CM-P00057111

PARITY-CONSERVING NON-LEPTONIC HYPERON DECAYS IN $SU(6)$

W. Alles ^{*)} and G. Segrè ^{**)}

CERN -- Geneva

---

^{*)} On leave from Istituto di Fisica dell'Università, Bologna,
and from Istituto Nazionale di Fisica Nucleare (Sezione di
Bologna).

^{**)} National Science Foundation Postdoctoral Fellow.

We wish to examine, within the framework of the recently discovered SU(6) symmetry ¹⁾, the parity-conserving part of the non-leptonic hyperon decays. Relationships which appear to be in agreement with experiment have been recently derived ²⁾ for the parity-violating part of non-leptonic hyperon decays by assuming the Hamiltonian to transform as the regular representation of SU(6) or more precisely like the K_{02} of 35. The parity-conserving part necessarily leads to P waves and cannot be calculated unless one has a technique for introducing orbital angular momentum. Gell-Mann ³⁾ has recently proposed just such a technique, which essentially consists of introducing an orbital angular momentum spurion, transforming as the (1,3) member of the regular representation of SU(6).

To obtain the most general expression for the parity-conserving Hamiltonian, we must examine how many times $\overline{56} \times 56$ is contained in the product of $35 \times 35 \times 35$, where we have assumed the baryons to transform as 56 and the mesons as 35. The answer is eighteen times; thus the most general Hamiltonian depends on eighteen independent amplitudes, which we list below.

$$1) \quad \overline{B}_{\alpha\beta\gamma} B^{\alpha\beta\gamma} M_{\lambda}^{\rho} W_{\rho}^{\nu} L_{\nu}^{\lambda}$$

$$2) \quad \overline{B}_{\alpha\beta\gamma} B^{\alpha\beta\gamma} M_{\lambda}^{\rho} L_{\rho}^{\mu} W_{\mu}^{\lambda}$$

$$3) \quad \overline{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\delta}^{\gamma} L_{\nu}^{\mu} W_{\mu}^{\nu}$$

$$4) \quad \overline{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} L_{\delta}^{\gamma} M_{\nu}^{\mu} W_{\mu}^{\nu}$$

(1)

2.

$$5) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} W_{\delta}^{\gamma} L_{\nu}^{\mu} M_{\mu}^{\nu}$$

$$6) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\mu}^{\gamma} L_{\delta}^{\mu} W_{\mu}^{\nu}$$

$$7) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\mu}^{\gamma} L_{\nu}^{\mu} W_{\delta}^{\nu}$$

$$8) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\delta}^{\nu} L_{\mu}^{\gamma} W_{\nu}^{\mu}$$

$$9) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\nu}^{\mu} L_{\mu}^{\gamma} W_{\delta}^{\nu}$$

$$10) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\delta}^{\nu} L_{\nu}^{\mu} W_{\mu}^{\gamma}$$

$$11) \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\delta} M_{\mu}^{\nu} L_{\delta}^{\mu} W_{\nu}^{\gamma}$$

$$12) \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\delta}^{\beta} L_{\mu}^{\gamma} W_{\epsilon}^{\mu}$$

(1)

$$13) \quad \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\mu}^{\beta} L_{\delta}^{\gamma} W_{\epsilon}^{\mu}$$

$$14) \quad \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\delta}^{\beta} L_{\epsilon}^{\mu} W_{\mu}^{\gamma}$$

$$15) \quad \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\mu}^{\beta} L_{\epsilon}^{\mu} W_{\delta}^{\gamma}$$

$$16) \quad \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\epsilon}^{\mu} L_{\delta}^{\beta} W_{\mu}^{\gamma} \quad (1)$$

$$17) \quad \bar{B}_{\alpha\beta\gamma} B^{\alpha\delta\epsilon} M_{\epsilon}^{\mu} L_{\mu}^{\beta} W_{\delta}^{\gamma}$$

$$18) \quad \bar{B}_{\alpha\beta\gamma} B^{\delta\epsilon\eta} M_{\delta}^{\alpha} L_{\epsilon}^{\beta} W_{\eta}^{\gamma}$$

M represents the mesons, W the weak interaction spurion and L the orbital angular momentum spurion. Since the L transforms like the $(1,3)_{35}$ and the W like the K_{02} , it is immediately clear that the first five amplitudes do not contribute to our decays. A tedious, but straightforward, calculation leads to the following relationships

4.

$$1) \quad 3\sqrt{6} \Lambda^0_- = -3(a_6 + a_7 + a_9) - (a_{15} + a_{17}) + a_{18}$$

$$2) \quad 6\sqrt{6} \Xi^-_- = 2(a_6 + a_7 + a_9) - (a_{12} + a_{14}) + 2a_{13} \\ + (a_{15} + a_{17}) - 3a_{18}$$

$$3) \quad 18 \Sigma^-_- = 2(a_6 + a_7 + a_9) - (a_{12} + a_{14}) - 4a_{13} \\ - (a_{15} + a_{17}) + 5a_{18}$$

$$4) \quad 18 \Sigma^+_+ = (a_{12} + a_{14}) - 5(a_{15} + a_{17}) + a_{18}$$

$$5) \quad 3\sqrt{3} \Omega^-_{\pi^-} = 2(a_6 + a_7 + a_9) - a_{13}$$

$$6) \quad -3\sqrt{2} \Omega^-_{K^-} = (a_{12} + a_{14}) - (a_{15} + a_{17})$$

From the above, it is evident that the six experimental quantities can be expressed via five parameters, $(a_6 + a_7 + a_9)$, $(a_{12} + a_{14})$, a_{13} , $(a_{15} + a_{17})$, and (a_{18}) ; we thus obtain one relationship between the six quantities. This relation is

$$\Omega_{K^-}^- = \frac{\sqrt{3}}{2} \left\{ \Lambda_-^0 + 2 \Xi_-^- - \frac{\sqrt{6}}{2} (\Sigma_+^+ - \Sigma_-^-) \right\} \quad (2)$$

which, by the $\Delta I = \frac{1}{2}$ rule, reduces to

$$\Omega_{K^-}^- = \frac{\sqrt{3}}{2} \left\{ \Lambda_-^0 + 2 \Xi_-^- - \sqrt{3} \Sigma_0^+ \right\} \quad (3)$$

The right-hand side equal to zero is the famous relation obtained for S waves by Gell-Mann ⁴⁾ using CP invariance, a current-current interaction and SU(3) symmetry and by Lee ⁵⁾ for S and P waves using RP invariance ^{*)}. This last hypothesis is, however, highly questionable in SU(3) symmetry. As we see, the validity of the relationship for P waves in SU(6) is proportional to the magnitude of the decay $\Omega^- \rightarrow \Lambda^0 + K^-$. CP invariance and a current-current interaction leads to $a_6 = a_8$, $a_7 = a_{10}$, $a_9 = a_{11}$, $a_{12} = a_{14}$, $a_{13} = a_{16}$, and $a_{15} = a_{17}$, which unfortunately does not place any additional restrictions on the amplitudes.

Consideration of the amplitude for $\Omega^- \rightarrow \Xi^{*0} + \pi^-$ leads to the additional sum rule

$$\Omega_{*}^- = 2\sqrt{5} \Omega_-^- - \sqrt{5} \left\{ \frac{3}{2\sqrt{3}} (\Sigma_+^+ + \Sigma_-^-) - \frac{3\Lambda_-^0}{\sqrt{2}} \right\} \quad (4)$$

The decay rate of Ω_{*}^- is, however, certainly very small because of the Q value and therefore it will be very difficult to obtain an expression for the amplitude.

---

*) Our expression appears with $-\Lambda_-^0$ rather than Λ_-^0 because we use a slightly different phase convention.

Lastly, we would like to point out that the decay rate for $\Omega^- \rightarrow \Lambda^0 + K^-$ is expected to be smaller than that estimated by Glashow and Socolow⁶⁾, as the amplitude is given by (3) rather than being characterized by the same coupling constant as the Λ^0 decay and experimentally

$$\left[\frac{\Lambda^0}{\frac{\sqrt{3}}{2} \left\{ \Lambda^0 + 2\Xi^- - \sqrt{3}\Sigma^+ \right\}} \right]^2 \approx \begin{cases} 2.3 \\ 1.5 \end{cases}$$

for respectively solutions i) and ii) of Σ^+ ⁷⁾.

In conclusion, we would like to make one additional remark about Ω^- decays, namely that for the S wave $\Omega^- \rightarrow \Xi^{0*} + \pi^-$ decay, SU(6) and PC predict the following relation

$$\Omega_{*-}^- = -\sqrt{2} \Lambda^0$$

One of us (G.S.) would like to thank Professor L. Van Hove and the Theoretical Study Division of CERN for the hospitality offered him.

R E F E R E N C E S

- 1) F. Gürsey and L. Radicati, Phys. Rev. Letters 13, 173 (1964).
B. Sakita, to be published.
- 2) G. Altarelli, F. Buccella and R. Gatto, to be published.
M. Suzuki, to be published.
- 3) M. Gell-Mann, to be published.
- 4) M. Gell-Mann, Phys. Rev. Letters 12, 155 (1964).
- 5) B.W. Lee, Phys. Rev. Letters 12, 183 (1964).
- 6) S.L. Glashow and R. Socolow, Phys. Letters 10, 143 (1964).
- 7) R.H. Dalitz, Varenna Lectures, June 1964, to be published.