both strong and electromagnetic mass shifts lie along an eigenvector of A_8 whose eigenvalue is close to one.[13]

A series of more detailed papers treating the calculation of the A matrix, computation of some driving terms which may allow an estimate of the absolute magnitude of the baryon electromagnetic mass shifts, some effects of higher order terms, and other related topics is in preparation.

The authors would like to acknowledge the hospitality of the Lawrence Radiation Laboratory, where this work was completed.

---

*Work supported in part by the U. S. Atomic Energy Commission.

[1] M. Gell-Mann, Phys. Rev. 125, 1067 (1962).

[2] S. Okubo, Progr. Theoret. Phys. (Kyoto) 27, 949 (1962).

[3] S. Coleman and S. L. Glashow, Phys. Rev. 134, B671 (1964).

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

[5] R. E. Cutkosky and P. Tarjanne, Phys. Rev. 132, 1355 (1963). The general nature of the bootstrap mechanism was stressed by R. E. Cutkosky, Bull. Am. Phys. Soc. 8, 591 (1963).

[6] Extensive work along related lines has been done by R. H. Capps; e.g., Phys. Rev. 134, B1396 (1964).

[7] S. L. Glashow, Phys. Rev. 130, 2132 (1963).

[8] If strong symmetry violation is spontaneous, $D_{\text{strong}} = 0$ and the enhanced eigenvalue must equal unity in the linear approximation. When higher orders are included, however, the eigenvalue is no longer required to be exactly one. In any case the strong mass shifts are expected to lie along the eigenvector associated with eigenvalue $A_8 \sim 1$ whether or not $D_{\text{strong}} = 0$.

[9] The parity-violating weak interaction can be studied with the same techniques, but in this case a different A matrix with generally different eigenvalues and eigenvectors is involved.

[10] R. F. Dashen and S. C. Frautschi, Phys. Rev. 135, B1190 (1964).

[11] A. Martin and K. Wali, Phys. Rev. 130, 2455 (1963); R. Dalitz, Phys. Letters 5, 53 (1963).

[12] Here the numbers $dM_8^{\Delta}, \cdots,$ are the coefficients of normalized octet mass matrices.

[13] The Coleman-Glashow model[3] likewise predicts that electromagnetic mass splittings will follow the same pattern as strong mass splittings, but does not predict ratios among the strong splittings since they are needed to fix the parameters of the model.

BROKEN SYMMETRIES AND WEAK INTERACTIONS. II.†

Julian Schwinger
Harvard University, Cambridge, Massachusetts
(Received 14 September 1964)

In an earlier Letter with this title,[1] parity-preserving nonleptonic decays were related to the violation of SU(3) coupling-constant equalities. It was assumed, for the discussion of pionic hyperon decays, that SU(3) symmetry is strictly maintained within the π-baryon couplings and within the K-baryon couplings, but that the SU(3) equality of π and K coupling constants is broken. It is somewhat discomforting for this point of view to conclude that the fractional violation of the coupling-constant equality is significantly different for the two SU(3) coupling constants $f^{(1)}$ and $f^{(2)}$. We wish to point out that the situation is improved by including another contribution, the importance of which was not appreciated in I.

It was there remarked that weak mixing of the baryon octuplet and weak meson mixing cancel completely if the breakdown of SU(3) symmetry is limited to the mass displacements produced by the vacuon $\langle S_{33}\rangle$. There are other effects, however, which enable this parity-preserving decay mechanism to operate. One is the coupling-constant inequality, $f_K \neq f_\pi$. A second one is the weak mixing of the baryon octuplet with the singlet of the broken W_3 nonuplet. A third one is the failure of the Gell-Mann–Okubo octuplet mass formula, which we have attributed to strong octuplet-singlet mixing. The last effect was not considered in I, owing perhaps to the psychological influence of the oft repeated statement that the GMO formula is accurate to within one half of one percent. The more relevant number is the mass ratio

$$\rho = [\Lambda - \tfrac{1}{3}(2N + 2\Xi - \Sigma)]/(\Lambda - N) = 0.045,$$

and its consequences are not negligible.

The p-wave coupling constants implied by the three contributing factors are

$$f_{\Sigma^+} = -\vartheta_+[\tfrac{1}{2}\rho(f^{(1)} + f^{(2)}) + \tfrac{1}{3}\gamma f_{\Phi Y}];$$

$$f_{\Sigma^-} = \theta_+[\Delta f^{(2)} - \tfrac{1}{2}\rho(f^{(1)} + f^{(2)}) - \tfrac{1}{3}\gamma f_{\Phi Y}];$$

$$f_{\Lambda} = \theta_+ 6^{-1/2}[2\Delta f^{(1)} - \Delta f^{(2)} - 3\rho f^{(1)}];$$

$$f_{\Xi^-} = \theta_+ 6^{-1/2}\left[2\Delta f^{(2)} - \Delta f^{(1)} + 3\rho \frac{\Lambda - N}{\Xi - \Lambda} f^{(2)}\right].$$

The p-wave sum rule changes into

$$2f_{\Xi^-}+f_\Lambda-(\tfrac{3}{2})^{1/2}(f_{\Sigma^-}-f_{\Sigma^+})$$
$$=\theta_+6^{1/2}\rho\frac{\Lambda-N}{\Xi-\Lambda}\left(f^{(2)}-\frac{1}{2}\frac{\Xi-\Lambda}{\Lambda-N}f^{(1)}\right),$$

where

$$\frac{1}{2}\frac{\Xi-\Lambda}{\Lambda-N}=0.577.$$

It is interesting that an $f^{(2)}/f^{(1)}$ ratio of 0.577, which would leave the sum rule intact, is consistent with the present imprecise experimental information about this ratio. In view of the crudeness of the decay data, any ratio between $\frac{1}{2}$ and $\frac{2}{3}$ might be acceptable.

If we combine $f^{(2)}/f^{(1)}=0.577$ with $f_{\Sigma^-}=0$, we now find that

$$\Delta f^{(2)}/f^{(2)}=0.061\pm0.094=0.16 \text{ or } -0.03,$$

where the ambiguity arises from the unknown algebraic sign of $rf_{\Phi Y}/f^{(2)}$. The comparison of f_{Σ^+} with either f_Λ or f_{Ξ^-} then gives the unique result

$$\Delta f^{(1)}/f^{(1)}=0.17 \text{ or } 0.05.$$

The upper sign seems the more plausible one, and we conclude that the K-baryon coupling constants,[2] $f^{(1)}$ and $f^{(2)}$, are smaller than the corresponding π-baryon constants by a common factor $\simeq 0.8$. The corrected value of the parameter θ_+ is 2.1×10^{-6}.

[†] Publication assisted by the U. S. Air Force Office of Scientific Research under Contract No. AF 49(638)-1380.

[1] J. Schwinger, Phys. Rev. Letters 13, 355 (1964). Note the following typographical errors: The symbol in the seventeenth line, left-hand column, of p. 355 is γ_5, not λ_5. The reference to footnote 3 should appear on p. 356, in the fourth line before "Calculations." In the top line, right-hand column, of p. 356, read γ^μ instead of Y^μ. On p. 357, left-hand column, the first line of the last paragraph should contain $\langle S_{23}\rangle$, not $\langle S_{33}\rangle$.

[2] The K-nucleon coupling constants are $f_{KN\Lambda}=6^{-1/2}(2f_K^{(1)}-f_K^{(2)})$, $f_{KN\Sigma}=2^{-1/2}f_K^{(2)}$, while $f_{\pi N}=2^{-1/2}f_\pi^{(1)}$. Thus we anticipate the pseudovector coupling ratios: $f_{KN\Lambda}^2/f_{\pi N}^2\simeq1/2$, $f_{KN\Sigma}^2/f_{\pi N}^2\simeq\frac{1}{4}$.

ERRATUM

SPLITTING OF SPIN-UNITARY SPIN MULTIPLETS. Mirza A. Baqi Bég and Virendra Singh [Phys. Rev. Letters 13, 418 (1964)].

The by-line address of the first author was omitted from the printed version. It should be "The Rockefeller Institute, New York, New York."