$\underline{27}$ contribution to weak electromagnetic decays

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We notice that the assumption of octet dominance of the Cabibbo weak Hamiltonian is not required to explain the weak electromagnetic decays. In order to explain large asymmetry parameter $\alpha(\Sigma^+\to p\gamma)$ we consider λ_7 contribution to the parity-violating Hamiltonian.

Recent observations[1] have renewed the interest in the weak electromagnetic decays of hyperons. These decays have been studied by many authors[2] in symmetry considerations. In a current × current model, an octet-dominant weak Hamiltonian transforming as a λ_6 component gives the following results[2]:

$$\langle p\gamma|\Sigma^+\rangle = \langle\Sigma^-\gamma|\Xi^-\rangle = 0\,, \tag{1a}$$

$$\begin{aligned}\sqrt{3}\langle n\gamma|\Lambda\rangle &= -\sqrt{3}\langle\Lambda\gamma|\Xi^0\rangle\\ &= \langle n\gamma|\Sigma^0\rangle\\ &= -\langle\Sigma^0\gamma|\Xi^0\rangle\end{aligned} \tag{1b}$$

for parity-violating (pv) decays, and

$$2\langle\Lambda\gamma|\Xi^0\rangle + \langle n\gamma|\Lambda\rangle = \sqrt{3}\langle n\gamma|\Sigma^0\rangle\,, \tag{2a}$$

$$\langle\Lambda\gamma|\Xi^0\rangle + 2\langle n\gamma|\Lambda\rangle = \sqrt{3}\langle\Sigma^0\gamma|\Xi^0\rangle \tag{2b}$$

for parity-conserving (pc) decays.[3]

In this note we remark that the assumption of octet dominance is not required to get these results. In SU(3), the $\underline{27}$ component of the weak Hamiltonian transforms like

$$\begin{aligned}H_w^{27} = {}& a_1\,\bar{B}^m_c B^a_d \Lambda^b_m H^{(c,d)}_{(a,b)} + a_2\,\bar{B}^a_c B^b_m \Lambda^m_d H^{(c,d)}_{(a,b)}\\ &+ a_3\,\bar{B}^a_m B^b_c \Lambda^m_d H^{(c,d)}_{(a,b)} + a_4\,\bar{B}^a_c B^m_d \Lambda^b_m H^{(c,d)}_{(a,b)}\\ &+ a_5\,\bar{B}^m_c B^a_m \Lambda^b_d H^{(c,d)}_{(a,b)} + a_6\,\bar{B}^a_m B^m_c \Lambda^b_d H^{(c,d)}_{(a,b)}\,.\end{aligned} \tag{3}$$

The trace terms of the $\underline{27}$ Hamiltonian can be absorbed in the octet Hamiltonian with the space-time properties of the octet pieces intact. *CP* invariance leads to:

$$\begin{aligned}&a_1 = a_2\,,\quad a_3 = a_4\,,\quad \text{for } P=+1 \text{ decays}\\ &a_1 = -a_2\,,\quad a_3 = -a_4\,,\quad a_5 = a_6 = 0\,,\quad \text{for } P=-1 \text{ decays.}\end{aligned} \tag{4}$$

Now, in the conventional model of weak interactions,[4] Cabibbo currents generate only one $\underline{27}$ component $\sim H^{(2,1)}_{(3,1)}$. We notice that relations (1) and (2) are satisfied by $\underline{27}$ contributions as well. Even the introduction of an independent singlet component in electromagnetic current does not disturb the relations.

The relation $\langle p\gamma|\Sigma^+\rangle = 0$ is not satisfied experimentally, since the symmetry parameter α for this decay has been measured[5] to be $(-1.03^{+0.52}_{-0.42})$. In order to remove the discrepancy, we suggest a λ_7 admixture to the pv Hamiltonian, i.e., $H_w^{pv} = a\lambda_7 + b\lambda_6$. This structure of the weak Hamiltonian has also been suggested[6] in recent models of weak interactions having second-class currents and/or right-handed currents. In this case, relations (2) for pc decays remain valid, but relations (1) are modified to give

$$\sqrt{3}(\langle n\gamma|\Lambda\rangle + \langle\Lambda\gamma|\Xi^0\rangle) = \langle\Sigma^0\gamma|\Xi^0\rangle + \langle n\gamma|\Sigma^0\rangle\,, \tag{5}$$

and the relative strength of the λ_7 admixture is determined to be

$$\frac{b}{a} = \frac{\langle\Lambda\gamma|\Xi^0\rangle + 2\langle n\gamma|\Lambda\rangle - \sqrt{3}\langle\Sigma^0\gamma|\Xi^0\rangle}{2(\langle\Lambda\gamma|\Xi^0\rangle + \langle n\gamma(\Lambda\rangle) - 1/\sqrt{6}(\langle p\gamma)\Sigma^+\rangle - \langle\Sigma^-\gamma|\Xi^-\rangle)}\,. \tag{9}$$

The relation (5) is valid even in the presence of the $\underline{27}$ weak Hamiltonian and the independent singlet component in the electromagnetic current. This happens, perhaps, because of the specific behavior of photons, which selects only those parts of the $\underline{27}$ Hamiltonian which behave similar to the octet Hamiltonian.

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