Semi-Leptonic Processes and Chiral $SU_3 \times SU_3$ Symmetry.

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Summary. — There have been several papers devoted to the problem of introducing baryons in the $SU_3 \times SU_3$ symmetry. We are going to offer in this paper a systematic treatment of this matter especially in what concerns the phenomenological currents acting in semi-leptonic weak processes. We have also studied couplings with spin-1 mesons, looking for pole model approaches of weak form factors. We get Goldberger-Treiman relations which exhibit for $\Delta S = 1$ a breaking dependence that is taken along the $\sigma_0$ and $\sigma_8$ directions. The $SU_3$ breaking characterized by introducing a parameter

$$\lambda = \frac{\sqrt{2} \langle \sigma_0 \rangle_0 - (1/2 \sqrt{3}) \langle \sigma_8 \rangle_0}{\sqrt{2} \langle \sigma_0 \rangle_0 + (1/\sqrt{3}) \langle \sigma_8 \rangle_0}$$

seems to be near unity everywhere. We have omitted electromagnetic and weak interactions because the only breaking that can be explained in terms of exclusively spontaneous rupture is the so-called medium-strong breaking.

1. — The Lagrangian.

a) Let $B_i$ and $\bar{B}_i$ be the usual octets of baryonic fields with axial and vector variations under $SU_3 \times SU_3$:

$$\delta B_i = - f_{ijk} \alpha_j B_k, \quad \delta \bar{B}_i = - f_{ijk} \beta_j \gamma_k B_k,$$
$$\delta \bar{B}_i = - f_{ijk} \alpha_j \bar{B}_k, \quad \delta B_i = f_{ijk} \beta_j \bar{B}_k \gamma_k \quad (i, j, k = 1, 2, \ldots, 8).$$

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In matrix notation

\[ B = \frac{1}{\sqrt{2}} \lambda_i B_i, \quad \bar{B} = \frac{1}{\sqrt{2}} \lambda_i \bar{B}_i, \]

where \( \lambda_i \) are the well-known Gell-Mann matrices (see Appendix A).

Now we can define

\[ B^\pm = (1 \pm \gamma_5) B, \quad \bar{B}^\pm = \bar{B}(1 \mp \gamma_5). \]

In the same way we may introduce the matrix expressions of the spin-0 fields which will be

\[ \Sigma = \frac{1}{\sqrt{2}} \lambda_i \sigma_i, \quad \Phi = \frac{1}{\sqrt{2}} \lambda_i \phi_i, \quad (i = 0, 1, ..., 8). \]

From this we define the following linear combinations (1):

\[ M = \Sigma + i\Phi, \quad M^+ = \Sigma - i\Phi, \]

the variations of which are

\[ \delta M = \frac{i}{\sqrt{2}} [\alpha, M], \quad \delta\bar{M} = \frac{i}{\sqrt{2}} \{\beta, M\}, \]

\[ \delta M^+ = \frac{i}{\sqrt{2}} [\alpha, M^+], \quad \delta\bar{M}^+ = -\frac{i}{\sqrt{2}} \{\beta, M^+\} \]

with

\[ \alpha = \frac{1}{\sqrt{2}} \lambda_i \alpha_i, \quad \beta = \frac{1}{\sqrt{2}} \lambda_i \beta_i \quad (i = 0, 1, ..., 8). \]

b) As is well known, you cannot construct a chiral-invariant baryonic mass term, unless you introduce an interaction between baryons and scalar fields. Therefore, we are going to combine both baryonic and spin-0 fields in order to obtain new «objects» with which to be able to construct an invariant-mass Lagrangian for baryons.

So we write the following fields (2):

\[ (B^+ M), \quad (M B^-), \quad (\bar{B}^+ M), \quad (M \bar{B}^-), \]

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(1) Take into account that \( M^+ = P M P^{-1} \), where \( P \) is the parity operator.