Am. Phys. Soc. 13, 598(T) (1968).

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[1]J. M. Wilcox and N. F. Ness, J. Geophys. Res. 70, 5793 (1965).

[2]For a review of the interplanetary magnetic field see J. M. Wilcox, to be published.

[3]D. H. Fairfield and N. F. Ness, J. Geophys. Res. 72, 2379 (1967).

[4]P. J. Coleman, Jr., L. Davis, Jr., E. J. Smith, and D. E. Jones, J. Geophys. Res. 72, 1637 (1967).

[5]J. R. Asbridge, S. J. Bame, H. E. Felthauser, and J. T. Gosling, Trans. Am. Geophys. Union 48, 172 (1967).

[6]Similar to the procedure described in Ref. 1.

[7]N. F. Ness and J. M. Wilcox, Phys. Rev. Letters 13, 461 (1964).

[8]J. M. Wilcox and N. F. Ness, Solar Phys. 1, 437 (1967).

[9]S. Mori, H. Ueno, K. Nagashima, and S. Sagisaka, Rept. Ionosphere Research Japan 18, 275 (1964).

[10]J. M. Wilcox, in Proceedings of the Thirteenth General Assembly, International Astronomical Union, Prague, September, 1967 (to be published).

[11]N. F. Ness and J. M. Wilcox, Astrophys. J. 143, 23 (1966).

[12]V. Bumba and R. Howard, to be published.

SU(3), GOLDBERGER-TREIMAN RELATION, AND CABIBBO ANGLE

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Recent determinations[1,2] of the $KN\Lambda$ and $KN\Sigma$ coupling constants indicate that, firstly, the trilinear pseudoscalar meson-baryon coupling constants are consistent with exact SU(3) symmetry, and secondly, the F-D mixing parameter of the pseudoscalar meson-baryon vertices, in the form of gradient coupling, agrees very well with the corresponding parameter of the axial-vector vertex functions for baryon leptonic decays[3] within the framework of Cabibbo theory.[4] While further verification of these results is desired, we wish to point out two simple but interesting implications: (i) The Goldberger-Treiman (GT) relations for the K-meson decay constant are well satisfied; the degree of their validity is comparable with that of the ordinary GT relation for the pion decay constant. (ii) The empirical relation[3,5]

$$\theta_A^{(B)} \simeq \theta_A^{(M)}, \tag{1}$$

where $\theta_A^{(B)}$ and $\theta_A^{(M)}$ are the phenomenological axial-vector Cabibbo angles for the baryon leptonic decays and pseudoscalar-meson decays, respectively, can be understood on the basis of the GT relations. These two assertions will become clear in what follows.

Assuming SU(3) symmetry[6] for the pseudoscalar-meson–baryon vertices in the form of gradient coupling,[7]

$$\mathcal{L}_{M\bar{B}B} = g\,\mathrm{Tr}[\alpha(\bar{B}\gamma_\mu i\gamma_5 B\partial^\mu M + \bar{B}\gamma_\mu i\gamma_5 \partial^\mu MB) - (1-\alpha)(\bar{B}\gamma_\mu i\gamma_5 B\partial^\mu M - \bar{B}\gamma_\mu i\gamma_5\partial^\mu MB)], \tag{2}$$

where B and M are the usual 3×3 arrays for the baryons and pseudoscalar mesons, respectively, we write down the following GT relations:

$$\text{for } \Delta S = 0,\quad G_A(n\to p) = -g(F_\pi \cos\theta),\ \text{etc.} \tag{3}$$

$$\text{for } |\Delta S| = 1,\quad G_A(\Lambda\to p) = (\tfrac{3}{2})^{1/2}(1-2\alpha/3)g(F_K\sin\theta),$$

$$G_A(\Sigma^-\to n) = (1-2\alpha)g(F_K\sin\theta),\ \text{etc.,} \tag{4}$$

where θ is the Cabibbo angle,[4] and F_π and F_K are defined by

$$\langle 0 | A_\lambda^{(\pi^+)}(0) | \pi^+(q)\rangle = iF_\pi q_\lambda, \tag{5}$$

$$\langle 0 | A_\lambda^{(K^+)}(0) | K^+(q)\rangle = iF_K q_\lambda. \tag{6}$$

It is clear from (3) and (4) that on the basis of the GT relations all strangeness-changing axial-vector coupling constants for the baryon leptonic decays have a universal multiplicative factor F_K/F_π, relative to the strangeness-conserving ones. This factor can be absorbed as a renormalization[8] of the Cabibbo angle, allowing the "apparent" axial-vector vertex functions for baryon decays to be expressed in terms of two reduced matrix elements as in the SU(3) limit. The corresponding apparent Cabibbo angle $\theta_A^{(B)}$ is related to the "bare" Cabibbo angle θ through

$$\tan\theta_A^{(B)} = (F_K/F_\pi)\tan\theta. \tag{7}$$

On the other hand, as follows from the definitions (5) and (6), the "apparent" axial-vector angle $\theta_A^{(M)}$ for pseudoscalar meson decays is related to θ by the same relation:

$$\tan\theta_A^{(M)} = (F_K/F_\pi)\tan\theta. \tag{8}$$

Consequently, the relation (1) follows.

It should be pointed out that the GT relations (3) and (4) also imply the equality[9] of the F-D mixing parameter α of the baryon axial-vector vertex functions with the corresponding parameter of the pseudoscalar meson-baryon vertices. This, again, is in agreement with the empirical finding, and consequently provides additional evidence for the inner consistency of the set of GT relations (3) and (4).

The GT relations, of course, are not exact. But the relation (7) expresses, essentially, the relative strengths of the strangeness-changing and strangeness-conserving axial-vector coupling constants. That the set of GT relations (3) and (4), as a whole, provides an adequate basis of parametrization for the baryon leptonic decays demonstrates that the degrees of validity of these GT relations are comparable.

The implications of these simple observations are clear: (i) The notion of partially conserved axial-vector current for the strangeness-changing axial-vector current is expected to be a good working hypothesis. (ii) Belief is enhanced in the original assumption of Cabibbo[4] that there is only one angle parameter for both the vector and axial-vector currents; the empirical equality, $\theta_A^{(B)} \simeq \theta_A^{(M)}$, is dynamical, rather than being "intrinsic," in origin.

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[1]J. K. Kim, Phys. Rev. Letters 19, 1079 (1967).

[2]C. H. Chan and F. T. Meiere, Phys. Rev. Letters 20, 568 (1968).

[3]N. Brene, L. Veje, M. Roos, and C. Cronström, Phys. Rev. 149, 1288 (1966). See also N. Cabibbo, in Proceedings of the Thirteenth International Conference on High Energy Physics, Berkeley, California, 1966 (University of California Press, Berkeley, Calif., 1967).

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

[5]H. T. Nieh and M. M. Nieto, to be published. According to this recent fit to the baryon leptonic decay data, the equality (1) is slightly disturbed.

[6]Actually, in what follows, we only need to assume SU(3) symmetry for the π- and K-coupling constants.

[7]For a lucid and interesting discussion bearing on the question as to why the gradient coupling, in the case of the pion-nucleon system, is favored, see J. J. Sakurai, talk given at the Conference on Pion-Nucleon Scattering, University of California, Irvine, Calif., 1967 (unpublished). For the relevance of the gradient coupling to the GT relation, see R. Feynman, in Proceedings of the International School of Physics "Ettore Majorana," Erice, Italy, 1964, edited by A. Zichichi (Academic Press, Inc., New York, 1965); see also H. T. Nieh, Phys. Rev. 146, 1012 (1966), appendix.

[8]H. T. Nieh, Phys. Rev. Letters 15, 902 (1965).

[9]This has been previously observed by J. J. Sakurai, Phys. Rev. Letters 12, 79 (1964); B. W. Lee, ibid. 12, 83 (1964), footnote 8. We emphasize that the meson-baryon vertices should be in the form of the gradient coupling.