms of the corresponding amplitudes involving only pure isospin states (which we shall henceforth call “isospin-purified” amplitudes) by

$$M(\Lambda \to p\pi^-) = M(\Lambda^o \to p\pi^-) - \theta_m M(\Sigma^o \to p\pi^-)$$

$$M(\Lambda \to n\pi^o) = M(\Lambda^o \to n\pi_3) + \theta_m [M(\Lambda^o \to n\pi_8) - M(\Sigma^o \to n\pi_3)] .$$

We know empirically that hyperon decay amplitudes are dominantly $\Delta I = \frac{1}{2}$ and can therefore ignore the small $\Delta I = \frac{3}{2}$ components of the $\Sigma$ amplitudes in the correction terms in Eqn. (3).
Let us write $\Delta I = \frac{1}{2}, \frac{3}{2}$ decompositions for the $\Lambda^o$ amplitudes

$$M(\Lambda^o \to p\pi^-) = \sqrt{\frac{2}{3}} c_{\Lambda}(1/2) - \sqrt{\frac{1}{3}} c_{\Lambda}(3/2)$$
$$M(\Lambda^o \to n\pi_3) = -\sqrt{\frac{1}{3}} c_{\Lambda}(1/2) - \sqrt{\frac{2}{3}} c_{\Lambda}(3/2),$$

(4)

where $c_{\Lambda}(1/2), c_{\Lambda}(3/2)$ are the $\Delta I = \frac{1}{2}$ and $\Delta I = \frac{3}{2}$ reduced matrix elements (with $\Lambda \to A, B$ for s- and p-waves, respectively), and use the $\Delta I = \frac{1}{2}$ relations

$$M(\Sigma^o \to p\pi^-) = -M(\Sigma^+ \to p\pi_3) = \frac{\sqrt{2}}{3} D^{3/2}_3(1/2) - \frac{\sqrt{2}}{3} D^{1/2}_3(1/2)$$
$$M(\Sigma^o \to n\pi_3) = \frac{1}{2}[M(\Sigma^+ \to n\pi^+) + M(\Sigma^- \to n\pi^-)] = \frac{2}{3} D^{3/2}_3(1/2) + \frac{1}{3} D^{1/2}_3(1/2)$$

(5)

for the $\Sigma$ amplitudes, where $D^{3/2}_3(1/2)$ and $D^{1/2}_3(1/2)$ are the reduced matrix elements of the $\Delta I = \frac{1}{2}$ transition operator for final $N\pi$ isospins $\frac{3}{2}$ and $\frac{1}{2}$, respectively, and we have ignored the small $\Delta I = \frac{3}{2}$ parts of the transitions. The $\Delta I = \frac{3}{2}$ component of the isospin-purified amplitudes can be extracted by forming the combination

$$c_{\Lambda}(3/2) = -\sqrt{\frac{1}{3}} M(\Lambda^o \to p\pi^-) - \sqrt{\frac{2}{3}} M(\Lambda^o \to n\pi_3).$$

(6)

If, however, we form the analogous combination of the physical amplitudes, we obtain

$$-\sqrt{\frac{1}{3}} M(\Lambda \to p\pi^-) - \sqrt{\frac{2}{3}} M(\Lambda \to n\pi^o) = c_{\Lambda}(3/2) - \theta_m \left[ \sqrt{\frac{2}{3}} M(\Lambda^o \to n\pi_8) - \sqrt{\frac{2}{3}} D^{3/2}_3(1/2) \right].$$

(7)

The terms proportional to $\theta_m$ in Eqn. (7), though pure $\Delta I = \frac{1}{2}$, enter the nominal $\Delta I = \frac{3}{2}$ combination. Since $\theta_m$ is of the same order as the normally extracted $\Delta I = \frac{3}{2}$ to $\Delta I = \frac{1}{2}$ amplitude ratio, these corrections may, in general, be expected to produce significant errors in extracting the true $\Delta I = \frac{3}{2}$ amplitudes. Similar corrections are present in the $\Delta I = \frac{3}{2}$ $\Xi$ relation and the $\Delta I = \frac{1}{2}$-rule-violating $\Sigma$ triangle relation.

To obtain the corrections necessary to convert the physical to the isospin-purified amplitudes, and hence to obtain the true $\Delta I = \frac{3}{2}$ contributions, we require the amplitudes for the processes $\Sigma^o \to n\pi_3, \Sigma^o \to p\pi^-, \Lambda^o \to n\pi_8, \Sigma^+ \to p\pi_8, \Xi^o \to \Lambda^o\pi_8, \Xi^- \to \Sigma^o\pi^-, \Xi^o \to \Sigma^o\pi_3$. 


and $\Omega \to \Xi^0\pi_8$. The first two of these can be obtained, to good accuracy, from the physical amplitudes for $\Sigma^+ \to n\pi^+$, $\Sigma^+ \to p\pi^0$ and $\Sigma^- \to n\pi^-$, using the $\Delta I = \frac{1}{2}$ relations of Eqn. (5).

The remaining correction amplitudes, however, are not observable, and must be obtained theoretically. We treat the s- and p-waves separately.

For the s-waves, it is well-known that a lowest order chiral SU(3) analysis provides an excellent fit to the experimental amplitudes\textsuperscript{2,6}. We, therefore, take the desired correction amplitudes from the same analysis. In terms of the usual $F, D$ parameters one obtains

$$A(\Lambda^0 \to n\pi_8) = -\sqrt{3}(3F + D)/2f_\pi$$
$$A(\Sigma^o \to n\pi_3) = -\sqrt{3}(F - D)/2f_\pi$$
$$A(\Sigma^o \to p\pi^-) = -\sqrt{6}(F - D)/2f_\pi$$
$$A(\Sigma^+ \to p\pi_8) = -3\sqrt{2}(F - D)/2f_\pi$$
$$A(\Xi^- \to \Sigma^o\pi^-) = \sqrt{6}(F + D)/2f_\pi$$
$$A(\Xi^o \to \Sigma^o\pi_3) = \sqrt{3}(F + D)/2f_\pi$$
$$A(\Xi^o \to \Lambda^o\pi_8) = \sqrt{3}(3F - D)/2f_\pi$$

with $f_\pi \simeq 93$ MeV the $\pi$ decay constant and $\frac{F}{D} = -0.92 \times 10^{-7}$, $D/F = -0.42$. The resulting corrections are presented in Table 1, where we display the experimental amplitudes, together with the corrections to be added to convert them to the corresponding isospin-purified amplitudes. Extracting, then, the true $\Delta I = \frac{3}{2}$ combinations, $A_\Lambda(3/2)$, $A_\Xi(3/2)$ and $\Delta^3 = A(\Sigma^+ \to n\pi^+) - A(\Sigma^- \to n\pi^-) - \sqrt{2}A(\Sigma^+ \to p\pi_3)$ one finds

$$A_\Lambda(3/2) = 0.059 \times 10^{-7} - 0.0047 \times 10^{-7}$$
$$A_\Xi(3/2) = -0.227 \times 10^{-7} - 0.050 \times 10^{-7}$$
$$\Delta^3 = 0.499 \times 10^{-7} + 0.177 \times 10^{-7}$$

where, in all cases, the first number is obtained using the uncorrected physical amplitudes.
and the second is the correction resulting from using, instead, the isospin-purified amplitudes. The corrections, in this case, are modest, no more than \( \simeq 25\% \).

The situation for the p-wave amplitudes is rather different. Here, as is well-known, the leading contributions are expected to be due to baryon pole graphs produced through parity-conserving (PC) weak baryon-baryon transitions. The SU(3) parametrization of these transitions obtained from the leading soft-pion analysis of the s-wave decays, however, fails miserably in accounting for the p-wave amplitudes. A reasonable fit, including now small \( K \) pole contributions, can be obtained\(^7\) only by using a considerably different SU(3) parametrization. Even then the fit is not nearly as good as in the s-wave case and, although ideas exist for explaining the apparent discrepancy between \( s \)- and p-wave fit parameters\(^2\), the theoretical situation is not at all clear, giving us somewhat less confidence in the extraction of values for the unobservable amplitudes. In order to investigate theoretical uncertainties we will, therefore, also evaluate the p-wave correction amplitudes using the model of Ref. 8, which includes \( K \) pole as well as \( \frac{1}{2}^+ \) and \( \frac{1}{2}^{++} \) baryon pole contributions to the amplitudes. This model actually provides a somewhat better numerical fit to the data, though at the cost of employing a \( K \)-to-\( \pi \) weak transition strength an order of magnitude greater than that extracted from \( K \to \pi\pi \), which makes it appear somewhat suspect. As we will see, the resulting corrections to the extracted \( \Delta I = \frac{3}{2} \) amplitudes turn out to be rather similar in the two cases, giving us improved confidence in our numerical results, despite the increased theoretical uncertainty.

We begin with the fit of Refs. 2,7. \( F_A, D_A \) are the axial vector coupling parameters \((F_A + D_A = 1.25)\) relevant to the pseudovector couplings of the pseudoscalar octet to the baryon octet, and \( f, d \) those for the baryon-baryon weak couplings. The parametrization of Ref. 7 is \( D_A/F_A = 1.8, \ d/f = -0.85, \ f = 4.7 \times 10^{-5} \text{ MeV} \). The expressions for the ground state baryon pole contributions to the isospin-purified versions of the observed p-wave amplitudes are given in Ref. 8 (Eqns. (3.2) and (3.9)). To convert these expressions to our conventions,
the $f_\pi$ of Ref. 8 must be replaced by $\sqrt{2}f_\pi$. There is also a typographical error in the second term of the last of Eqns. (3.9), where (3$f + d$) should read (3$f - d$). The ground state pole contributions to those correction amplitudes not quoted in Ref. 8, and not obtainable from the $\Sigma^o$ $\Delta I = \frac{1}{2}$ relations, are then

$$B_p(\Lambda^o \rightarrow n\pi s) = \frac{(m_N + m_\Lambda)}{6f_\pi} \frac{[(3f + d)(3F_A + D_A)]}{(m_\Lambda - m_N)}$$

$$B_p(\Sigma^+ \rightarrow p\pi s) = \sqrt{\frac{3}{2}} \frac{(m_N + m_\Sigma)}{f_\pi} \frac{[(f - d)(F_A - D_A)]}{(m_\Sigma - m_N)}$$

$$B_p(\Xi^o \rightarrow \Lambda^o \pi s) = -\frac{(m_\Lambda + m_\Xi)}{6f_\pi} \frac{[(3f - d)(3F_A - D_A)]}{(m_\Xi - m_\Lambda)}$$

$$B_p(\Xi^o \rightarrow \Sigma^o \pi s) = -\frac{(m_\Sigma + m_\Xi)}{6f_\pi} \frac{[(3f + d)(F_A + D_A)]}{(m_\Xi - m_\Sigma)} + \frac{2(3f - d)D_A}{(m_\Xi - m_\Lambda)}$$

$$B_p(\Xi^- \rightarrow \Sigma^o \pi^-) = -\frac{(m_\Xi + m_\Delta)}{\sqrt{2}f_\pi} \frac{[(f + d)(F_A + D_A)]}{(m_\Xi - m_\Sigma)}$$

(10)

The $K$ pole contributions can be obtained in terms of $D_A$, $F_A$ and the $K$-to-$\pi$ transition matrix element $a_{K^\pi} = \langle \pi^- | H_{PC}^{weak} | K^- \rangle$, if one takes the $K$-to-$\pi$ and $K^{\ast}$-to-$\pi s$ transitions elements to be given by the lowest order chiral effective Lagrangian\textsuperscript{2,6}. Using $K \rightarrow \pi \pi$ data\textsuperscript{2}, and dropping again the small $\Delta I = \frac{1}{2}$ contributions, one finds $a_{K^\pi} = 3.18 \times 10^{-3}$ MeV\textsuperscript{2}, and $\langle \pi^o | H_{PC}^{weak} | K^{\ast} \rangle = -a_{K^\pi}/\sqrt{2}$, $\langle \pi s | H_{PC}^{weak} | K^{\ast} \rangle = -a_{K^\pi}/\sqrt{2}$. (A numerically very similar relation between the $\pi_{3,8}$ matrix elements results from estimating them using the QCD-evolved effective weak Hamiltonian in the factorization approximation.) The $K$ pole contributions to the isospin-purified versions of the observed amplitudes are then as quoted in the “Fit b” column of Table 6.10 of Ref. 2, while the corresponding contributions to the correction amplitudes are obtainable, for $\Sigma^o$, from the $\Delta I = \frac{1}{2}$ relations, and otherwise, from

$$B_K(\Lambda^o \rightarrow n\pi s) = -\frac{a_{K^\pi}}{6\sqrt{2}} \frac{[(m_N + m_\Lambda)]}{(m_K^2 - m_\Xi^2)} \frac{(3F_A + D_A)}{f_K}$$

$$B_K(\Sigma^+ \rightarrow p\pi s) = \frac{a_{K^\pi}}{2\sqrt{3}} \frac{[(m_N + m_\Sigma)]}{(m_K^2 - m_\Xi^2)} \frac{(D_A - F_A)}{f_K}$$

$$B_K(\Xi^o \rightarrow \Lambda^o \pi s) = \frac{a_{K^\pi}}{6\sqrt{2}} \frac{[(m_\Lambda + m_\Xi)]}{(m_K^2 - m_\Xi^2)} \frac{(3F_A - D_A)}{f_K}$$

$$B_K(\Xi^o \rightarrow \Sigma^o \pi_3) = -\frac{a_{K^\pi}}{2\sqrt{2}} \frac{[(m_\Xi + m_\Sigma)]}{(m_K^2 - m_\Xi^2)} \frac{(F_A + D_A)}{f_K}$$

$$B_K(\Xi^- \rightarrow \Sigma^o \pi^-) = -\frac{a_{K^\pi}}{2} \frac{[(m_\Xi + m_\Delta)]}{(m_K^2 - m_\Xi^2)} \frac{(F_A + D_A)}{f_K}$$

(11)
where the overall sign has been adjusted as in Ref. 2. The $K$ pole terms are, in all cases, much smaller than the baryon pole terms. The resulting total amplitudes are listed in column 1 of Table 2, the corresponding physical amplitudes (where such exist) in column 3. The $\Sigma^o$ amplitudes are obtained using the $\Delta I = \frac{1}{2}$ relations, rather than from the model.

For the alternate model of Ref. 8, the ground state pole contributions employ the parametrization $F_A = 0.43$, $D_A = 0.82$ and $f/d = -1.5$, with $f = 3.9 \times 10^{-5}$ MeV (the $f,d$ values being obtained from a fit to the s-wave amplitudes which includes $70^-$ baryon pole terms in addition to the usual commutator terms), and are given formally by Eqns (3.29) of Ref. 8 and Eqns. (10) above (recall the difference in conventions for $f_\pi$). The $K$ pole contributions can be obtained from those above by simply rescaling by the ratio, $-10.7$, of $a_{K\pi}$ in the two models. The remaining contributions, associated with the $\frac{1}{2}^+\Sigma$ baryon poles, are given in terms of $F^*, D^*$ values for the $BB^*\pi$ couplings, $f'', d''$ values for the $<B^*|H_{PC}|B>$ couplings, the mean splitting, $\omega \simeq 500$ MeV of the $\frac{1}{2}^+$ and $\frac{1}{2}^+\Sigma$ multiplets, and the mean splitting, $\delta m \simeq 200$ MeV, of baryons in a given multiplet differing by one unit of strangeness. The relations $d''/f'' = -1$ and $F^*/D^* = 1.91$ are assumed, $F^*$ is fit to the $P_{11}(1440)$ decay width, and $d'' = -4.4 \times 10^{-5}$ MeV obtained by optimizing the the p-wave amplitude fit. The contributions of these poles to the isospin-purified versions of the observed amplitudes are given by Eqns. (3.2), (3.21) of Ref. 8 and those to the correction amplitudes not obtainable using the $\Sigma^o \Delta I = \frac{1}{2}$ relations by

\begin{align}
B_*(\Lambda^o \to n\pi_8) &= \frac{2d''(m_N + m_A)}{3\sqrt{2}(2m_N + \omega)} \left[ \frac{(3F^* - D^*)}{(2m_N + \omega)} - \frac{2D^*\alpha}{(\omega + \delta m)} \right] \\
B_*(\Sigma^+ \to p\pi_8) &= \frac{2d''(m_N + m_{\Sigma})}{\sqrt{2}(2m_N + \omega)} \left[ \frac{(3F^* - D^*)}{(\omega - \delta m)} + \frac{2D^*\alpha}{(\omega + \delta m)} \right] \\
B_*(\Xi^o \to \Lambda^o\pi_8) &= \frac{4d''(m_A + m_{\Xi})}{3\sqrt{2}(2m_N + \omega)} \left[ \frac{2D^*\alpha}{(\omega - \delta m)} + \frac{(3F^* + D^*)\beta}{(\omega + \delta m)} \right] \\
B_*(\Xi^o \to \Sigma^o\pi_3) &= \frac{-8d''(m_{\Sigma} + m_{\Xi})}{3\sqrt{2}(2m_N + \omega)} \left[ \frac{D^*\alpha}{(\omega - \delta m)} \right] \\
B_*(\Xi^- \to \Sigma^o\pi^-) &= 0
\end{align}

(12)

where $\alpha = (2m_N + \omega)/(2m_N + 2\omega + 2\delta m) = 0.86$ and $\beta = (2m_N + \omega)/(2m_N + \omega + 4\delta M) = 0.75$. The total
amplitudes are listed in column 2 of Table 2. The $\Sigma^o$ amplitudes are again taken, not from the model, but from the experimental amplitudes, using the $\Delta I = 1/2$ relations. As mentioned above, the model of Ref. 8 actually appears somewhat suspect, in view of the large value of $a_{K\pi}$. Moreover, as can be seen from Table II of Ref. 8, although the numerical fit to the p-wave amplitudes is quite reasonable, there is considerable cancellation amongst the three independent contributions. The point of employing the model is simply to test the potential model-dependence of the computed corrections to the physical amplitudes.

We tabulate, in Table 3, the predicted corrections to the experimental p-wave amplitudes. Column 1 re-lists, for convenience, the experimental values, while columns 2,3 contain the corrections obtained using the models of Refs. 2,7 (8), respectively. The results of column 2(3) are to be added to those of column 1 to convert from the experimental to the isospin-purified versions of the amplitudes in question. While there are non-trivial differences in the predicted corrections for the $\Sigma^+ \rightarrow p\pi^o$ and $\Xi^- \rightarrow \Lambda\pi^-$ amplitudes in the two models, when we calculate the p-wave $\Delta I = 3/2$ quantities, $B_{\Lambda}(3/2)$, $B_{\Xi}(3/2)$ and $\Delta B_{\Sigma}$, we find for the two models

$$B_{\Lambda}(3/2) = 0.141 \times 10^{-7} + 0.526 \times 10^{-7}(0.566 \times 10^{-7})$$
$$B_{\Xi}(3/2) = 0.530 \times 10^{-7} + 0.755 \times 10^{-7}(0.643 \times 10^{-7})$$
$$\Delta B_{\Sigma} = 5.92 \times 10^{-7} - 0.77 \times 10^{-7}(0.42 \times 10^{-7})$$

(13)

where, as for the s-wave case, the second term in each equation represents the correction, and the first term the value extracted using the uncorrected physical amplitudes. The corrections, at least for $\Lambda$ and $\Xi$ decays, are model-independent at the $10 - 15\%$ level. They are also very large, the ratio of corrected to uncorrected values being $4.73(5.01)$ for $\Lambda \rightarrow N\pi$ and $2.42(2.21)$ values for $\Xi \rightarrow \Lambda\pi$, for the models of Refs. 2,7 (8), respectively.

We conclude with a discussion of the decays $\Omega \rightarrow \Xi^-\pi^o$ and $\Omega \rightarrow \Xi^o\pi^-$, which are dominated by the PC p-wave process. They are expected to have very small baryon pole contributions$^9-11$, and hence be dominated by the $K$ pole term. Neglecting the baryon
pole term completely and recalling that the $\pi_8 K$ pole contribution is $1/\sqrt{3}$ that for $\pi_3$ in leading order, we obtain

$$
B(\Omega \to \Xi^-\pi_3) = (1 - \theta_m/\sqrt{3})B(\Omega \to \Xi^-\pi^o) .
$$

(14)

The resulting change in the extracted $\Delta I = \frac{3}{2}$ amplitude is only $+5.7\%$. If we use, instead, the results of Ref. 11 for the baryon pole and $K$ pole contributions, and the fact that the $10_F \to 8_F \times 8_F \pi_8$ strong coupling is $-\sqrt{3}$ times that for $\pi_3$, the correction term in Eqn. (14) is increased by a factor of 1.38, leading to a net change in the $\Delta I = \frac{3}{2}$ amplitude of $+7.9\%$. In either case the correction is small. This smallness results, first, from the small coefficient in Eqn. (14) and, second, from the fact that the nominal $\Delta I = \frac{1}{2}$ to $\Delta I = \frac{3}{2}$ ratio is much smaller in this case than for other hyperon decays.

It should be noted that, in making the estimates above, we have ignored isospin-mixing due to electromagnetism (EM). It is easy to see that this is a rather good approximation. First, the EM $\pi_3 - \pi_8$ mixing is known to vanish at leading order in the chiral expansion\textsuperscript{12}, and hence will be very small. Second, using $U$-spin arguments, one may derive\textsuperscript{13}, for $\Lambda^o - \Sigma^o$ mixing, the generalized Coleman-Glashow relation

$$
\delta m_{\Lambda^o\Sigma^o}^{\text{EM}} = \frac{1}{\sqrt{3}} [\delta m_{\Sigma^o} - \delta m_{\Sigma^+} - \delta m_n + \delta m_p]^{\text{EM}} .
$$

(15)

If one then uses the estimates of Ref. 3 for the octet baryon EM self-energies (based on the Cottingham formula), one finds $\delta m_{\Lambda^o\Sigma^o}^{\text{EM}} = -0.09$ MeV, which would alter $\theta_b$ by less than $8\%$. Since such a shift is significantly smaller than the $\simeq 20\%$ effects one might expect beyond leading order in the quark masses, we neglect it. We have, similarly, neglected the effects of mixing between $\pi_3$ and $\pi_o$, where $\pi_o$ is the SU(3) scalar member of the pseudoscalar nonet. Again one can see that this is likely to be a good approximation since, for s-waves, the leading $\pi_o$ commutator terms vanish, while for p-waves, using the pole model picture, the $K$ pole terms remain small and the sum of the two distinct baryon pole terms vanishes for
each $\pi_o$ decay process as a result of the SU(3) scalar nature of the $B'B\pi_o$ strong couplings. Combined with the fact that, using quark model arguments, one expects the $\pi_3 - \pi_o$ mixing angle to be $\simeq 0.4\theta_m$, such contributions to the corrections should be safely negligible. (It should be noted that an analogous treatment of particle mixing effects for the s-wave amplitudes was performed previously by de la Torre\textsuperscript{14}. The numerical values of the corrections differ considerably from those obtained here. The origin of the difference is a very large EM contribution to $\Lambda^o - \Sigma^o$ mixing (17 times that obtained from Eqn. (15)), which is 3 times as large as the mass mixing contribution and of opposite sign. This contribution is obtained using the quark model picture for the baryons, together with the SU(3) limit of one photon exchange. The resulting EM contributions, however, do not satisfy the SU(3) relation Eqn. (15). The situation is presumably similar to that of the pseudoscalar sector where the analogous treatment, ignoring the class of photon loop graphs, fails to satisfy the known chiral constraints\textsuperscript{15} on the pseudoscalar EM self-energies\textsuperscript{16}, e. g., the vanishing of the $\pi_3$ EM self-energy and $\pi_3 - \pi_8$ EM mixing.)

In conclusion, we have demonstrated that corrections due to $\Lambda^o - \Sigma^o$ and $\pi_3 - \pi_8$ mixing are required in order to extract the true $\Delta I = \frac{3}{2}$ transition amplitudes from experimental data on hyperon non-leptonic decays. The corrections are modest, though non-trivial, for s-waves amplitudes, and extremely large, though somewhat model-dependent, for p-wave amplitudes. It is to the corrected values, and not those usually extracted, that any attempts to model the $\Delta I = \frac{3}{2}$ amplitudes must be compared.
ACKNOWLEDGEMENTS

I would like to thank John Donoghue for bringing the work of Ref. (14) to my attention. The continuing support of the Natural Sciences and Engineering Research Council of Canada, and the hospitality of the Department of Physics and Mathematical Physics of the University of Adelaide are also gratefully acknowledged.
REFERENCES

1. G. Karl, Phys. Lett. **B328** (1994) 149
2. J.F. Donoghue, E. Golowich and B. Holstein, Phys. Rep. **131** (1986) 319
3. J. Gasser and H. Leutwyler, Phys. Rep. **87** (1982) 77
4. J.F. Donoghue, Ann. Rev. Nucl. Part. Sci. **39** (1989) 1
5. Particle Data Group, Review of Particle Properties, Phys. Rev. **D45** (1992)
6. A very clear exposition of the lowest order chiral analysis may be found in J.F. Donoghue, E. Golowich and B. Holstein, “Dynamics of the Standard Model”, Cambridge University Press, New York, N.Y., 1992
7. M. Gronau, Phys. Rev. Lett. **28** (1972) 188
8. G. Nardulli, Il Nuov. Cim. **100A** (1988) 485
9. J. Finjord, Phys. Lett. **B76** (1978) 116
10. J. Finjord and M.K. Gaillard, Phys. Rev. **D22** (1980) 778
11. M. Lusignoli and A. Pugliese, Phys. Lett. **B132** (1983) 178
12. R. Dashen, Phys. Rev. **183** (1969) 1245
13. R.H. Dalitz and F. von Hippel, Phys. Lett. **10** (1964) 153
14. L. de la Torre, “On Particle Mixing and Hypernuclear Decay”, Univ. of Mass. PhD thesis, Sept. 1992
15. R. Dashen, Phys. Rev. **183** (1969) 1245
16. K. Maltman, G.J. Stephenson Jr. and T. Goldman, Nucl. Phys. **A530** (1991) 539
Table 1. Corrections to the s-wave amplitudes\(^a\)

| Process           | Experiment | Correction |
|-------------------|------------|------------|
| \(\Lambda \rightarrow p\pi^-\) | 3.25       | 0.048      |
| \(\Lambda \rightarrow n\pi^o\) | -2.37      | -0.028     |
| \(\Sigma^+ \rightarrow p\pi^o\) | -3.27      | -0.083     |
| \(\Sigma^+ \rightarrow n\pi^+\) | 0.13       | 0          |
| \(\Sigma^- \rightarrow n\pi^-\) | 4.27       | 0          |
| \(\Xi^- \rightarrow \Lambda\pi^-\) | -4.51      | -0.020     |
| \(\Xi^o \rightarrow \Lambda\pi^o\) | 3.43       | 0.068      |

\(^a\)All entries in units of \(10^{-7}\). To obtain, e. g. \(A(\Lambda^o \rightarrow n\pi_3)\) one adds the results of columns 2,3 for the process \(\Lambda \rightarrow n\pi^o\).
Table 2. Octet hyperon p-wave amplitudes\textsuperscript{a}

| Process                  | Model 1 | Model 2 | Experiment |
|--------------------------|---------|---------|------------|
| $\Lambda^o \rightarrow p\pi^-$ | 16.3    | 17.9    | 22.1       |
| $\Lambda^o \rightarrow n\pi_3$ | -11.4   | -12.8   | -15.8      |
| $\Sigma^+ \rightarrow p\pi_3$ | 20.3    | 32.6    | 26.6       |
| $\Sigma^+ \rightarrow n\pi^+$ | 28.4    | 45.8    | 42.4       |
| $\Sigma^- \rightarrow n\pi^-$ | -0.8    | -0.3    | -1.44      |
| $\Xi^- \rightarrow \Lambda^o\pi^-$ | 23.9    | 13.3    | 16.6       |
| $\Xi^o \rightarrow \Lambda^o\pi_3$ | -17.0   | -9.4    | -12.3      |
| $\Sigma^o \rightarrow p\pi^-$ | -26.6   | -26.6   | —          |
| $\Sigma^o \rightarrow n\pi_3$ | 20.4    | 20.4    | —          |
| $\Lambda^o \rightarrow n\pi_8$ | 44.5    | 46.2    | —          |
| $\Sigma^+ \rightarrow p\pi_8$ | -34.5   | -20.0   | —          |
| $\Xi^- \rightarrow \Sigma^o\pi^-$ | -15.0   | -3.6    | —          |
| $\Xi^o \rightarrow \Sigma^o\pi_3$ | -63.7   | -43.5   | —          |
| $\Xi^o \rightarrow \Lambda^o\pi_8$ | -20.9   | -0.5    | —          |

\textsuperscript{a}All entries in units of $10^{-7}$. Models 1,2 are the models of Refs. 2,7 and 8, respectively, and are described in the text. Experimental values refer, where listed, to the corresponding physical amplitude.
Table 3. Corrections to the p-wave amplitudes\textsuperscript{a}

| Process               | Experiment | Model 1 | Model 2 |
|-----------------------|------------|---------|---------|
| $\Lambda \to p\pi^-$  | 22.1       | -0.399  | -0.399  |
| $\Lambda \to n\pi^0$ | -15.8      | -0.362  | -0.388  |
| $\Sigma^+ \to p\pi^0$| 26.6       | 0.518   | 0.300   |
| $\Sigma^+ \to n\pi^+$| 42.4       | 0       | 0       |
| $\Sigma^- \to n\pi^-$| -1.44      | 0       | 0       |
| $\Xi^- \to \Lambda\pi^-$| 16.6      | -0.225  | -0.053  |
| $\Xi^0 \to \Lambda\pi^0$| -12.3     | -0.642  | -0.644  |

\textsuperscript{a}All entries in units of $10^{-7}$. Models 1,2 are as described in Table 2. To obtain, e. g. $B(\Lambda^o \to n\pi_3)$, one adds the entry of column 2(or 3) to that of column 1 for the corresponding physical process $\Lambda \to n\pi^o$. 
