RENORMALIZATION OF BARYON VECTOR CURRENT BY BREAKING OF SU(6) SYMMETRY

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It is known [1] that in the first approximation in the broken SU(3) symmetry the vector constants of weak baryon currents are not renormalized. Renormalization takes place in the second order of this violation, owing to the increased number of independent amplitudes [2]. In SU(6) symmetry the interaction H_{MS}, which splits the supermultiplets, does not have, in contrast with SU(3), any definite transformation properties, being at the utmost a combination of the representations 35, 189, and 405 [3], which generally speaking contain arbitrary linear combinations of SU(3) singlets and octets. In this connection it is of interest to obtain an analog of the Ademollo-Gatto theorem [1] in SU(6) symmetry. The vector current of the baryons belonging to the representation $56(B^{\alpha\beta\gamma})$ of the SU(6) group are transformed in accordance with representation 35 and have in unbroken symmetry the form

$$I^{(0)\rho}_{\sigma} \equiv I^{(0)Rp}_{Sq} = \bar{B}^{\alpha\beta\rho}B_{\alpha\beta\sigma} - \frac{1}{6}\delta^R_S\delta^p_q\bar{B}^{\alpha\beta\gamma}B_{\alpha\beta\gamma} \qquad (1)$$

(the Greek indices run through the values from 1 through 6 throughout, capital Latin indices assume values 1, 2, and 3, and lower-case Latin indices assume values 1 and 2).

We choose for the SU(6)-symmetry-breaking interaction H_{MS} an arbitrary linear combination of the representations (1, 1), (8, 1), and (27, 1) of the group SU(3) ⊗ SU(2) from the representations 35, 189, $280 + \overline{280}$ 1) and 405 of the SU(6) group:

$$H_{MS} = H^{\alpha}_{\beta} + H^{\alpha,\beta}_{\gamma,\delta} + \{H^{\alpha,\beta}_{\gamma\delta} + H^{\alpha\beta}_{\gamma,\delta}\} + H^{\alpha\beta}_{\gamma\delta} \qquad (2)$$

where, for example

$$H^{\alpha,\beta}_{\gamma,\delta} \quad H^{Ai,Bj}_{Ck,D\ell} = f[189^1](\delta^A_C\delta^B_D\delta^i_\ell\delta^j_k - \delta^A_D\delta^B_C\delta^i_k\delta^j_\ell) + f[189^8]((T^A_C\delta^B_D + T^B_D\delta^A_C)\delta^i_\ell\delta^j_k -$$
$$- (T^B_C\delta^A_D + T^A_D\delta^B_C)\delta^i_k\delta^j_\ell) + f[189^{27}]T^{AB}_{CD}(\delta^i_k\delta^j_\ell - \delta^i_\ell\delta^j_k) \qquad (2')$$

($T^A_C = \delta^A_3\delta^3_C$ and $T^{AB}_{CD} = \delta^A_3\delta^3_C\delta^B_3\delta^3_D$; symmetry holds for adjacent Greek indices, and indices separated by a comma are antisymmetrical. The SU(6) and SU(3) broken-symmetry characteristics are indicated in f from (2')).

The "inclusion" of H^{α}_{β} from (2) in the current leads to four independent amplitudes, which we denote by $a_i[35^8]$ (i = 1, 2, 3, 4). $H^{\alpha,\beta}_{\gamma,\delta}$ gives three amplitudes: $a[189^1]$, $a[183^8]$, and $[189^{27}]$. Violation of $280 + \overline{280}$ gives two amplitudes $a_i[280^8]$ (i = 1, 2). The term $H^{\alpha\beta}_{\gamma\delta}$ leads to twelve independent amplitudes: $a_i[405^1]$, $a_i[405^8]$, and $a_i[405^{27}]$ (i = 1, 2, 3, 4).

The condition of charge parity for the covariants of the first class (γ_μ, $\sigma_{\mu\nu}$, q_ν) yields four relations between the amplitudes, so that we have ultimately seventeen independent amplitudes generated by the symmetry-breaking interaction (2).

We now use the non-renormalizability of the electromagnetic current, i.e., we stipulate that the component I^{1p}_{1p} of the perturbed current I^{Rp}_{Sq}, which we have obtained (but is too unwieldy to write out), must coincide with $I^{(0)1p}_{1p}$ from (1). This imposes 13 conditions on the amplitudes a, allowance for which causes the baryon vector current I^{ρ}_{σ} to have in first order in H_{MS} the form

$$
\begin{aligned}
I^{\rho}_{\sigma} \equiv I^{Rp}_{Sq} &= \bar{B}^{AiCkRp}B_{AiCkSq} - \tfrac{1}{6}\delta^R_S\delta^p_q\bar{B}^{AiCkD\ell}B_{AiCkD\ell} + a_1[35^8][\delta^R_3\bar{B}^{AiCk3p}B_{AiCkSq} + \\
&+ \delta^3_S\bar{B}^{AiCkRp}B_{AiCk3q}] + a_2[35^8]\delta^R_3\delta^3_S\delta^p_q\bar{B}^{AiCkD\ell}B_{AiCkD\ell} + [a[189^8] + a_1[405^8] + \\
&+ a_1[280^8]]\delta^R_3\delta^3_S\bar{B}^{AiCkDp}B_{AiCkDq} + [-a[189^8] + a_1[405^8]][\delta^R_3\delta^p_q\bar{B}^{AiCk3\ell}B_{AiCkS\ell} + \\
&+ \delta^3_S\delta^p_q\bar{B}^{AiCkR\ell}B_{AiCk3\ell}] + 2[a[189^{27}] + a_1[405^{27}]]\bar{B}^{AiCk3\ell}B_{AiCk3\ell}\delta^R_3\delta^3_S\delta^p_q + \\
&+ 2[-a[189^{27}] + a_1[405^{27}]]\delta^R_3\delta^3_S\bar{B}^{AiCk3p}B_{AiCk3q}
\end{aligned}
\tag{3}
$$

We retain for convenience three conditions on the amplitudes contained in (3):

$$
\begin{aligned}
&a_1[35^8] - 2a[189^8] + 2a_1[405^8] + a[189^{27}] + 3a_1[405^{27}] = 0 \\
&a[189^8] + a_1[405^8] - a_1[280^8] = 0 \\
&a_2[35^8] + a_1[280^8] = 0
\end{aligned}
\tag{3'}
$$

If we start from the fact that the weak vector current enters in one representation 35 with the electromagnetic current, then it follows from (3) and (3') for a weak strangeness-changing current that

$$
I^{3(1)p}_{1(3)p} = (1 - a[189^{27}] - 3a_1[405^{27}])\ \bar{B}^{\,AiCk3(1)\ell}B_{AiCk1(3)\ell} \tag{4}
$$

which yields the Ademollo-Gatto theorem if we confine ourselves only to the representations (1, 1) and (8, 1). It is seen from (4) that the symmetry-breaking (2) leads to renormalization of the F-coupling of the octet baryons, without leading to the occurrence of a D-coupling [2]. Therefore, in first order in (2), the relations that characterize the F-coupling hold for the vector constants of the strangeness-changing currents of the octet (cf., e.g., [4]), as does the relation $(\Xi^{0*}\Omega^-) = \sqrt{2}(\bar{p}\Lambda^0)$ typical of SU(6). In addition, all the vector constants of the weak currents of the decimet-octed transitions vanish even if account is taken of the broken SU(6) symmetry.

If we assume that the current (3) combines both the charges ((8,1)) and the total magnetic moments of the particles ((8,3)), then we find that the magnetic moments (corresponding to $I^{11}_{11} - I^{12}_{12}$) are not renormalized in first order of the broken symmetry (2). This circumstance is attractive in connection with the very good agreement between the theoretical and experimental values of the ratio μ_p/μ_n (the 3% discrepancy corresponds exactly to the approximate scales of the second order in broken symmetry).

Making an analogous assumption for the components of current (3) corresponding to weak magnetism, we obtain:

$$I^{1(3)\ 1(2)}_{3(1)\ 1(2)} = (1 + a_1[35^8] - a[189^8] + a_1[405^8])\ \bar{B}^{AiCk1(3)\ 1(2)}B_{AiCk3(1)\ 1(2)}$$

$$I^{1(3)\ 1(2)}_{3(1)\ 2(1)} = (1 + a_1[35^8])\ \bar{B}^{AiCk1(3)\ 1(2)}B_{AiCk3(1)\ 2(1)}.$$

[1] M. Ademollo and R. Gatto, Phys. Rev. Lett. 13, 264 (1964).

[2] V. I. Zakharov and I. Yu. Kobzarev, ITEF Preprint No. 298, 1964.

[3] M. A. Beg and V. Singh, Phys. Rev. Lett. 13, 418 (1964).

[4] L. B. Okun', ITEF Preprint No. 287, 1964.

1) For the sake of generality we are considering also the reducible self-conjugate representation $280 + \overline{280}$. It is easy to see that it does not contain the representations (1, 1) and (27, 1) of the group $SU(3) \otimes SU(2)$.

2) The latter circumstance is connected with the fact that the baryons belong to the representation of the 56 group of SU(6). In the case of a mesic weak vector current, H_{MS} leads to the appearance of D-coupling.

CORRECTION

to the article by E. V. Gedalin, O. V. Kancheli, and S. G. Matinyan "Renormalization of Baryon Vector Current by Breaking of SU(6) Symmetry" (JETP Letters 1, No 3, 35 (1965), translation p 93).

Expression (3) for the perturbed current J_{σ}^{ρ} was obtained in fact not by equating J_{1p}^{1p} to $J_{1p}^{(0)1p}$, but by equating the individual components J_{1q}^{1p} (p = q) to the corresponding components $J_{1q}^{(0)1p}$, and is therefore incorrect. The correct procedure referred to in our paper yields 11 conditions on the amplitude a. Nonetheless, formula (4), which is a generalization of the Ademollo-Gatto theorem, and all the deductions connected with it, remain unchanged. The deduction that there is no renormalization of the magnetic moments also remains in force, but only if we confine ourselves to symmetry breaking of the type 35^8.

If the weak axial current belongs to the same 35 representation as the weak vector current, then only the "bare" constant G_A^0 becomes renormalized when the breaking of SU(6) considered in the letter is "turned on." For A-current with $\Delta S = 0$ we have

$$G_A = (1 + 2a[189^1] - 2a_1[405^1]G_A^0$$

and for $\Delta S = 1$

$$G_A' = (1 + 2a[189^1] - 2a_1[405^1] + a_1[35^8])G_A^0$$

Similar formulas were obtained for the weak-magnetism constants.