Symmetries and Dynamics of Nonleptonic Decays*

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It is shown that the strength of the $K_1 \to$ vacuum vertex, arising solely through medium-strong $SU(3)$-breaking interactions, is large and can provide a natural explanation for the octet enhancement of the parity-violating nonleptonic amplitudes. Furthermore, the sum rule $-A(\Lambda \to p+\pi^-)+2A(\Xi^- \to \Lambda+\pi^-) = \sqrt{3}A(\Sigma^+ \to p+\pi^0)$ for parity-violating hyperon decays, derived on the basis of the λ_6 transformation, also holds if the amplitudes are dominated by any or all of the following: the baryon octet, baryon decuplet, or scalar- or vector-octet pole terms, arising through the K_1 tadpole. This is true even though the latter transforms like λ_7. Thus it is concluded that neither the forbiddenness of the K_1 tadpole in the limit of $SU(3)$ nor the existence of the sum rule for the parity-violating decays on the basis of the λ_6 transformation provide any argument against a possible dynamical picture of octet enhancement in nonleptonic transitions. The dynamics considered in the present note should be important regardless of whether the octet transformation has a dynamical or primary origin. Comments are also made on some other directly related problems: (i) the possible effect of symmetry violation on an otherwise forbidden transition (especially $K_1 \to 2\pi$ decay), (ii) the meaning of enhancement of nonleptonic rates compared with leptonic ones, and (iii) the ratio of $\Gamma(K^+ \to \pi^+ + \pi^0)$ to $\Gamma(K_1 \to \pi^+ + \pi^-)$.

IT has been proposed that the nonleptonic (NL) $\Delta T = \frac{1}{2}$ rule is either (a) primary, so that in the current $\times$ current picture, it must be built out of products of charged as well as neutral hadron currents; or (b) it is dynamical,[1,2] in which case the primary Lagrangian involves both $\Delta T = \frac{1}{2}$ and $\frac{3}{2}$ components, but the dynamics enhances[1,2] transitions involving $\Delta T = \frac{1}{2}$ relative to the $\frac{3}{2}$ ones.

In the eightfold way the natural generalizations of (a) and (b) are: Either (a′) the primary NL Lagrangian transforms purely like an octet, or (b′) the dynamics enhances the octet[3] transitions relative to the 27-plet ones. Some suggestions[4,5] have been made to distinguish between these possibilities experimentally. Pending such a distinction, there have been some theoretical arguments in favor of (a) and (a′). They are:

(I) If one assumes CP invariance and that the NL Lagrangian is built out of products of usual[6] Cabibbo[7] currents, it follows[8,9] that the octet part of both the parity-violating (p.v.) and parity-conserving (p.c.) decay Lagrangian must transform like λ_6 (rather than λ_7). This forbids the $K_1 \to$ vacuum-tadpole as well as the $K_1 \to 2\pi$ decay in the limit of $SU(3)$. The forbiddenness of the former, it has been pointed out,[8] makes the alternative (b) or (b′) somewhat less attractive than it was without $SU(3)$.

(II) Secondly the sum rule[10] $[-A(\Lambda \to p+\pi^-) + 2A(\Xi^- \to \Lambda+\pi^-) = \sqrt{3}A(\Sigma^+ \to p+\pi^0)]$ for the parity-violating amplitudes in hyperon decays, derived[8] on the basis of λ_6 transformation, is found to be consistent[11] with experiment. If such amplitudes were dominated by the K_1 tadpole, one should not expect[12] the sum rule to hold, since the K_1 tadpole effectively transforms like λ_7, which does not predict the sum rule in general.

The *purpose* of this note is to stress that neither of the above two arguments against the dynamical scheme (b) and (b′) is convincing; both (I) and (II) can be circumvented in a relatively simple and reasonable way. We show that the strength of the K_1-vacuum vertex, arising solely through $SU(3)$ violation, is in fact capable of providing a natural explanation for the octet enhance-

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[1] S. Oneda, J. C. Pati, and B. Sakita, Phys. Rev. **119**, 482 (1960); Phys. Rev. Letters **6**, 24 (1961). The possibility of a dynamical $\Delta T = \frac{1}{2}$-rule was proposed in these papers on the basis of fundamental Sakata triplet (Λ,n,p). This was based on the observation that transitions involving $\Lambda \leftrightarrow n$, which automatically satisfy $\Delta T = \frac{1}{2}$, make dominant contributions to NL decays as compared to other structures. Such a picture may still be maintained at least qualitatively if quarks (Λ',n',p') or some other heavy triplets turn out to be real and fundamental, in which case transitions involving $\Lambda' \leftrightarrow n'$ not only satisfy $\Delta T = \frac{1}{2}$, but also the desired octet transformation property under $SU(3)$. In the dynamical sense such explanations may be regarded as partially equivalent to the tadpole models of Refs. 2 and 3.

[2] A. Salam and J. C. Ward, Phys. Rev. Letters **5**, 390 (1960). A simple explanation of possible dynamical $\Delta T = \frac{1}{2}$ rule was proposed in this paper on the basis of dominance of the K_1 tadpole. To extend this picture to parity-conserving decays one will presumably need the existence of the scalar K meson. However, see A. Salam, Phys. Letters **8**, 217 (1964).

[3] S. Coleman and S. L. Glashow, Phys. Rev. **134**, B681 (1964). In this work the octet enhancement in NL amplitudes was attributed to the existence of an octet of pseudoscalar mesons and possibly scalar mesons, which give rise to K_1 and κ_1 tadpoles, respectively.

[4] R. Dashen, S. Frautschi, M. Gell-Mann, and Y. Hara, *Eight-Fold Way* (W. A. Benjamin, Inc., New York, 1964), p. 254.

[5] J. C. Pati and S. Oneda, Phys. Rev. **136**, B1097 (1964).

[6] To obtain the λ_6 transformation, it is crucial to take the usual Cabibbo currents (Ref. 7) with $\theta_V = +\theta_A$. Any departure will not lead to the λ_6 transformation [see for example, K. Matsumoto, M. Nakagawa and Y. Ohnuki, Prog. Theoret. Phys. (Kyoto) **32**, 668 (1964) and Ref. 3], although the discussion in the present note will still be relevant.

[7] N. Cabibbo, Phys. Rev. Letters **10**, 531 (1963).

[8] M. Gell-Mann, Phys. Rev. Letters **12**, 155 (1964).

[9] N. Cabibbo, Phys. Rev. Letters **12**, 62 (1964).

[10] K. Fujii and D. Ito, Progr. Theoret. Phys. (Kyoto) **30**, 718 (1963). B. W. Lee, Phys. Rev. Letters **12**, 83 (1964). H. Sugawara, Progr. Theoret. Phys. (Kyoto) **31**, 213 (1964). B. Sakita, Phys. Rev. Letters **12**, 379 (1964).

[11] M. L. Stevenson, J. P. Berge, J. R. Hubbard, G. R. Kalbfleisch, J. B. Schafer, F. T. Solmitz, S. G. Wojcicki, and P. G. Wohlmut, Phys. Letters **9**, 349 (1964).

[12] See (for example) footnote 22 of Ref. 4.

ment and that the sum rule for p.v. hyperon decays is expected to hold, even if the amplitudes are dominated by the K_1 tadpole corresponding to λ_7 transformation. We also comment on some other directly related problems: (i) the possible effect of symmetry violation on an otherwise forbidden transition, (ii) the meaning of the enhancement of NL rates compared with the leptonic ones, and (iii) the ratio of $\Gamma(K^+\to\pi^++\pi^0)$ to $\Gamma(K_1\to\pi^++\pi^-)$.

For the purpose of this work, we will confine our attention to parity-violating decays only. Firstly we note that in reality[13] the strength of the K_1 tadpole is *large* to the same extent that $K_1\to 2\pi$ decay occurs, although both are forbidden in the limit of $SU(3)$. To be more precise, let us suppose that we estimate the strength of the K_1 tadpole from the observed rate of the $K_1\to\pi^++\pi^-$ decay as follows: We write an unsubtracted dispersion relation for the amplitude in the variable $t=(P_K-P_{\pi^+}-P_{\pi^-})^2$ and evaluate the dispersion integral at $t=0$. Assuming that the integral is dominated by low-lying meson states, the $K_1\to 2\pi$ amplitude would then be dominated in the sense of dispersion theory by the process $K_1\to K_1+\pi+\pi\to\pi+\pi$. We may reasonably estimate (within perhaps a factor of 2–3) the strength of the $KK\pi\pi$ vertex from that of $\pi\pi\pi\pi$ coupling through unitary symmetry. Inserting this strength[14] into the $K_1\to 2\pi$ amplitude, the strength of the K_1 tadpole is found to be

$$i|g_{K_1}m^3|=i\left\{\frac{\Gamma(K_1\to\pi^++\pi^-)m_K{}^5}{64\pi\lambda^2[1-4(m_\pi/m_K)^2]^{1/2}}\right\}^{1/2}\approx i\frac{(0.75\times10^{-8})}{|\lambda|}m_K{}^3,\quad(1)$$

where $4\pi\lambda$ denotes the strength of the $\pi\pi\pi\pi$ coupling $(|\lambda|\simeq0.18)$.[15]

To examine whether such a strength can account for the observed magnitudes of p.v. amplitudes in hyperon decays, let us estimate the corresponding amplitude for $\Lambda\to p+\pi^-$ decay (for example) via[16] $\Lambda\to n+\bar{K}^0\to n\to p+\pi^-$. Inserting the strength of K_1-tadpole given by Eq. (1) in the second step and using $g_{\pi N}{}^2/4\pi\simeq15$, we find

$$|A(\Lambda\to p+\pi^-)|\simeq|g_{\Lambda n\bar{K}^0}/\lambda|(3.5\times10^{-8}).\quad(2)$$

Taking $g_{\Lambda n\bar{K}^0}{}^2/4\pi\simeq1-10$ (say), which seems reasonable, and $|\lambda|=0.18$, the right-hand side of (2) is $(1-3.3)(7\times10^{-7})$, to be compared with the observed value 3.3×10^{-7}. A similar situation holds for $\Sigma\to N+\pi$ and $\Xi\to\Lambda+\pi$ decays. We thus see that the strength of the K_1 tadpole, estimated from the $K_1\to\pi^++\pi^-$ rate, is in fact *large enough* to account for the observed magnitudes of the p.v. hyperon-decay amplitudes. It could thus provide a *natural explanation* for the *octet enhancement* in the dynamical scheme [(b) and (b′)], while in the primary scheme [(1) and (a′)] it would still provide an *important mechanism*[17] for the dynamics of all parity-violating amplitudes in spite of its forbiddenness in the limit of $SU(3)$ in either picture.

What we have said above is based on the observed absolute value of the $K_1\to\pi^++\pi^-$ rate. We might ask whether it is reasonable that an amplitude which is zero in the limit of $SU(3)$ could in reality be so large as practically not to bear any impression of the forbiddenness? We would like to answer this question by saying that it is quite possible. Let us consider an amplitude, which is proportional to $(m_K{}^2-m_\pi{}^2)/(m_K{}^2+m_\pi{}^2)$; this goes to zero for $m_K=m_\pi$, but is close to unity for the physical masses. We may think of a *model* (which may in fact be a good one, if a normal scalar octet exists) that demonstrates a somewhat similar situation. Assume the existence of a scalar octet[18] $(\epsilon^+,\epsilon^0,\epsilon^-,\xi^0,\kappa^+,\kappa^0,\bar{\kappa}^0,\kappa^-)$. There are then three pole[19,20] diagrams corresponding to (i) $K_1\to\xi^0\to\pi^++\pi^-$, (ii) $K_1\to\kappa^++\pi^-\to\pi^++\pi^-$, and (iii) $K_1\to\kappa^-+\pi^+\to\pi^-+\pi^+$. Assume that the weak vertices transform like λ_6 while the strong vertices are $SU(3)$-invariant. The sum of the above three diagrams then yields an amplitude which is proportional to $\{(m_K{}^2-m_\pi{}^2)+(m_\kappa{}^2-m_\xi{}^2)\}/\{(m_\pi{}^2-m_\kappa{}^2)(m_K{}^2-m_\xi{}^2)\}$. This goes to zero for $m_K=m_\pi$ and $m_\kappa=m_\xi$, as it should.

[13] By "reality," we mean the broken $SU(3)$ picture.

[14] The value of the $KK\pi\pi$ vertex, extrapolated to one of the K line going to vacuum ($p_\mu=0$), could be quite different from that of the physical $KK\pi\pi$ coupling, especially if the scattering amplitude is dominated by a pole in the $K\bar{K}$ channel with a mass close to that of the K. This will affect the evaluation of the strength of the K_1 tadpole, but will not alter sensibly the qualitative aspects of the discussion presented here. This question will be discussed in a separate note.

[15] J. Hamilton, P. Menotti, G. C. Oades, and L. J. Vick, Phys. Rev. **128**, 1881 (1962).

[16] There are other diagrams with K_1 tadpoles, such as $\Lambda\to\Sigma^++\pi^-\to(p+\bar{K}^0)+\pi^-\to p+\pi^-$. At the moment we are interested in the order of magnitude of individual diagrams arising through the K_1 tadpole, since there is no cancellation effect, in general, between different diagrams.

[17] This would mean that both in the dynamical as well as in the primary scheme, there will, in general, be a *dominant* λ_7 *contribution* to all p.v. nonleptonic amplitudes. In practice, the λ_7 contribution may be much larger than the λ_6 part, unless there is some enhancement mechanism for the λ_6 part as well. For the p.c. decays, however, the octet part of the amplitude will transform like λ_6 in both the dynamical as well as the primary scheme. This is because the κ_1 tadpole, if it exists, corresponds to the λ_6 transformation.

[18] See D. Loebbaka and J. C. Pati, Phys. Rev. Letters **14**, 929 (1965) for tentative assignment and nomenclature of the scalar octet.

[19] With the K_1 tadpole model, the K^* intermediate state alone (involving the K^*-π vertex) can contribute to the rate of $K_1\to2\pi$ decay only by 1%. (See also footnote 26.)

[20] The implications of the existence of a scalar octet with or without a singlet on $K_1\to2\pi$ decay, K_1-K_2 mass difference, and the widths of scalar mesons are discussed in detail in a separate note (to be published). Note that the singlet-octet mixing in scalar mesons could play a very important role in the dynamics of $K_1\to2\pi$ decay especially as regards the effect of $SU(3)$ violation. For example, consider the mechanism $K_1\to\sigma_1\to$ vacuum, where σ_1 is the unitary singlet scalar meson. This is forbidden in the limit of $SU(3)$, but is proportional to $\sin\theta$ where θ is the singlet octet mixing angle in the broken $SU(3)$ picture. Large values of $\sin\theta$ [such as $\sqrt{\frac{1}{3}}$] are not unnatural.

However, for physical masses this could be quite large. For example, if we take $m_\kappa \approx m_\xi$,[18] the above amplitude is proportional to $(m_K^2-m_\pi^2)/\{(m_\pi^2-m_\kappa^2)(m_K^2-m_\xi^2)\}$, which has a behavior similar[21] to what we mentioned above.

Another remark with regard to whether or not the observed rate of $K_1 \to \pi^+ + \pi^-$ decay is a "normal" rate rather than a suppressed one is the following. It is usually said that all strangeness-violating NL rates are enhanced compared with the leptonic ones. Since the leptonic and NL decays involve different systems, one ought to define what one means by enhancement. A way to do this is given below. Consider the following leptonic and NL processes, which may be presumed to have "normal" rates: (i) $\Lambda \to p + e^- + \bar{\nu}_e$, (ii) $\pi^- \to e^- + \bar{\nu}_e$, and (iii) $\Lambda \to p + \pi^-$. The weak interactions responsible for these decays are[22]: (i) $G \sin\theta s_\alpha l_\alpha$, (ii) $G \cos\theta j_\alpha l_\alpha$, and (iii) $G \sin\theta \cos\theta j_\alpha s_\alpha$, respectively. The matrix elements for the leptonic decays can be expressed in the *factorized* form as

$$\begin{aligned} G \sin\theta\langle p e^- \bar{\nu}_e | s_\alpha l_\alpha | \Lambda\rangle &= (G \sin\theta)\langle p | s_\alpha | \Lambda\rangle \bar{e}\gamma_\alpha(1+\gamma_5)\nu_e \\ &\simeq (G \sin\theta)(K\bar{p}\gamma_\alpha(1+A\gamma_5)\Lambda)\bar{e}\gamma_\alpha(1+\gamma_5)\nu_e , \end{aligned} \quad (3)$$

$$\begin{aligned} G \cos\theta\langle e^- \bar{\nu}_e | j_\alpha l_\alpha | \pi^-\rangle &= (G \cos\theta)\langle 0 | j_\alpha | \pi^-\rangle \bar{e}\gamma_\alpha(1+\gamma_5)\nu_e \\ &= (G \cos\theta)(F_\pi P_{\pi\alpha})\bar{e}\gamma_\alpha(1+\gamma_5)\nu_e . \end{aligned} \quad (4)$$

The form factors K, A, and F_π are given by experiments on β decay of Λ and the rate of $\pi^- \to e^- + \bar{\nu}_e$ decay. Assuming that K and A are not rapidly varying functions of their arguments, if we now evaluate the NL amplitude in the same factorized approximation[23] as the leptonic ones, then

$$\begin{aligned} G \cos\theta \sin\theta\langle p\pi^- | j^+{}_\alpha s_\alpha | \Lambda\rangle_{\text{factorized}} &= (G \cos\theta \sin\theta)\langle \pi^- | j^+{}_\alpha | 0\rangle\langle 0 | s_\alpha | \bar{p}\Lambda\rangle \\ &\simeq (G \cos\theta \sin\theta)(F_\pi P_{\pi\alpha})(K\bar{p}\gamma_\alpha(1+A\gamma_5)\Lambda) . \end{aligned} \quad (5)$$

The right-hand side of Eq. (5) leads to a rate of $\Lambda \to p + \pi^-$ decay which is smaller than the observed rate by about a factor of 30. This, then, is what one means by *enhancement*[24] of the NL rates compared to the leptonic ones. Similar enhancement factors apply (within a factor of 2) to other NL decays such as $\Sigma \to N + \pi$ and $\Xi \to \Lambda + \pi$, etc. Thus the above factor defines (within a factor of 2–3, say) a scale of enhancement of NL rates compared to leptonic ones. Such enhancement should be attributed to nonfactorized structures such as, for example, $\langle p\pi^- | n\rangle\langle n | j^+{}_\alpha s_\alpha | \Lambda\rangle$, as discussed in Refs. 1–3. For what it may be worth, applying the same idea to the $K_1 \to 2\pi$ decay, we have

$$M(\bar{K}^0 \to 2\pi)_{\text{factorized}} = (G \cos\theta \sin\theta)\langle \pi^- | j^+{}_\alpha | 0\rangle\langle 0 | s_\alpha | \bar{K}^0\pi^+\rangle . \quad (6)$$

The first factor on the right-hand side is given by the $\pi_{\mu 2}$ decay rate, while the second one is given by the form factors of $K_{\mu 3}$-decay. These lead to a rate of $K_1 \to \pi^+ + \pi^-$ decay smaller than the *observed* rate again by about a factor of 30. This suggests that the observed absolute rate of $K_1 \to \pi^+ + \pi^-$ decay is perhaps a "normal" one, being consistent with a normal enhancement factor (within a factor of 2–3, say).

We now address ourselves to the problem of the ratio of $\Gamma(K^+ \to \pi^+ + \pi^0)$ to $\Gamma(K_1 \to \pi^+ + \pi^-)$, whose observed value is nearly 1/400. Since the octet-enhancement mechanism (through the K_1 tadpole, say) cannot contribute to the $K^+ \to \pi^+ + \pi^0$ decay by $SU(2)$ invariance, one will expect that, in the *dynamical scheme* (b′), the $K^+ \to \pi^+ + \pi^0$ amplitude is well represented by the factorized structure as mentioned above. Thus we have

$$\begin{aligned} &\Gamma(K^+ \to \pi^+ + \pi^0)_{\text{theoretical}} / \Gamma(K_1 \to \pi^+ + \pi^-)_{\text{observed}} \\ &\simeq (\Gamma(K^+ \to \pi^+ + \pi^0)_{\text{factorized}} / \Gamma(K_1 \to \pi^+ + \pi^-)_{\text{factorized}}) \\ &\quad \times (\Gamma(K_1 \to \pi^+ + \pi^-)_{\text{factorized}} / \Gamma(K_1 \to \pi^+ + \pi^-)_{\text{observed}}) \\ &\simeq (1/4)(1/30) = 1/120 . \end{aligned} \quad (7)$$

The factor $\frac{1}{4}$ comes from $SU(2)$ Clebsch-Gordan coefficients. The fact that the above number, although higher than the experimental value by about a factor of 3, has the right order of magnitude[25] is quite interesting. In the *primary scheme* (a′), both the factorized and the octet-enhanced amplitude for $K^+ \to \pi^+ + \pi^0$ are zero except for electromagnetism. Thus in the primary scheme, we feel that the explanation of the ratio of $\Gamma(K^+ \to \pi^+ + \pi^0)$ to $\Gamma(K_1 \to \pi^+ + \pi)$ should lie at least partially in *enhanced electromagnetic* effects in so far as the absolute rate of $K_1 \to \pi^+ + \pi^-$ is rather "normal" (within a factor of 3, say). This should be distinguished from the explanation suggested in Refs. 8 and 9.

Finally we turn to the question of the sum rule for p.v. hyperon decays (mentioned before) in a framework in which the amplitudes are presumed to be dominated by the K_1 tadpole. Since this corresponds effectively to a λ_7 transformation [assuming that the strong vertices are $SU(3)$-invariant], as is well known, no sum rule can be

[21] One way to judge the $SU(3)$ suppression effect on the physical $K_1 \to \pi^+ + \pi^-$ amplitude is to consider the order of magnitude of the individual terms arising through the scalar-meson poles compared to their sum, both evaluated with physical masses. This way, one finds that the ξ-pole term contribution $\propto m_\pi^{-2}/14$, the sum of the two κ-pole contributions $\propto -m_\pi^{-2}/26$, and the sum of the three $\propto m_\pi^{-2}/30$. Thus the suppression is at most by a factor of 2 or so.

[22] j_α and s_α stand for strangeness-preserving and strangeness-violating hadron currents, respectively; l_α for the lepton current; $G \cos\theta$ is the usual Fermi coupling constant, and θ is the usual Cabibbo angle.

[23] *A priori*, this is, of course, not expected to be a good approximation for NL decays, as we will see. (For a discussion on this point, see Ref. 1.)

[24] The enhancement mechanism would arise from nonfactorized structures, where factorized structures correspond to the insertion of intermediate states between j_α and s_α. Such mechanisms have been suggested in Refs. 1, 2, and 3.

[25] This explanation of the ratio of $\Gamma(K^+ \to \pi^+ + \pi^0)$ to $\Gamma(K_1 \to \pi^+ + \pi^-)$ is the same as the one proposed earlier by J. C. Pati, S. Oneda and B. Sakita, Nucl. Phys. **18**, 318 (1960) and by J. Schwinger, Phys. Rev. Letters **12**, 630 (1964).

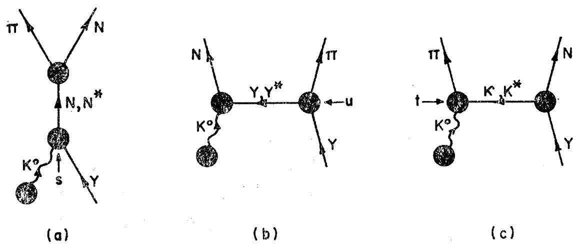

FIG. 1. s-, t-, and u-channel pole diagrams for the K_1-tadpole dominated hyperon decay amplitudes $Y \rightarrow N+\pi$. Y stands for Σ and Λ; Y^* for Y_1^*. Similar diagrams describe the $\Xi \rightarrow \Lambda+\pi$ decay. We have included the $J=\frac{1}{2}^+$ octet and the $J=\frac{3}{2}^+$-decuplet pole terms in the s and u channels, and the scalar κ and the vector K^* pole terms in the t channel.

obtained in general. However, an interesting and reasonable dynamical model for hyperon decays is one, in which the corresponding inverse associated production amplitudes $K^0+Y \rightarrow \pi+N$ and $K^0+\Xi \rightarrow \pi+\Lambda$ are dominated by the relevant pole terms in s, t, and u channels (see Fig. 1). In Fig. 1 we have included the $J=\frac{1}{2}^+$ baryon octet as well as the $J=\frac{3}{2}^+$-baryon-decuplet pole terms in the s and u channels and the scalar κ and vector K^*[26] pole terms in the t channel. In the amplitudes, thus obtained, if we insert $SU(3)$-symmetric coupling constants at the strong vertices and degenerate masses for members of the same multiplet, interestingly enough we find that *the sum rule is satisfied separately* by the baryon octet, the baryon decuplet, the κ, and the K^* pole terms. This holds irrespective of the choice of the d/f ratio at the strong vertices, wherever applicable. Thus the sum rule could be expected to hold even in the dynamical scheme (b′).

To summarize, we see that arguments based on forbiddenness of the K_1 tadpole and of the $K_1 \rightarrow 2\pi$ decay in the limit of $SU(3)$ may be quite misleading. The strength of the K_1 tadpole can in fact provide a natural explanation for octet enhancement in the p.v. amplitudes in spite of its forbiddenness in the limit of $SU(3)$. Parity-violating baryon pole terms involving two fermion vertices (such as $Y \leftrightarrow N$ or $\Xi \leftrightarrow Y$, etc.) with nonderivative coupling, that are forbidden by the λ_6 transformation and CP invariance, are in reality[13] quite large and should, therefore, be retained in any dynamical model[27] of hyperon decays. The question of whether or not the $\Delta T=\frac{1}{2}$ rule and the octet transformation property of the NL amplitudes are primary or dynamical is still an open one and it will be interesting if experiments of the type suggested in Refs. 4 and 5 shed light on it in the near future.

[26] Although the inclusion of K^* pole terms satisfies the sum rule, they probably do not make significant contributions to the absolute values of the p.v. amplitudes. This is based on the evaluation of the $K^* \rightarrow \pi$ vertex via the process $K^* \rightarrow K^0+\pi \rightarrow \pi$, which seems reasonable. Inserting the maximum possible strength of the K_1 tadpole, consistent with Eq. (1) and reasonable values of YNK^* coupling constants, the $K^* \rightarrow \pi$ vertex thus obtained leads to hyperon decay rates smaller than the observed rates by a factor $\simeq 50$. Thus the dynamical explanation of the sum rule on the basis of K^* pole terms [see B. W. Lee and A. R. Swift, Phys. Rev. **136**, B228 (1964)] is rather fortuitous.

[27] Such pole terms were dropped by many authors on the ground that they are forbidden in the limit of $SU(3)$. See for example, Y. Hara, Phys. Rev. Letters **12**, 378 (1964); B. W. Lee and A. R. Swift (Ref. 26) and W. W. Wada, Phys. Rev. **138**, B1488 (1965).