

This possibility can only be realized in the s wave, if the low-energy behavior $\tan\delta \sim K^{2l+1}$ is to be preserved. While the position of the Ω^- mass might be shifted by their arguments, it is not possible to argue away its existence within the framework of unitary symmetry.

³These sheets are defined by the conditions $\text{Im}E^{1/2}$ is positive (negative) on I and IV (II and III), and $\text{Im}(E - M^2)^{1/2}$ is positive (negative) on I and II (III and IV). Thus sheet

I is the physical sheet of this Riemann surface.

⁴For angular-momentum states higher than S -wave these poles will meet at $E=0$. This arises from the well-known result that the width of a resonance goes as E^{l+1} .

⁵The single-channel aspect of this problem is discussed in somewhat more detail by P. V. Landshoff, *Nuovo Cimento* **28**, 123 (1963).

NONLEPTONIC WEAK DECAYS AND THE EIGHTFOLD WAY*

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Assuming that the strongly interacting particles approximately obey the "eightfold way" symmetry,^{1,2} we may try to investigate the consequences of the further assumption that the weak interactions of baryons and mesons have simple transformation properties under the same symmetry.

It was suggested¹ that the weak current for interaction with leptons consists of a vector term, which is the current of a component of the F spin, plus an axial-vector term that constitutes the same component of another unitary octet. This model leads to the selection rules $\Delta Y=0$, $|\Delta\tilde{I}|=1$ and $\Delta Y/\Delta Q=+1$, $|\Delta\tilde{I}|=1/2$ for the current, as well as a conserved vector current for $\Delta Y=0$ and a nearly conserved vector current for $\Delta Y/\Delta Q=+1$. Let us suppose that the model is correct.

In reference 1, the component of the F spin involved was taken to be $F_1 + iF_2 + F_4 + iF_5$ (equal strength for $\Delta Y=0$ and $\Delta Y/\Delta Q=+1$). However, an alternative and, in some ways, more attractive form for universality was suggested by Gell-Mann and Lévy,³ which amounts in the eightfold way to taking a different component, namely, $\cos\theta(F_1 + iF_2) + \sin\theta(F_4 + iF_5)$ with θ small. This form of the eightfold-way model has been studied in an elegant paper of Cabibbo,⁴ who finds that several experiments indicate a consistent value of θ around 0.26 radian.

Let us now apply the model to the nonleptonic weak interactions formed from the weak current times its Hermitian conjugate; such a current-current interaction may, of course, be carried by an intermediate boson. The strangeness-changing part of this nonleptonic interaction is then the sixth component of a unitary octet plus a term that transforms like the representation 27. The octet part obeys $|\Delta\tilde{I}|=1/2$ while the 27 part has $|\Delta\tilde{I}|=1/2, 3/2$. Both obey $|\Delta Y|=1$, of course.

There are two simple possibilities that may explain the predominance⁵ of $|\Delta\tilde{I}|=1/2$ in nonleptonic decays: (a) There are other terms, formed from neutral current products, such that $|\Delta\tilde{I}|=3/2$ is canceled out, with $|\Delta Y|$ still equal to 1, or (b) some mechanism, such as the predominance of scalar and pseudoscalar meson intermediate states, selectively enhances the contribution of $|\Delta\tilde{I}|=1/2$ "spurions" compared with that of $|\Delta\tilde{I}|=3/2$ "spurions." Let us assume that in either case the mechanism that gets rid of the $|\Delta\tilde{I}|=3/2$ term gets rid of the whole 27 and leaves just the octet,^{6,7} for $|\Delta Y|=1$.

Now every octet that goes into itself under charge conjugation has a characteristic number $\mathcal{C}=\pm 1$, which is the charge-conjugation quantum number C of its 1, 3, 4, 6, and 8 components; the charge-conjugation quantum number C of the 2, 5, and 7 components is $-\mathcal{C}$. When two octets are combined to make a third octet, the value of $\mathcal{C}$ for the third one is the product of the $\mathcal{C}$ values for the first two octets times η , where η is $+1$ when the octets are coupled through the symmetric symbol d_{ijk} (which is nonvanishing only when an even number of 2's, 5's, and 7's occur among the indices) and -1 when they are coupled through the antisymmetric symbol f_{ijk} (which is nonvanishing only for an odd number of 2's, 5's, and 7's).

The vector current has $\mathcal{C}=-1$, like the vector-meson octet, while the axial-vector current has $\mathcal{C}=+1$ (with no $\mathcal{C}=-1$ impurity ever proved) like the pseudoscalar meson octet. In forming the nonleptonic interaction, the symmetric coupling through the d_{ijk} symbol is what comes in and thus the octet that results has $\mathcal{C}=+1$ for the parity-conserving (p-c) term and $\mathcal{C}=-1$ for the parity-violating (p-v) term. The sixth component thus has $CP=+1$ in each case.

By contrast, the K_1^0 particle, in the eightfold

way, is the seventh component of a pseudoscalar octet with $\mathcal{C} = +1$. Again $CP = +1$, but the transition between the p - v spurion and K_1^0 is forbidden by $SU(3)$. This fact tends to make alternative (b) above somewhat less attractive than it was without unitary symmetry.

Next, consider the transition from the p - v spurion to $K_1^0 + \pi^+ + \pi^-$ or $K_1^0 + \pi^0 + \pi^0$ in a symmetrical state, which is responsible for the decays $K_1^0 \rightarrow 2\pi$. Since the K and π 's all belong to the same octet, the unitary spin coupling of the three octets to form the fourth must be totally symmetric. With this coupling, we can form out of $K_1^0 + 2\pi$ the seventh component of a pseudoscalar octet with $\mathcal{C} = +1$ (like K_1^0) but not the sixth component of a pseudoscalar octet with $\mathcal{C} = -1$ (like the p - v spurion). Thus, $K_1^0 \rightarrow 2\pi$ is forbidden⁸ by $SU(3)$.

Finally, the property $\mathcal{C} = -1$ of the p - v spurion gives one condition on the four independent observable p - v amplitudes A in the weak decay of strange baryons into baryon plus pion:

$$-A(\Lambda - p + \pi^-) + 2A(\Xi^- - \Lambda + \pi^-) = \sqrt{3}A(\Sigma^+ - p + \pi^0).$$

This condition, compatible with experimental evidence, is valid in the limit of unitary symmetry in the model presented here. In references 6 and 7, the same condition is found for both p - v and p - c amplitudes, but on the basis of R invari-

ance, which does not appear to be a good approximation, at any rate for baryons.

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¹M. Gell-Mann, California Institute of Technology Synchrotron Laboratory Report CTS-20, 1961 (unpublished); Phys. Rev. **125**, 1067 (1962).

²Y. Ne'eman, Nucl. Phys. **26**, 222 (1961).

³M. Gell-Mann and M. Lévy, Nuovo Cimento **16**, 705 (1960). See also M. Gell-Mann, Proceedings of the Tenth Annual International Rochester Conference on High-Energy Physics, 1960 (Interscience Publishers, Inc., New York, 1960).

⁴N. Cabibbo, Phys. Rev. Letters **10**, 531 (1963).

⁵The current evidence for this rule is reviewed by R. H. Dalitz (to be published).

⁶Benjamin Lee (to be published).

⁷Hirota Sugawara (to be published).

⁸The author is much indebted to Professor Cabibbo for a discussion of this matter. N. Cabibbo (to be published) points out that with $K_1^0 \rightarrow 2\pi$ forbidden by $SU(3)$, the comparatively high rate of $K^+ \rightarrow 2\pi$ need not be an obstacle to a theory of purely electromagnetic violation of the nonleptonic rule $|\Delta I| = 1/2$, in accordance with possibility (a) above. One simple theory of type (a) would involve a single neutral current, transforming like $(-F_3 - 3^{-1/2}F_8) \cos \theta + (F_6 + iF_7) \sin \theta$, to accompany the single charged current transforming like $(F_1 + iF_2) \times \cos \theta + (F_4 + iF_5) \sin \theta$. Each would be multiplied by its Hermitian conjugate.

E R R A T A

Σ -RADIATIVE DECAY AS A METHOD OF DETERMINING THE ANGULAR MOMENTUM OF THE Σ -PIONIC DECAY. Saul Barshay, Uriel Nauenberg, and Jonas Schultz [Phys. Rev. Letters **12**, 76 (1964)].

In Fig. 3 the dashed lines refer to the P -wave case and the solid lines to the S -wave case.

VARIATIONAL PROPERTY OF FREE-ENERGY PERTURBATION THEORY. Harold Falk [Phys. Rev. Letters **12**, 93 (1964)].

A printer's error occurred in the last term of Eq. (4). In the upper limit of the $d\lambda_1$ integral, the subscript p should be deleted. In Eq. (7), the exponent of $(-\beta)$ should be $m - 1$.