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Weak nonleptonic decays of $3/2^+$ isobars in SU(3)

KUSUM SHARMA* and RAMESH C VERMA
Department of Physics, Panjab University, Chandigarh 160 014
*Permanent Address: DAV College for Women, Karnal 132 001,

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Abstract. Weak transitions of decuplet isobars are expanded in terms of eigen-amplitudes of the direct channel in the framework of SU(3). Starting with the most general weak Hamiltonian and assuming intermediate states to be non-exotic, we obtain $\Delta I=\frac{1}{2}$ rule for Ω^- decays. Invoking of the CP invariance forbids all the *pv* weak processes $D(10)\rightarrow D(10) + P(8)$. Decays of the charmed multiplets are also discussed in these dynamical considerations. We obtain triplet dominance of charm changing weak Hamiltonian for $\Omega_3{}^{*++}$ decays.

Keywords. Non leptonic decays; $3/2^+$ isobars; weak transitions.

1. Introduction

Structure of the weak Hamiltonian for hadronic decays is not clear, though many models of weak interaction have been proposed (Glashow *et al* 1970; Branco *et al* 1975; Fritzsch and Minkowski 1976; Abe *et al* 1977). Structure of the weak Hamiltonian for the non-leptonic decays of $1/2^+$ hyperons has been analysed in a dynamical consideration (Taha 1968; Bajaj *et al* 1974). Phenomenon of octet dominance was obtained with a simple dynamical assumption corresponding to the intermediate states. In this paper, we study the structure of the weak Hamiltonian for the weak non-leptonic decays of $3/2^+$ charmed and uncharmed isobars in the SU(3) symmetry framework using similar dynamical assumption.

Inclusion of charm quark predicts the existence of ten $[D(6)\ D(3),\ D(1)]\,3/2^+$ charmed states (Amati *et al* 1964) in addition to the uncharmed decuplet isobars. Recently observed mass values (Cazzoli *et al* 1975; Knapp *et al* 1976; Goldhaber *et al* 1976) of few charmed states indicate (Gupta 1976; de Rujula *et al* 1977; Verma and Khanna 1977a) that $\Omega_3{}^{*++}$ $(D(1))$ may be the only possible purely weakly decaying. We discuss the weak non-leptonic decays of $\Omega_3{}^{*++}$ and Ω^- in the modes $3/2^+\rightarrow 3/2^+/1/2^+ + 0^-$. Starting with the most general Hamiltonian and assuming that only the eigen amplitudes corresponding to the non-exotic states can contribute to the transitions, we obtain $\Delta I=1/2$ rule for *pv* as well as *pc* decays of Ω^- in the modes $\Omega^-\rightarrow \Xi/\Xi^* + \pi$. CP invariant SU(3) weak Hamiltonian further forbids all the *pv* decays $D(10)\rightarrow D(10)+P(8)$, but it gives no constraints for the decays of charmed baryons. For $\Omega_3{}^{*++}$ decays, dynamical assumption alone leads to triplet dominance of the charm-changing weak Hamiltonian. The Cabibbo enhanced decays $(\Delta C=\Delta S=-1)$ of $\Omega_3{}^{*++}$ are forbidden in *pv* as well as *pc* modes. We include weak decays of $D(3)$ and $D(6)$ multiplets for the sake of completeness.

Simple relations are obtained among the decay amplitudes of these charmed isobars. An outline of the method and the weak Hamiltonian are described in § 2 whereas § 3 gives the details for *pv* and *pc* decays.

2. Preliminaries

We assume current ⊗ current form of the weak interaction. GIM weak current transforms like

$$J = \bar{p}n \cos\theta + \bar{p}\lambda \sin\theta - \bar{c}n \sin\theta + \bar{c}\lambda \cos\theta, \tag{1a}$$

component of $\underline{15}$ representation of SU(4), where θ is the Cabibbo angle. (Dirac operators have been omitted). It has the following SU(3) decomposition

$$J^8 = \bar{p}n \cos\theta + \bar{p}\lambda \sin\theta,$$

$$J^3 = -\bar{c}n \sin\theta + \bar{c}\lambda \cos\theta.$$

Then weak Hamiltonian $H_w \sim \{J, J^\dagger\}$ has the following components:

$$H_w \sim (\{8, 8\} + \{3, 3^*\}_{\triangle c=0}) + \{3, 8\}_{\triangle c=-1} + \{8, 3^*\}_{\triangle c=+1}. \tag{2a}$$

Thus charm conserving weak Hamiltonian belongs to the representations present in the direct products

$$\underline{8}\otimes\underline{8} = \underline{1}\oplus 2(\underline{8})\oplus\underline{10}\oplus\underline{10}^*\oplus\underline{27}$$

$$\underline{3}\otimes\underline{3}^* = \underline{1}\oplus\underline{8}.$$

Tensor structure $T_{(SII_z)}$ of SU(3) weak Hamiltonian can be written as:

$$H_w^{\triangle c=0} \sim T^8_{(1,\,1/2,\,-1/2)} + T^{10}_{(1,\,3/2,\,-1/2)} + T^{10*}_{(1,\,1/2,\,-1/2)} + T^{27}_{(1,\,1/2,\,-1/2)}$$

$$- \sqrt{5}\, T^{27}_{(1,\,3/2,\,-1/2)} \tag{2b}$$

whereas charm changing ($\triangle C = -1$) weak Hamiltonian lies in the direct product:

$$\underline{8}\otimes\underline{3} = \underline{3}\oplus\underline{6}^*\oplus\underline{15}.$$

Charm changing decays can occur through three modes depending upon the change in strangeness. The tensor structure of various components is as follows:

$$H^{\triangle c=-1} \sim [T^{6*}_{(-1,\,1,\,1)} + T^{15}_{(-1,\,1,\,1)}] \cot\theta + [T^{6*}_{(1,\,0,\,0)} + T^{15}_{(1,\,1,\,0)}] \tan\theta$$

$$+ [T^{3}_{(0,\,1/2,\,1/2)} + T^{6*}_{(0,\,1/2,\,1/2)} + T^{15}_{(0,\,1/2,\,1/2)} - \sqrt{2}\, T^{15}_{(0,\,3/2,\,1/2)}]. \tag{2c}$$

The hyperon decay process $A \to B+P$ can be understood as:

$$S + A \to m \to B + P,$$

where the spurion s has the same tensor structure as the weak Hamiltonian so as to conserve all the quantum numbers in the above reaction. The transition amplitude are expressed in terms of reduced amptitudes (Gourdin 1967) by using SU(3) Clebsch Gordan coefficients corresponding to the projection of the initial and the final states on the eigen states $|m\rangle$. We use the Biedenharn's (1963) conventions for the isoscalar factors. Appendix B gives the isoscalar factors for the direct product $\underline{27} \otimes \underline{10}$ as calculated from Pandit and Mukunda (1965). For other products, the isoscalar factors are taken from Haacke *et al* (1976).

2.1. $D(10) \to D(10)+P(8)$ *decays*

Reduced amplitudes are defined as:

$$a_m = \langle 10_{D'} | 8_P | m\rangle \langle m | 8 | 10_D\rangle$$

$$b_m = \langle 10_{D'} | 8_P | m\rangle \langle m | 27 | 10_D\rangle$$

$$c_m = \langle 10_{D'} | 8_P | m\rangle \langle m | 10 | 10_D\rangle$$

$$d_m = \langle 10_{D'} | 8_P | m\rangle \langle m | 10^* | 10_D\rangle. \tag{3}$$

In all, we have twelve reduced matrix elements corresponding to a_8, a_{10}, a_{27}, a_{35}, b_8, b_{10}, b_{27}, b_{35}, c_{27}, c_{35}, d_8 and d_{27}. Assuming the intermediate states to be non-exotic, we get the following constraints:

$$a_{27,\,35} = b_{27\ 35} = c_{27,\,35} = d_{27} = 0. \tag{4}$$

2.2. $D(10) \to B(8) + P(8)$ *decays*

Here, *CP* invariance gives no constraints. We define:

$$a'_m = \langle 8_B | 8_P | m\rangle \langle m | 8 | 10_D\rangle$$

$$b'_m = \langle 8^B | 8_P | m\rangle \langle m | 27 | 10_D\rangle$$

$$c'_m = \langle 8_B | 8_P | m\rangle \langle m | 10 | 10_D\rangle$$

$$d'_m = \langle 8_B | 8_P | m\rangle \langle m | 10^* | 10_D\rangle. \tag{5}$$

The consequences of CP-invariance are derived by writing the cross channel: $D'+\bar{s} \to D+\bar{P}$ transition amplitudes and then applying the conditions: $A(D \to D'\bar{P}) = -A(D' \to D\bar{P})$ for pv amplitudes and $B(D \to D'p) = B(D' \to D\bar{p})$ for pc amplitudes.

We have 14 parameters i.e. a'_{27}, a'_{10}, a'_{8_D}, a'_{8_F}, b'_{27}, b'_{10}, b'_{10*}, b'_{8_D}, b'_{8_F} c'_{10*}, c'_{27} d'_{8_D}, d'_{8_F} and d'_{27}. The dynamical assumption for the intermediate states imposes the following conditions

$$a'_{27} = 0; \quad b'_{27,\,10}{}^{*} = 0; \quad c'_{27,\,10}{}^{*} = 0; \quad d'_{27} = 0. \tag{6}$$

The number of independent parameters is reduced to eight.

2.3. *Weak decays of* Ω_3^{*++}

Ω_3^{*++} can decay through the following channels:

$$D(1) \to D(3)\ /\ B(3) + P(8)$$

$$D(1) \to D(6)\ /\ B(6)\ /\ B(3^*) + P(3^*).$$

We denote the reduced amplitudes as:

(i) $D(1) \to D(3)\ /\ B(3) + P(8)$

$$a_3{}^n = \langle 3 | 8 | m \rangle \langle m | 3 | 1 \rangle \qquad m=3, \quad n=1/2 \text{ or } 3/2,$$

$$a^n_{6*} = \langle 3 | 8 | m \rangle \langle m | 6^* | 1 \rangle \qquad m=6^*,$$

$$a^n_{15} = \langle 3 | 8 | m \rangle \langle m | 15 | 1 \rangle \qquad m=15, \tag{7}$$

(ii) $D(1) \to D(6)\ /\ B(6) + P(3^*)$

$$b^n_3 = \langle 6 | 3^* | m \rangle \langle m | 3 | 1 \rangle \qquad m=3,$$

$$b^n_{6*} = \langle 6 | 3^* | m \rangle \langle m | 6^* | 1 \rangle \qquad \text{no intermediate state},$$

$$b^n_{15} = \langle 6 | 3^* | m \rangle \langle m | 15 | 1 \rangle \qquad m=15, \tag{8}$$

(iii) $D(1) \to B(3^*) + P(3^*)$

$$c_3 = \langle 3^* | 3^* | m \rangle \langle m | 3 | 1 \rangle \qquad m=3,$$

$$c_{6*} = \langle 3 | 3^* | m \rangle \langle m | 6^* | 1 \rangle \qquad m=6^*,$$

$$c_{15} = \langle 3^* | 3^* | m \rangle \langle m |_{15} | 1 \rangle \qquad \text{no intermediate state}, \tag{9}$$

where n denotes the spin of the baryon in the final state. Assumption of the intermediate states leads to

$$a^n_{6*,15} = 0; \quad b^n_{15} = 0; \quad c_{6*} = 0. \tag{10}$$

2.4. *Decays of* $D(3)$ *multiplet*

D(3) isobars decay through the channels

$$D(3) \rightarrow D(6)/B(6)+P(8),$$
$$\rightarrow D(10)/B(8)+P(3^*),$$
$$\rightarrow B(3^*)+P(8).$$

For $\triangle C = \triangle S = -1$ mode, we define the reduced amplitudes as follows:

(i) $D(3) \rightarrow D(6)/B(6)+P(8)$

$$A_m{}^n = \langle 6 | 8 | m \rangle \langle m | 6^* | 3 \rangle = 3^*, 15^* \quad n = \tfrac{1}{2} \text{ or } \tfrac{3}{2},$$

$$B_m{}^n = \langle 6 | 8 | m \rangle \langle m | 15 | 3 \rangle \; m = 6, 15^*, 24, \tag{11}$$

where n denotes the spin of the final state baryon.

(ii) $D(3) \rightarrow D(10) + P(3^*)$

$$C_m = \langle 10 | 3^* | m \rangle \langle m | 6^* | 3 \rangle \text{ no intermediate state}$$

$$D_m = \langle 10 | 3^* | m \rangle \langle m | 15 | 3 \rangle \; m = 6, 24. \tag{12a}$$

(iii) $D(3) \rightarrow B(8) + P(3^*)$

$$E_m = \langle 8 | 3^* | m \rangle \langle m | 6^* | 3 \rangle \; m = 3^*, 15^*,$$

$$F_m = \langle 8 | 3^* | m \rangle \langle m | 15 | 3 \rangle \; m = 6, 15^*. \tag{12b}$$

(iv) $D(3) \rightarrow B(3^*) + P(8)$

$$G_m = \langle 3^* | 8 | m \rangle \langle m | 6^* | 3 \rangle \; m = 3^*, 15^*,$$

$$H_m = \langle 3^* | 8 | m \rangle \langle m | 15 | 3 \rangle \; m = 6, 15^*. \tag{13}$$

The dynamical assumption leads to the following constraints

$$A^n_{15^*} = B^n_{15^*, 24} = 0,$$

$$D_{24} = E_{15^*} = F_{15^*} = G_{15^*} = H_{15^*} = H_{15^*} = 0. \tag{14}$$

2.5. *Weak decays of* $D(6)$ *multiplet*

$D(6)$ isobars decay through the following channels:

$$D(6) \rightarrow D(10)/B(8) + P(8).$$

For $\triangle C = \triangle S = -1$ mode, the reduced amplitudes are defined as follows.

(i) $D(6) \to D(10) + P(8)$

$$g_m = \langle 10 | 8 | m \rangle \langle m | 6^* | 6 \rangle \quad m=8, 27,$$

$$h_m = \langle 10 | 8 | m \rangle \langle m | 15 | 6 \rangle \quad m=8, 10, 27. \tag{15}$$

(ii) $D(6) \to B(8) + P(8)$

$$j_m = \langle 8 | 8 | m \rangle \langle m | 6^* | 6 \rangle \quad m=8, 27,$$

$$k_m = \langle 8 | 8 | m \rangle \langle m | 15 | 6 \rangle \quad m=8, 10, 10^*, 27. \tag{16}$$

The assumption of intermediate states imposes the conditions

$$g_{27} = h_{27} = 0, \quad j_{27} = k_{10^*, 27} = 0. \tag{17}$$

3. Decay amplitudes

In this section we give the results obtained for various decay modes of charmed and uncharmed isobars. Expressions for all the possible decay amplitudes of charmed multiplets are given in appendix A.

3.1. $D(10) \to D(10) + P(8)$

Most of these decays are not observed as the parent particle decays strongly. But, in principle, these can occur and we consider them to obtain conditions from CP-invariance. The relations obtained among the reduced matrix elements are

$$2a_{27} = -(9\sqrt{6})\, a_8 - (3\sqrt{30})\, a_{10},$$

$$2a_{35} = -(\sqrt{70})\, a_8 + (\sqrt{14})\, a_{10},$$

$$1/2\,(\sqrt{70})\, b_{35} = (\sqrt{3}/6\sqrt{7})\, b_{27} = -(\sqrt{10}/15\sqrt{7})\, b_{10} = b_8, \tag{18a}$$

for *pv* decays,

and $$a_{35} = -\sqrt{14/5}\, a_8 - (\sqrt{14}/2)\, a_{10} + 2\sqrt{7}/\sqrt{15}\, a_{27}$$

$$b_{35} = (4\sqrt{7})/(5\sqrt{10})\, b_8 + 4/5\, b_{10} + (6\sqrt{3})/(5\sqrt{10})\, b_{27} \tag{18b}$$

for *pc* decays.

This does not lead to any useful relation since the number of parameters is large, while the dynamical assumption alone reduces the Ω^- decay amplitudes to the following:

$$-\langle \Xi^{*\circ}\pi^{-}/\Omega^{-}\rangle = -(1/\sqrt{15})\, a_8 - (1/4\sqrt{3})\, a_{10} - (1/3\sqrt{10})\, b_8$$

$$-(1/3\sqrt{7})\, b_{10} + (1\sqrt{30})\, d_8,$$

$$\langle \Xi^{*-}\pi^{\circ}/\Omega^{-}\rangle = -(1/\sqrt{30})\, a_8 - (1/4\sqrt{6})\, a_{10} - (1/6\sqrt{5})\, b_8$$

$$-(1/3\sqrt{14})\, b_{10} + (1/2\sqrt{15})\, d_8 \qquad (19)$$

and further it gives null contribution to the matrix element

$$\langle 10,\, 8 \mid T^{27}_{(1,3/2,-1/2)} \mid 10\,(-2,\, 0)\rangle.$$

Thus $\triangle I = 1/2$ rule is obtained for both the *pv* as well as *pc* modes. Actually in *pv* mode, none of the decays $D(10) \rightarrow D(10) + P(8)$ are allowed to occur in nature under dynamical assumption and *CP* invariance. The result $\langle \Xi^{*}\pi \mid \Omega^{-}\rangle = 0$ in *pv* mode has been obtained in SU(4) (Verma and Khanna 1977b) but with $\underline{20}''$ dominance. It is to be noted that in SU(3) tensor analysis, $\underline{27}$ piece of weak Hamiltonian under CP invariance gives null contribution to $\Omega^{-} \rightarrow \Xi^{*}\pi$ decays in *pv* mode. In SU(4) current algebra framework, $\langle \Xi^{*}\pi \mid \Omega^{-}\rangle$ are forbidden in *pc* mode too (Khanna 1976). In our analysis for the *pc* mode $\underline{27}$ contribution vanishes for $\Omega^{-} \rightarrow \Xi^{*}\pi$ decays under the dynamical assumption thus leading to octet dominance for Ω^{-} decays. We would like to point out that CP invariance along with dynamical assumption does not lead to octet dominance for *pc* decays of other resonances in D (10).

3.2. $D(10) \rightarrow B(8) + P(8)$ *decays*

Here, we discuss the Ω^{-} decays only. We obtain the following amplitudes after retaining only those amplitudes which correspond to physical states.

$$-\langle \Xi^{0}\pi^{-} \mid \Omega^{-}\rangle = (\sqrt{3/5})\, a'_{8_D} + (1/\sqrt{15})\, a'_{8_F} + (1/2\sqrt{6})\, a'_{10}$$

$$+ (1/5\sqrt{2})\, b'_{8_D} + (1/3\sqrt{10})\, b'_{8_F} + (2/3\sqrt{14})\, b'_{10}$$

$$- (3/5\sqrt{6})\, d'_{8_D} - (1/\sqrt{30})\, d'_{8_F},$$

$$\langle \Xi^{-}\pi^{0} \mid \Omega^{-}\rangle = (\sqrt{6}/10)\, a'_{8_D} + (1/\sqrt{30})\, a'_{8_F} + (1/4\sqrt{3})\, a'_{10}$$

$$+ (1/10)\, b'_{8_D} + (1/6\sqrt{5})\, b'_{8_F} + (1/3\sqrt{7})\, b'_{10}$$

$$- (3/10\sqrt{3})\, d'_{8_D} - (1/2\sqrt{15})\, d'_{8_F},$$

$$\langle \Lambda K^{-} \mid \Omega^{-}\rangle = (1/5\sqrt{2})\, a'_{8_D} + (1/\sqrt{10})\, a'_{8_F} - (1/4)\, a'_{10}$$

$$+ (1/10\sqrt{3})\, b'_{8_D} + (1/2\sqrt{15})\, b'_{8_F} - (1/\sqrt{21})\, b'_{10} \qquad (20)$$

$$- (1/10)\, d'_{8_D} - (1/2\sqrt{5})\, d'_{8_F}.$$

Here also dynamical assumption alone gives null contribution to the matrix element $\langle 8, 8 \mid T^{27}_{(1, 3/2, -1/2)} \mid 10\,(-2, 0)\rangle$. Thus leading to $\triangle I = 1/2$ rule i.e.

$$\Omega^-_- = -\sqrt{2}\,\Omega^-_0 .$$

3.3. Ω_3^{*++} *decays*

Using conditions (10) we obtain triplet dominance for SU(3) charm changing weak Hamiltonian. For $\triangle C = -1$, $\triangle S = 0$, we obtain the following relations:

(i) $D(1) \to D(3)/B(3) + P(8)$

$$\langle \Xi_2^{*+} / \Xi_2^{+}\,\pi^+ \mid \Omega_3^{*++}\rangle = -\sqrt{2}\,\langle \Xi_2^{*++} / \Xi_2^{++}\,\pi^0 \mid \Omega_3^{*++}\rangle$$

$$= -\sqrt{6}\,\langle \Xi_2^{*++} / \Xi_2^{++}\,\eta \mid \Omega_3^{*++}\rangle = -\sqrt{3}\,\langle \Omega_2^{*+} / \Omega_2^{+}\,K^+ \mid \Omega_3^{*++}\rangle \tag{21a}$$

(ii) $D(1) \to D(6)/B(6) + P(3^*)$

$$\sqrt{2}\,\langle \Xi_1^{*+} / \Xi_1^{+}\,F^+ \mid \Omega_3^{*++}\rangle = -\sqrt{2}\,\langle \Sigma_1^{*+} / \Sigma_1^{+}\,D^+ \mid \Omega_3^{*++}\rangle$$

$$= \langle \Sigma_1^{*++} / \Sigma_1^{++}\,D^0 \mid \Omega_3^{*++}\rangle \tag{21b}$$

(iii) $D(1) \to B(3^*) + P(3^*)$

$$\langle \Xi'^{+}_1\,F^+ \mid \Omega_3^{*++}\rangle = -\langle \Lambda'^{+}_1\,D^+ \mid \Omega_3^{*++}\rangle. \tag{21c}$$

Notice that $\triangle C = \pm \triangle S$ decays are not allowed.

3.4. *Decays of* $D(3)$ *multiplet*

Conditions (14) yield the following relations among the decay amplitudes:

(i) $D(3) \to D(6)\,/\,B(6) + P(8)$

$$0 = \langle \Omega_1^{*0} / \Omega_1^{0}\,\pi^+ \mid \Omega_2^{*+}\rangle = \langle \Xi_1^{*+} / \Xi_1^{+}\,\bar{K}^0 \mid \Omega_2^{*+}\rangle$$

$$= \langle \Xi_1^{*+} / \Xi_1^{+}\,\pi^+ \mid \Xi_2^{*++}\rangle = \langle \Sigma_1^{*++} / \Sigma_1^{++}\,\bar{K}^0 \mid \Xi_2^{*++}\rangle, \tag{22a}$$

$$\sqrt{2}\,\langle \Xi_1^{*+}/\Xi_1^{+}\pi^0 \mid \Xi_2^{*+}\rangle = \langle \Xi_1^{*0}/\Xi_1^{0}\pi^+ \mid \Xi_2^{*+}\rangle, \tag{22b}$$

$$\sqrt{2}\,\langle \Sigma_1^{*+}/\Sigma_1^{+}\bar{K}^0 \mid \Xi_2^{*+}\rangle = \langle \Sigma_1^{*++}/\Sigma_1^{++}K^- \mid \Xi_2^{*+}\rangle, \tag{22c}$$

$$\sqrt{6}\,\langle \Xi_1^{*+}/\Xi_1^{+}\eta \mid \Xi_2^{*+}\rangle = \langle \Xi_1^{*0}/\Xi_1^{0}\pi^+ \mid \Xi_2^{*+}\rangle - 2\langle \Sigma_1^{*+}/\Sigma_1^{+}\bar{K}^0 \mid \Xi_2^{*+}\rangle \tag{22d}$$

(ii) $D(3)\to D(10)+P(3^*)$

$$0 = \langle \Xi^{*0} D^+ \mid \Omega_2^{*+}\rangle = \langle \Sigma^{*+} D^+ \mid \Xi_2^{*++}\rangle, \tag{23a}$$

$$\langle \Xi^{*0} F^+ \mid \Xi_2^{*+}\rangle = \langle \Sigma^{*+} D^0 \mid \Xi_2^{*+}\rangle = \sqrt{2}\,\langle \Sigma^{*0} D^+ \mid \Xi_2^{*+}\rangle. \tag{23b}$$

(iii) $D(3)\to B(8)+P(3^*)$

$$0 = \langle \Xi^0 D^+ \mid \Omega_2^{*+}\rangle = \langle \Sigma^+ D^+ \mid \Xi_2^{*++}\rangle, \tag{24a}$$

$$\sqrt{2}\,\langle \Sigma^0 D^+ \mid \Xi_2^{*+}\rangle = \langle \Sigma^+ D^0 \mid \Xi_2^{*+}\rangle, \tag{24b}$$

$$-2\langle \Xi^0 F^+ \mid \Xi_2^{*+}\rangle + \langle \Sigma^+ D^0 \mid \Xi_2^{*+}\rangle = \sqrt{6}\,\langle \Lambda D^+ \mid \Xi_2^{*+}\rangle. \tag{24c}$$

(iv) $D(3)\to B(3^*)+P(8)$

$$0 = \langle \Xi'^{+}_1 \bar{K}^0 \mid \Omega_2^{*+}\rangle = \langle \Xi'^{+}_1 \pi^+ \mid \Xi_2^{*++}\rangle, \tag{25a}$$

$$\sqrt{2}\,\langle \Xi'^{+}_1 \pi^0 \mid \Xi_2^{*+}\rangle = \langle \Xi'^{0}_1 \pi^+ \mid \Xi_2^{*+}\rangle, \tag{25b}$$

$$\sqrt{6}\,\langle \Xi'^{+}_1 \eta \mid \Xi_2^{*+}\rangle = \langle \Xi'^{0}_1 \pi^+ \mid \Xi_2^{*+}\rangle - 2\langle \Lambda'^{+}_1 \bar{K}^0 \mid \Xi_2^{*+}\rangle, \tag{25c}$$

Notice that weak decays of Ω_2^{*+} and Ξ_2^{*++} are totally forbidden. Cabibbo enhanced component (6^*) of the weak Hamiltonian does not contribute to $D(3)\to D(10)+P(3^*)$ decays.

3.5. *Decays of D(6) multiplet*

Dynamical assumption leads to the following relations among decay amplitudes

(i) $D(6)\to D(10)+P(8)$

$$0 = \langle \Omega^- \pi^+ \mid \Omega_1^{*0}\rangle = \langle \Xi^{*0} \bar{K}^0 \mid \Omega_1^{*0}\rangle = \langle \Xi^{*0} \pi^+ \mid \Xi_1^{*+}\rangle$$

$$= \langle \Sigma^{*+} \bar{K}^0 \mid \Xi_1^{*+}\rangle = \langle \Sigma^{*+} \pi^+ \mid \Sigma_1^{*++}\rangle = \langle \Delta^{++} \bar{K}^0 \mid \Sigma_1^{*++}\rangle \tag{26a}$$

$$\langle \Sigma^{*+} \pi^- \mid \Sigma_1^{*0}\rangle = -\langle \Xi^{*0} K^0 \mid \Sigma_1^{*0}\rangle, \tag{26b}$$

$$-\langle \Xi^{*0} K^{+} | \Sigma^{*+} \rangle = \sqrt{2} \langle \Sigma^{*0} \pi^{+} | \Sigma_1^{*+} \rangle = \sqrt{2} \langle \Sigma^{*+} \pi^{0} | \Sigma_1^{*+} \rangle, \quad (26c)$$

$$\langle \Sigma^{*+} K^{-} | \Xi_1^{*0} \rangle = \sqrt{2} \langle \Sigma^{*0} \bar{K}^{0} | \Xi_1^{*0} \rangle, \quad (26d)$$

$$-1/\sqrt{3} \langle \Omega^{-} K^{+} | \Xi_1^{*0} \rangle = \langle \Xi^{*-} \pi^{+} | \Xi_1^{*0} \rangle = \sqrt{2} \langle \Xi^{*0} \pi^{0} | \Xi_1^{*0} \rangle,$$

$$= -1/\sqrt{2} \langle \Delta^{0} \bar{K}^{0} | \Sigma_1^{*0} \rangle = -(1/\sqrt{2}) \langle \Delta^{0} K^{-} | \Sigma_1^{*0} \rangle \quad (26e)$$

$$\langle \Delta^{++} K^{-} | \Sigma_1^{*+} \rangle = \sqrt{3} \langle \Delta^{+} \bar{K}^{0} | \Sigma_1^{*+} \rangle$$

$$= \sqrt{3/2} \langle \Xi^{*-} K^{+} | \Sigma_1^{*0} \rangle = -\sqrt{3/2} \langle \Sigma^{*-} \pi^{+} | \Sigma_1^{*0} \rangle, \quad (26f)$$

$$\sqrt{6} \langle \Xi^{*0} \eta | \Xi_1^{*0} \rangle = \langle \Xi^{*-} \pi^{+} | \Xi_1^{*0} \rangle - 2 \langle \Sigma^{*+} K^{-} | \Xi_1^{*0} \rangle, \quad (26g)$$

$$-\sqrt{2} \langle \Sigma^{*+} K^{-} | \Xi_1^{*0} \rangle = \langle \Sigma^{*-} \pi^{+} | \Sigma_1^{*0} \rangle - \langle \Delta^{+} K^{-} | \Sigma_1^{*0} \rangle$$

$$-2 \langle \Sigma^{*0} \pi^{+} | \Sigma_1^{*+} \rangle, \quad (26h)$$

$$\sqrt{3} \langle \Sigma^{*0} \eta | \Sigma_1^{*0} \rangle + \langle \Sigma^{*0} \pi^{0} | \Sigma_1^{*0} \rangle - \langle \Sigma^{*-} \pi^{+} | \Sigma_1^{*0} \rangle,$$

$$= -\langle \Delta^{+} K^{-} | \Sigma_1^{*0} \rangle, \quad (26i)$$

$$2 \langle \Sigma^{*0} \pi^{0} | \Sigma_1^{*0} \rangle = \langle \Sigma^{*+} \pi^{-} | \Sigma_1^{*0} \rangle + \langle \Sigma^{*-} \pi^{+} | \Sigma_1^{*0} \rangle \quad (26j)$$

$$3 \langle \Sigma^{*+} \eta | \Sigma_1^{*+} \rangle = \sqrt{3} \langle \Sigma^{*0} \pi^{+} | \Sigma_1^{*+} \rangle - \sqrt{2} \langle \Delta^{++} K^{-} | \Sigma_1^{*+} \rangle. \quad (26k)$$

(ii) $D(6) \to B(8) + P(8)$

$$0 = \langle \Sigma^{+} \pi^{+} | \Sigma_1^{*++} \rangle = \langle \Xi^{0} \pi^{+} | \Xi_1^{*+} \rangle = \langle \Sigma^{+} \bar{K}^{0} | \Xi_1^{*+} \rangle$$

$$= \langle \Xi^{0} \bar{K}^{0} | \Omega_1^{*0} \rangle \quad (27a)$$

$$\langle \Xi^{-} \pi^{+} | \Xi_1^{*0} \rangle = -\sqrt{2} \langle \Xi^{0} \pi^{0} | \Xi_1^{*0} \rangle, \quad (27b)$$

$$\langle \Sigma^{+} K^{-} | \Xi_1^{*0} \rangle = -\sqrt{2} \langle \Sigma^{0} \bar{K}^{0} | \Xi_1^{*0} \rangle, \quad (27c)$$

$$\langle \Lambda \pi^{0} | \Sigma_1^{*0} \rangle = \langle \Lambda \pi^{+} | \Sigma_1^{*+} \rangle, \quad (27d)$$

$$\langle \Sigma^{0} \pi^{0} | \Sigma_1^{*0} \rangle = -\langle \Lambda \eta | \Sigma_1^{*0} \rangle, \quad (27e)$$

$$\langle \Sigma^{-} \pi^{+} | \Sigma_1^{*0} \rangle = -\langle \Sigma^{+} \pi^{-} | \Sigma_1^{*0} \rangle, \quad (27f)$$

$$\langle \Sigma^{0} \eta | \Sigma_1^{*0} \rangle = \langle \Sigma^{+} \eta | \Sigma_1^{*+} \rangle, \quad (27g)$$

$$-\langle p K^- | \Sigma_1^{*0} \rangle + \langle n \overline{K}^0 | \Sigma_1^{*0} \rangle = -\sqrt{2} \langle p \overline{K}^0 | \Sigma_1^{*+} \rangle \tag{27h}$$

$$-\langle \Xi^0 K^0 | \Sigma_1^{*0} \rangle + \langle \Xi^- K^+ | \Sigma_1^{*0} \rangle = -\sqrt{2} \langle \Xi^0 K^+ | \Sigma_1^{*+} \rangle \tag{27i}$$

$$\langle \Sigma^- \pi^+ | \Sigma_1^{*0} \rangle - \langle \Sigma^0 \pi^0 | \Sigma_1^{*0} \rangle = \langle \Sigma^0 \pi^+ | \Sigma_1^{*+} \rangle . \tag{27j}$$

Notice that weak decays of Ω_1^{*0}, Ξ_1^{*+} and Σ_1^{*++} are forbidden.

4. Conclusions

In this paper we have discussed the weak nonleptonic decays of $3/2^+$ isobars in SU(3) symmetry framework. Without assuming the symmetric nature of current $\otimes$ current weak interaction and including all components (8, 10, 10*, 27) of the weak Hamiltonian we obtain $\triangle I=1/2$ selection rule for Ω^- decays in both the *pv* and *pc* decay modes under dynamical assumption. Using *CP* invariance further, all the parity violating amplitudes become zero for $D(10) \to D(10)+P(8)$ processes. For the Ω_3^{*++} decays, dynamical assumption alone forbids Cabibbo enhanced sextet component to contribute and weak Hamiltonian is predicted to be triplet dominant which allows only the $\triangle C=-1$, $\triangle S=0$ decay processes. For $D(3)$ and $D(6)$ multiplets, our dynamical assumption forbids all the weak decays of Ω_2^{*+}, Ξ_2^{*++}, Ω_1^{*0}, Ξ_1^{*+} and Σ_1^{*++}. We obtain simple relations among the decay amplitudes from the most general Hamiltonian. Our relations are valid for both *pv* and *pc* modes. The dynamical assumption used to derive these results is physically understandable (Bajaj *et al* 1974), since quarks appear in qqq and $\bar{q}q$ combinations only. Experimental search for Ω_3^{*++} decay modes may further justify this assumption. It is interesting to carry out these considerations to SU (4), where spurion may belong to $\underline{15}$, $\underline{20}''$ and $\underline{84}$ representations. For $\underline{20}''$ spurion, there is no physical intermediate state for the processes.

$$D(20) + S \to m \to D(20)/B(20') + P(15)$$

$\underline{15}$ spurion contributes only to $\triangle C=0$, $\triangle S=-1$ and $\triangle C=-1$, $\triangle S=0$ processes. $\underline{84}$ spurion may vanish for *pv* decays similar to $\underline{27}$ spurion in SU(3). This work will be taken up elsewhere.

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Appendix A

The complete transition amplitudes in terms of all the reduced matrix elements for various possible decays are listed below:

(I) Ω_3^{*++} *Decays*

(i) $\triangle C=\triangle S=-1$ *decay mode* ($\times$ cot θ)

$$\langle \Omega_2^{*+} / \Omega_2^{+}\pi^{+} / \Omega_3^{*++}\rangle = -(1/\sqrt{30})\, a_{15}^{n} - (1/\sqrt{12})\, a_{6*}^{n}$$

$$\langle \Xi_2^{*++} / \Xi_2^{++}\ \bar{K}^{0} / \Omega_3^{*++}\rangle = -(1/\sqrt{30})\, a_{15}^{n} + (1/\sqrt{12})\, a_{6*}^{n}$$

$$\langle \Xi_1^{*+} / \Xi_1^{+}\ D^{+} \mid \Omega_3^{*++}\rangle = -(1/\sqrt{15})\, b_{15}^{n}$$

$$\langle \Xi_1'^{+}\ D^{+} \mid \Omega_3^{*++}\rangle = (1/\sqrt{6})\, c_{6*}$$

(ii) $\triangle C=-1,\ \triangle S=+1$ *decay mode* ($\times$ tan θ)

$$\langle \Xi_2^{*+} / \Xi_2^{+}\ K^{+} \mid \Omega_3^{*++}\rangle = -(1/\sqrt{30})\, a_{15}^{n} + (1/\sqrt{12})\, a_{6*}^{n}$$

$$\langle \Xi_2^{*++} / \Xi_2^{++}\ K^{0} \mid \Omega_3^{*++}\rangle = -(1/\sqrt{30})\, a_{15}^{n} + (1/\sqrt{12})\, a_{6*}^{n}$$

$$\langle \Sigma_1^{*+} / \Sigma_1^{+} F^{+} \mid \Omega_3^{*++}\rangle = -(1/\sqrt{15})\, b_{15}^{n}$$

$$\langle \Lambda_1'^{+} F^{+} \mid \Omega_3^{*++}\rangle = (1/\sqrt{6})\, c_{6*}$$

(iii) $\triangle C=-1,\ \triangle S=0$ *decay mode*

$$\langle \Omega_2^{*+} / \Omega_2^{+}\ K^{+} \mid \Omega_3^{*++}\rangle = -(1/2\sqrt{10})\, a_{15}^{n} + (1/2\sqrt{2})\, a_{6*}^{n} - (1/2\sqrt{6})\, a_{3}^{n}$$

$$\langle \Xi_2^{*+} / \Xi_2^{+}\ \pi^{+} \mid \Omega_3^{*++}\rangle = (3/2\sqrt{10})\, a_{15}^{n} - (1/2\sqrt{6})\, a_{6*}^{n} + (1/2\sqrt{2})\, a_{3}^{n}$$

$$\langle \Xi_2^{*++} / \Xi_2^{++}\ \pi^{\circ} \mid \Omega_3^{*++}\rangle = (\sqrt{5}/4)\, a_{15}^{n} + (1/4\sqrt{3})\, a_{6*}^{n} - (1/4)\, a_{3}^{n}$$

$$\langle \Xi_2^{*++} / \Xi_2^{++}\ \eta \mid \Omega_3^{*++}\rangle = -(3/4\sqrt{15})\, a_{15}^{n} - (1/4)\, a_{6*}^{n} - (1/4\sqrt{3})\, a_{3}^{n}$$

$$\langle \Sigma_1^{*+} / \Sigma_1^{+} D^{+} \mid \Omega_3^{*++}\rangle = (7/6\sqrt{5})\, b_{15}^{n} - (1/2\sqrt{3})\, b_{3}^{n}$$

$$\langle \Sigma_1^{*++} / \Sigma_1^{++} D^{0} \mid \Omega_3^{*++}\rangle = (5/3\sqrt{10})\, b_{15}^{n} + (1/\sqrt{6})\, b_{3}^{n}$$

$\langle \Xi_1^{*+} / \Xi_1^+ F^+ | \Omega_3^{*++} \rangle = -(1/2\sqrt{5})\, b_{15}^n + (1/2\sqrt{3})\, b_3^n$

$\langle \Lambda_1'^+ D^+ | \Omega_3^{*++} \rangle = (1/\sqrt{12})\, c_{6*} - (1/\sqrt{12}) c_3$

$\langle \Xi_1'^+ F^+ | \Omega_3^{*++} \rangle = (1/\sqrt{12})\, c_{6*} + (1/\sqrt{12})\, c_3$

Hereafter, we omit the reduced amplitudes corresponding to the exotic states.

(II) $\underline{D(3) \to D(6)/B(6) + P(8)}$

$\langle \Omega_1^{*0} / \Omega_1^0 \pi^+ | \Omega_2^{*+} \rangle = 0$

$\langle \Xi_1^{*+} / \Xi_1^+ \bar{K}^0 | \Omega_2^{*+} \rangle = 0$

$\langle \Xi_1^{*+} / \Xi_1^+ \pi^+ | \Xi_2^{*++} \rangle = 0$

$\langle \Sigma_1^{*++} / \Sigma_1^{++} \bar{K}^0 | \Xi_2^{*++} \rangle = 0$

$\langle \Xi_1^{*+} / \Xi_1^+ \pi^0 | \Xi_2^{*+} \rangle = (1/4\sqrt{2})\, A_{3*}^n - (3/10\sqrt{6})\, B_6^n$

$\langle \Xi_1^{*+} / \Xi_1^+ \eta | \Xi_2^{*+} \rangle = (3/4\sqrt{6})\, A_{3*}^n + (1/10\sqrt{2})\, B_6^n$

$\langle \Xi_1^{*0} / \Xi_1^0 \pi^+ | \Xi_2^{*+} \rangle = 1/4\, A_{3*}^n - (3/10\sqrt{3})\, B_6^n$

$\langle \Sigma_1^{*+} / \Sigma_1^+ \bar{K}^0 | \Xi_2^{*+} \rangle = -(1/4)\, A_{3*}^n - (3/10\sqrt{3})\, B_6^n$

$-\langle \Sigma_1^{*++} / \Sigma_1^{++} K^- | \Xi_2^{*+} \rangle = (1/2\sqrt{2})\, A_{3*}^n + (3/5\sqrt{6})\, B_6^n.$

(III) $\underline{D(3) \to D(10) + P(3^*)}$

$\langle \Xi^{*0} D^+ | \Omega_2^{*+} \rangle = 0$

$\langle \Sigma^{*+} D^+ | \Xi_2^{*++} \rangle = 0$

$\langle \Sigma^{*0} D^+ | \Xi_2^{*+} \rangle = 1/5\, D_6$

$\langle \Sigma^{*+} D^0 | \Xi_2^{*+} \rangle = (2/5\sqrt{2})\, D_6$

$\langle \Xi^{*0} F^+ | \Xi_2^{*+} \rangle = (2/5\sqrt{2})\, D_6.$

(IV) $\underline{D(3) \to B(8) + P(3^*)}$

$\langle \Xi^0 D^+ | \Omega_2^{*+} \rangle = 0$

$$\langle \Sigma^+ D^+ | \Xi_2^{*++} \rangle = 0$$

$$\langle \Sigma^0 D^+ | \Xi_2^{*+} \rangle = (3/4\sqrt{6})\, E_{3*} - (1/2\sqrt{10})\, F_6$$

$$\langle \Lambda\, D^+ | \Xi_2^{*+} \rangle = -(1/4\sqrt{2})\, E_{3*} - (3/2\sqrt{30})\, F_6$$

$$\langle \Sigma^+ D^0 | \Xi_2^{*+} \rangle = (3/4\sqrt{3})\, E_{3*} - (1/2\sqrt{5})\, F_6$$

$$\langle \Xi^0 F^+ | \Xi_2^{*+} \rangle = (3/4\sqrt{3})\, E_{3*} + (1/2\sqrt{5})\, F_6$$

(V) $\underline{D(3) \to B(3^*) + P(8)}$

$$\langle \Xi_1^{'+} \overline{K^0} | \Omega_2^{*+} \rangle = 0$$

$$\langle \Xi_1^{'+} \pi^+ | \Xi_2^{*++} \rangle = 0$$

$$\langle \Lambda_1^{'+} K^0 | \Xi_2^{*+} \rangle = (3/4\sqrt{3})\, G_{3*} - (1/2\sqrt{5})\, H_6,$$

$$\langle \Xi_1^{'+} \pi^0 | \Xi_2^{*+} \rangle = (3/4\sqrt{6})\, G_{3*} + (1/2\sqrt{10})\, H_6$$

$$\langle \Xi_1^{'+} \eta | \Xi_2^{*+} \rangle = -(1/4\sqrt{2})\, G_3^* + (3/2\sqrt{30})\, H_6$$

$$\langle \Xi_1^{'0} \pi^+ | \Xi_2^{*+} \rangle = (3/4\sqrt{3})\, G_{3*} + (1/2\sqrt{5})\, H_6.$$

(VI) $\underline{D(6) \to D(10) + P(8)}$

$$0 = \langle \Omega^- \pi^+ | \Omega_1^{*0} \rangle = \langle \Xi^{*0} \bar{K}^0 | \Omega_1^{*0} \rangle = \langle \Xi^{*0} \pi^+ | \Xi_1^{*+} \rangle$$

$$= \langle \Sigma^* \bar{K}^{0+} | \Xi_1^{*+} \rangle = \langle \Sigma^{*+} \pi^+ | \Sigma_1^{*++} \rangle = \langle \Delta^{++} \bar{K}^0 | \Sigma_1^{*++} \rangle$$

$$\langle \Xi^{*-} \pi^+ | \Xi_1^{*0} \rangle = (g_8/5) + (2/15\sqrt{2})\, h_8 - (1/3\sqrt{10})\, h_{10}$$

$$-\langle \Xi^{*0} \pi^0 | \Xi_1^{*0} \rangle = -(1/5\sqrt{2})\, g_8 - (1/15)\, h_8 + (1/6\sqrt{5})\, h_{10}$$

$$-\langle \Sigma^{*+} K^- | \Xi_1^{*0} \rangle = (1/5)\, g_8 + (2/15\sqrt{2})\, h_8 + (2/3\sqrt{10})\, h_{10}$$

$$\langle \Xi^{*0} \eta | \Xi_1^{*0} \rangle = (3/5\sqrt{6})\, g_8 + (1/5\sqrt{3})\, h_8 + (1/2\sqrt{15})\, h_{10}$$

$$\langle \Sigma^{*0} \bar{K}^0 | \Xi_1^{*0} \rangle = -(1/5\sqrt{2})\, g_8 - (1/15)\, h_8 - (1/3\sqrt{5})\, h_{10}$$

$$\langle \Omega^- K^+ | \Xi_1^{*0} \rangle = -(3/5\sqrt{3})\, g_8 - (2/5\sqrt{6})\, h_8 + (1/\sqrt{30})\, h_{10}$$

$$\langle \Sigma^{*0} \pi^+ | \Sigma_1^{*+} \rangle = (1/5\sqrt{2})\, g_8 - (1/15)\, h_8 - (1/3\sqrt{5})\, h_{10}$$

$$-\langle \Sigma^{*+}\pi^0 | \Sigma_1^{*+}\rangle = -(1/5\sqrt{2})\,g_8 + (1/15)\,h_8 + (1/3\sqrt{5})\,h_{10},$$

$$\langle \Sigma^{*+}\eta | \Sigma_1^{*+}\rangle = (3/5\sqrt{6})\,g_8 - (1/5\sqrt{3})\,h_8,$$

$$-\langle \triangle^{++}K^- | \Sigma_1^{*+}\rangle = (3/5\sqrt{3})\,g_8 - (2/5\sqrt{6})\,h_8 + (1/\sqrt{30})\,h_8$$

$$\langle \triangle^{+}\overline{K^0} | \Sigma_1^{*+}\rangle = -(1/5)\,g_8 + (2/15\sqrt{2})\,h_8 - (1/3\sqrt{10})\,h_{10},$$

$$\langle \Xi^{*0}K^+ | \Sigma_1^{*+}\rangle = -(1/5)\,g_8 + (2/15\sqrt{2})\,h_8 + (2/3\sqrt{10})\,h_{10},$$

$$\langle \triangle^{0}\overline{K^0} | \Sigma_1^{*0}\rangle = -(2/5\sqrt{2})\,g_8 - (2/15)\,h_8 + (1/3\sqrt{5})\,h_{10},$$

$$-\langle \triangle^{+}K^- | \Sigma_1^{*0}\rangle = (2/5\sqrt{2})\,g_8 + (2/15)\,h_8 - (1/3\sqrt{5})\,h_{10},$$

$$\langle \Sigma^{*+}\pi^- | \Sigma_1^{*0}\rangle = -(4/15)\,h_8 - (1/3\sqrt{5})\,h_{10},$$

$$-\langle \Sigma^{*0}\pi^0 | \Sigma_1^{*0}\rangle = -(1/5\sqrt{2})\,g_8 + (1/5)h_8,$$

$$\langle \Sigma^{*0}\eta | \Sigma_1^{*0}\rangle = (3/5\sqrt{6})\,g_8 + (1/5\sqrt{3})\,h_8,$$

$$\langle \Sigma^{*-}\pi^+ | \Sigma_1^{*0}\rangle = (2/5\sqrt{2})\,g_8 - (2/15)\,h_8 + (1/3\sqrt{5})\,h_{10}$$

$$\langle \Xi^{*-}K^+ | \Sigma_1^{*0}\rangle = -(2/5\sqrt{2})\,g_8 + (2/15h_8) - (1/3\sqrt{5})\,h_{10},$$

$$-\langle \Xi^{*0}K^0 | \Sigma_1^{*0}\rangle = -(4/15)\,h_8 - (1/3\sqrt{5})\,h_{10}$$

(VII) <u>$D(6)\rightarrow B(8)+P(8)$</u>

$$0 = \langle \Sigma^+\pi^+ | \Sigma_1^{*++}\rangle = \langle \Xi^0\pi^+ | \Xi_1^{*+}\rangle = \langle \Sigma^+\overline{K^0} | \Xi_1^{*+}\rangle$$
$$= \langle \Xi^0\overline{K^0} | \Omega_1^{*0}\rangle,$$

$$\langle \Xi^0 K^{\bullet} | \Sigma_1^{*+}\rangle = -(3/10)j_{8_1} + (1/2\sqrt{5})j_{8_2} + (1/5\sqrt{2})k_{8_1}$$
$$- (1/3\sqrt{10})k_{8_2} + (1/3\sqrt{5})\,k_{10}$$

$$-\langle \Sigma^0\pi^+ | \Sigma_1^{*+}\rangle = -(1/\sqrt{10})j_{8_2} + (1/3\sqrt{5})k_{8_2} + (1/3\sqrt{10})k_{10}$$

$$\langle \Lambda\pi^+ | \Sigma_1^{*+}\rangle = (3/5\sqrt{6})j_{8_1} - (1/5\sqrt{3})k_{8_2} - (1/\sqrt{30})k_{10}$$

$$-\langle \Sigma^+\pi^0 | \Sigma_1^{*+}\rangle = (1/\sqrt{10})j_{8_2} - (1/3\sqrt{5})k_{8_2} - (1/3\sqrt{10})k_{10}$$

$$\langle \Sigma^+\eta | \Sigma_1^{*+}\rangle = (3/5\sqrt{6})j_8 - (1/5\sqrt{3})k_{8_2} + (1/\sqrt{30})k_{10}$$

$$\langle p\,\bar{K}^0 \mid \Sigma_1^{*+}\rangle = -(3/10)j_{8_1} - (1/2\sqrt{5})j_{8_2} + (1/5\sqrt{2})k_{8_1} + (1/3\sqrt{10})k_{8_2} - (1/3\sqrt{5})k_{10}$$

$$-\langle \Xi^0 K^0 \mid \Sigma_1^{*0}\rangle = (1/5\sqrt{2})j_{8_1} - (1/\sqrt{10})j_{8_2} - (1/5)k_{8_1} - (1/3\sqrt{5})k_{8_2} - (1/3\sqrt{10})k_{10}$$

$$\langle \Xi^- K^+ \mid \Sigma_1^{*0}\rangle = (2/5\sqrt{2})j_{8_1} + (2/3\sqrt{5})k_{8_2} - (1/3\sqrt{10})k_{10}$$

$$\langle \Sigma^- \pi^+ \mid \Sigma_1^{*0}\rangle = -(1/5\sqrt{2})j_{8_1} + (1/\sqrt{10})j_{8_2} - (1/5)k_{8_1} - (1/3\sqrt{5})k_{8_2} - (1/3\sqrt{10})\,k_{10}$$

$$\langle \Sigma^0 \pi^0 \mid \Sigma_1^{*0}\rangle = -(1/5\sqrt{2})j_{8_1} - (1/5)k_{8_1},$$

$$-\langle \Lambda\pi^0 \mid \Sigma_1^{*0}\rangle = -(3/5\sqrt{6})j_{8_1} + (1/5\sqrt{3})k_{8_1} + (1/\sqrt{30})k_{10},$$

$$-\langle \Sigma^0 \eta \mid \Sigma_1^{*0}\rangle = -(3/5\sqrt{6})j_{8_1} + (1/5\sqrt{3})k_{8_1} - (1/\sqrt{30})\,k_{10},$$

$$\langle \Lambda\eta \mid \Sigma_1^{*0}\rangle = (1/5\sqrt{2})j_{8_1} + (1/5)k_{8_1}$$

$$\langle \Sigma^+ \pi^- \mid \Sigma_1^{*0}\rangle = (1/5\sqrt{2})j_{8_1} - (1/\sqrt{10})j_{8_2} + (1/5)k_{8_1} + (1/3\sqrt{5})k_{8_2} + (1/3\sqrt{10})k_{10}$$

$$-\langle pK^- \mid \Sigma_1^{*0}\rangle = (2/5\sqrt{2})j_{8_1} - (2/3\sqrt{5})k_{8_2} + (1/3\sqrt{10})k_{10},$$

$$n\bar{K}_0 \mid \Sigma_1^{*0}\rangle = (1/5\sqrt{2})j_{8_1} + (1/\sqrt{10})j_{8_2} - (1/5)k_{8_1} + (1/3\sqrt{5})k_{8_2} + (1/3\sqrt{10})k_{10}$$

$$-\langle \Xi^0 \pi^+ \mid \Xi_1^{*0}\rangle = (3/10)j_{8_1} + (1/2\sqrt{5})j_{8_2} - (1/5\sqrt{2})k_{8_1} - (1/3\sqrt{10})k_{8_2} + (1/3\sqrt{5})k_{10}$$

$$-\langle \Xi^- \pi_0 \mid \Xi_1^{*0}\rangle = -(3/10\sqrt{2})j_{8_1} - (1/2\sqrt{10})j_{8_2} + (1/10)k_{8_1} + (1/6\sqrt{5})k_{8_2} - (1/3\sqrt{10})k_{10}^{*}$$

$$\langle \Xi^0 \eta \mid \Xi_1^{*0}\rangle = (3/10\sqrt{6})j_{8_1} - (3/2\sqrt{3})j_{8_2} - (1/10\sqrt{3})k_{8_1} + (1/2\sqrt{15})k_{8_2} + (1/\sqrt{30})k_{10}$$

$$-\langle \Sigma^+ K^- \mid \Xi_1^{*0}\rangle = (3/10)j_{8_1} - (1/2\sqrt{5})j_{8_2} - (1/5\sqrt{2})k_{8_1} + (1/3\sqrt{10})k_{8_2} - (1/3\sqrt{5})k_{10}$$

$$-\langle \Sigma^0 \bar{K}^0 \mid \Xi_1^{*0}\rangle = -(3/10\sqrt{2})j_{8_1} + (1/2\sqrt{10})j_{8_2} + (1/10)k_{8_1} - (1/6\sqrt{5})k_{8_2} + (1/3\sqrt{10})k_{10}$$

$$\langle \Lambda\, \overline{K}^0 \mid \Xi_1^{*0} \rangle = (3/10\sqrt{6}) j_{8_1} + (3/2\sqrt{30}) j_{8_2} - (1/10\sqrt{3}) k_{8_1} - (1/2\sqrt{15}) k_{8_2} - (1/\sqrt{30}) k_{10}.$$

Appendix B

Following are give the isoscalar factors for the direct product 27 ⊗ 10 used in the paper.

$Y=2,\ I=2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35
(1, 3/2) : (1, 3/2)	$\frac{1}{2\sqrt{5}}$	$\frac{2\sqrt{2}}{\sqrt{15}}$	$\frac{\sqrt{5}}{2\sqrt{3}}$
(1, 1/2) : (1, 3/2)	$\frac{1}{\sqrt{2}}$	$\frac{-1}{\sqrt{3}}$	$\frac{1}{\sqrt{6}}$

$Y=2,\ I=1$

(Y_1, I_1) : (Y_2, I_2)	64	27	35*
(1, 3/2) : (1, 3/2)	$\frac{2\sqrt{2}}{3\sqrt{7}}$	$\frac{5}{\sqrt{42}}$	$\frac{\sqrt{5}}{3\sqrt{2}}$
(1, 1/2) : (1, 3/2)	$\frac{5}{3\sqrt{7}}$	$\frac{1}{\sqrt{21}}$	$\frac{-\sqrt{5}}{3}$

$Y=2,\ I=0$

(Y_1, I_1) : (Y_2, I_2)	10*	35*
(2, 1) : (0, 1)	$\frac{-1}{\sqrt{3}}$	$\frac{\sqrt{2}}{\sqrt{3}}$
(1, 3/2) : (1, 3/2)	$\frac{\sqrt{2}}{\sqrt{3}}$	$\frac{1}{\sqrt{3}}$

$Y=1,\ I=5/2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35
(1, 3/2) : (0, 1)	$\frac{\sqrt{21}}{2\sqrt{10}}$	$\frac{2}{\sqrt{15}}$	$\frac{-\sqrt{5}}{2\sqrt{6}}$

$Y=1,\ I=3/2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35	35*	27	10
(1, 3/2) : (0, 1)	$\frac{\sqrt{3}}{\sqrt{70}}$	$\frac{2\sqrt{14}}{3\sqrt{15}}$	$\frac{\sqrt{5}}{3\sqrt{6}}$	$\frac{\sqrt{5}}{3\sqrt{3}}$	0	$\frac{-5\sqrt{2}}{3\sqrt{21}}$
(1, 1/2) : (0, 1)	$\frac{\sqrt{15}}{2\sqrt{7}}$	$\frac{-\sqrt{5}}{3\sqrt{21}}$	$\frac{-\sqrt{5}}{6\sqrt{3}}$	$\frac{-\sqrt{5}}{3\sqrt{6}}$	$\frac{\sqrt{3}}{\sqrt{14}}$	$\frac{-4}{3\sqrt{21}}$

$Y=1, \quad I=1/2$

(Y_1, I_1) : (Y_2, I_2)	64	35*	27	10*	8
(1, 3/2) : (0, 1)	$\frac{2\sqrt{5}}{3\sqrt{21}}$	$\frac{7}{6\sqrt{3}}$	$\frac{\sqrt{3}}{2\sqrt{7}}$	$\frac{1}{3\sqrt{3}}$	$\frac{-2\sqrt{2}}{3\sqrt{3}}$
(1, 1/2) : (0, 1)	$\frac{10}{3\sqrt{21}}$	$\frac{-\sqrt{5}}{3\sqrt{3}}$	$\frac{-\sqrt{3}}{\sqrt{35}}$	$\frac{\sqrt{5}}{3\sqrt{3}}$	$\frac{-\sqrt{2}}{3\sqrt{15}}$

$Y=0, I=0$

(Y_1, I_1) : (Y_2, I_2)	64	27	8
(1, 1/2) : (−1, 1/2)	$\frac{\sqrt{10}}{\sqrt{21}}$	$\frac{-4}{\sqrt{35}}$	$\frac{1}{\sqrt{15}}$

$Y=0, I=2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35	35*	27
(1, 3/2) : (−1, 1/2)	$\frac{3}{2\sqrt{10}}$	$\frac{4\sqrt{2}}{\sqrt{105}}$	$\frac{-\sqrt{5}}{2\sqrt{6}}$	$\frac{1}{2\sqrt{3}}$	$\frac{-\sqrt{5}}{2\sqrt{7}}$

$Y=0, I=1$

(Y_1, I_1) : (Y_2, I_2)	81	64	35	35*	27	10	10*	8
(1, 3/2) : (−1, 1/2)	$\frac{1}{2\sqrt{14}}$	$\frac{8\sqrt{2}}{9\sqrt{7}}$	$\frac{\sqrt{5}}{18\sqrt{2}}$	$\frac{11}{18}$	$\frac{-1}{2\sqrt{21}}$	$\frac{-4\sqrt{5}}{9\sqrt{7}}$	$\frac{-\sqrt{2}}{9}$	$\frac{-4}{9}$
(1, 1/2) : (−1, 1/2)	$\frac{\sqrt{5}}{\sqrt{14}}$	$\frac{\sqrt{10}}{9\sqrt{7}}$	$\frac{-7}{9\sqrt{2}}$	$\frac{-\sqrt{5}}{9}$	$\frac{1}{\sqrt{105}}$	$\frac{2}{9\sqrt{7}}$	$\frac{\sqrt{10}}{9}$	$\frac{-7}{9\sqrt{5}}$

$Y=-1, \quad I=3/2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35	35*	27	10*
(1, 3/2) : (−2, 0)	$\frac{1}{4}$	$\frac{2}{\sqrt{21}}$	$\frac{-\sqrt{5}}{4\sqrt{3}}$	$\frac{\sqrt{5}}{2\sqrt{6}}$	$\frac{-\sqrt{15}}{2\sqrt{14}}$	$\frac{-1}{\sqrt{6}}$

$Y=-1, I=1/2$

(Y_1, I_1) : (Y_2, I_2)	81	64	35	27	10	8
(1, 1/2) : (−2, 0)	$\frac{1}{\sqrt{7}}$	$\frac{\sqrt{2}}{\sqrt{21}}$	$\frac{-1}{\sqrt{3}}$	$\frac{-\sqrt{6}}{\sqrt{35}}$	$\frac{2}{\sqrt{21}}$	$\frac{1}{\sqrt{15}}$

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