Pramāṇa, Vol. 8, No. 6, 1977, pp. 524–532. © Printed in India.

SU (8) mass relations among $J^P = 1/2^+$ and $3/2^+$ baryons

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MS received 5 February 1977; in revised form 23 March 1977

Abstract. Mass relations among charmed and uncharmed baryons belonging to $\underline{20}$ and $\underline{20'}$ multiplets of SU(4) are derived in the framework of SU (8) symmetry. Spin singlet mass breaking interaction is found to give unsatisfactory results. Second order effects and spin triplet mass breaking interactions are studied to improve the situation.

Keywords. SU (8); hadron masses; baryons and baryon resonances.

1. Introduction

SU (4) charm scheme proposed to understand ψ resonances predicts a spectrum of large number of charmed particles. Subsequent experiments (Cazzoli *et al* 1975; Knapp *et al* 1976) have provided some evidence for the existence of these particles. In view of these, it is useful to study the properties of charmed particles in the framework of higher symmetries, as it helps the experimental physicist in his search for these particles. Moreover the study of the properties of these particles will provide tests for the validity of higher symmetries.

Mass relations among these particles have been obtained by several authors. Some of these have made explicit use of the quark models (Hendry and Lichtenberg 1975; Franklin 1975) while others have assumed a certain transformation property of the mass operator in SU (4) (Kobayashi 1972; Okubo 1975; Moffat 1975; Boal 1975; Gupta 1976). In this paper we discuss the masses of the charmed and uncharmed baryons and isobars in the framework of SU (8). We assume the interaction responsible for breaking the symmetry to transform like:

$$H' = a_1 T_1^1 + a_2 T_3^3 + a_3 T_4^4 \tag{1}$$

member of adjoint representation $\underline{15}$ in the SU (4) subgroup of SU (8). The electromagnetic (em) mass operator is assumed to transform as $T_1^1 + T_4^4 + \beta T_\alpha^\alpha$ component of $\underline{15} \oplus \underline{1}$ in SU (4). Hence in the symmetry breaking Hamiltonian (1) em mass breaking is also introduced. In this case masses of the baryons can be expressed in terms of only four parameters. We have calculated the masses of $1/2^+$ baryons in table 1 (column one) using three octet masses and Σ_1^0 (2·5 GeV) as input.

Table 1. Masses of the charmed baryons $J^P(1/2^+)$.

	Mass breaking Hamiltonian.		
Spin structure	Spin singlet	Spin singlet	Spin singlet + Spin triplet
Number of parameters	Four	Seven	Seven
SU(3) multiplet and particles	(first order) (GeV)	(first order + second order) (GeV)	(first order) (GeV)
$B(6)$ Σ_1^{++}	2·494	2·494	2·494
Σ_1^{+}	2·497	2·497	2·497
Σ_1^{0}	2·500 (input)	2·500 (input)	2·500 (input)
Ξ_1^{+}	2·619	2·684	2·684
Ξ_1^{0}	2·622	2·687	2·687
Ω_1^{0}	2·745	2·874	2·874
$B(3)^*$ $\Lambda_1'^{+}$	2·497	2·260 (input)	2·260 (input)
$\Xi_1'^{+}$	2·619	2·315	2·503
$\Xi_1'^{0}$	2·622	2·508	2·508
$B(3)$ Ξ_2^{++}	3·924	3·793	3·793
Ξ_2^{+}	3·927	3·796	3·799
Ω_2^{+}	4·049	4·054	4·043
(mixing masses)			
$m_{\Lambda\Sigma^0}$	0	−0·067	−0·0015
$m_{\Lambda_1'^+\Sigma_1^+}$	0	−0·208	−0·0015
$m_{\Xi_1'^0\Xi_1^0}$	0	−0·112	−0·0367
$m_{\Xi_1'^+\Xi_1^+}$	0	−0·313	−0·0382

We find that if mass breaking interaction is taken to be spin singlet, the masses of all the forty baryons obey equal spacing rule. Mass relations for $1/2^+$ baryons do not agree with experimental values. Furthermore the states mixed due to SU (2) and SU (3) breaking [*i.e.*, $\Lambda - \Sigma^0$ and $B(3^*) - B(6)$] are predicted to be mass degenerate and mixing angles cannot be fixed.

Second order mass breaking is considered to improve the situation. We take second order mass breaking Hamiltonian to transform like

$$H'' = b_1\, T^{11}_{11} + b_2\, T^{33}_{33} + b_3\, T^{44}_{44} + b_4\, T^{13}_{13} + b_5\, T^{14}_{14} + b_6\, T^{34}_{34} \tag{2}$$

component of $\underline{20}''$ and $\underline{84}$ representations at the SU (4) level. H'' is also assumed to be spin singlet. Resulting mass relations are given in section (2.1). Agreement of these relations with experiment is good. Second order effects also remove the degeneracy between the mixed states, but predicts very large mixing angles, *i.e.*,

$$\theta_{\Lambda\Sigma^0} = \theta_{\Lambda'_1\Sigma_1} = \theta_{\Xi_1\Xi_1} = 30^0 \tag{3}$$

while these mixing angles are expected to be of the order of $\sim 1°$.

To remove the discrepancies in the em mass relations obtained in SU (6), Kuo and Yao (1965) suggested the inclusion of the em mass splitting due to magnetic interactions (Lichtenberg 1975) which transform as $(\underline{8}, \underline{3})$ component of $\underline{35}$. SU (3) breaking in the spin singlet interaction is about 100 MeV in the SU (6) symmetry and SU (6) breaking difference of the spin singlet and triplet interactions is also found to be at least that much (Franklin 1968).

In view of these arguments, we include the spin triplet mass breaking contributions to the masses of the baryons. We obtain the well satisfied Coleman-Glashow relation and electromagnetically modified GMO mass sum rule for the uncharmed baryons. Various mass relations are given in section (2.2). We have used the particle symbol to denote its mass. Mass values of different charmed baryons and isobars are given in tables 1 and 2 respectively. Introduction of spin triplet mass breaking does not disturb the equal spacing rule for $3/2^+$ baryons. We have also calculated the mixing angles between the mixed states in section (2.3).

2. Mass relations

We assume the baryons ($J^P = 1/2^+$ and $3/2^+$) to belong to the symmetric representation $\underline{120} \equiv (\underline{20}', \underline{2}) + (\underline{20}, \underline{4})$ in SU(8). When mass operator is assumed to transform like $(\underline{15}, \underline{1})$ component of $\underline{63}$, we get the various mass values of baryons given in table 1. Mixed states are mass degenerate and mixing angles cannot be fixed.

2.1. *Second order effects*

Second order contributions are obtained from the following contractions:

$$\bar{B}^{AB'C'} B_{ABC} M^{B}_{B'} M^{C}_{C'} \tag{4}$$

where mass breaking Hamiltonian corresponds to $\underline{1232}$ representation of SU(8). Mass breaking Hamiltonians are taken to transform like $(\underline{20}'', \underline{1})$ and $(\underline{84}, \underline{1})$ components of $\underline{1232}$. It is found that $(\underline{20}'', \underline{1})$ and $(\underline{84}, \underline{1})$ components do not contribute to $3/2^+$ and $1/2^+$ baryons respectively. Thus the masses of $1/2^+$ and $3/2^+$ baryons are expressed in terms of seven and ten parameters respectively. We obtain ten mass relations (5, *a–d*) and (6, *a–e*) for $3/2^+$ isobars. Thirteen mass relations for $1/2^+$ baryons are given in (7, *a–g*) and (8, *a–e*). With five octet masses, $\Lambda'_3{}^+$ (2·26 GeV) and Σ_1^0 (2·5 GeV) as input we get different parameters for $1/2^+$ baryons:

Table 2. Masses of the charmed isobars J^P $(3/2^+)$

	SU(3) multiplets and Particles	Equal spacing rule (four parameters) (GeV)
D(6)	Σ_1^{*++}	2·494
	Σ_1^{*+}	2·497
	Σ_1^{*0}	2·500 (input)
	Ξ_1^{*+}	2·642
	Ξ_1^{*0}	2·645
	Ω_1^{*0}	2·790
D(3)	Ξ_2^{*++}	3·760
	Ξ_2^{*+}	3·763
	Ω_2^{*+}	3·908
D(1)	Ω_3^{*++}	5·026

$m_0 = 0{\cdot}941$ GeV, $a_1 = -1{\cdot}95$ MeV, $a_2^0 = 0{\cdot}186$ GeV,

$a_3 = 2{\cdot}34$ GeV, $b_4 = 2{\cdot}01$ MeV, $b_5 = 0{\cdot}405$ GeV,

$b_6 = 0{\cdot}422$ GeV.

Masses of $1/2^+$ baryons are given in table 1 (column two).

Second order contributions do not predict equal spacing rule for the $3/2^+$ isobars, rather relate the disciepancies present in this rule in the following manner

$$\Delta^{++} - \Delta^- = 3(\Delta^+ - \Delta^0) \quad (5\,a)$$

$$\Sigma^{*+} + \Sigma^{*-} - 2\Sigma^{*0} = \Delta^+ + \Delta^- - 2\Delta^0 = \Sigma_1^{*++} + \Sigma_1^{*0} - 2\Sigma_1^{*+} \quad (5\,b)$$

$$(\Xi^{*0} - \Xi^{*-}) + (\Delta^0 - \Delta^-) = 2(\Sigma^{*0} - \Sigma^{*-}) \quad (5\,c)$$

$$(\Xi_2^{*++} - \Xi_2^{*+}) + (\Delta^0 - \Delta^-) = 2(\Sigma_1^{*+} - \Sigma_1^{*0}) \quad (5\,d)$$

$$(\Omega_2^{*+} - \Xi_2^{*+}) + (\Omega^- - \Xi^{*-}) = 2(\Omega_1^{*0} - \Xi_1^{*0}) \quad (6\,a)$$

$$\Omega_1^{*0} + \Sigma_1^{*0} - 2\,\Xi_1^{*0} = \Omega^- + \Sigma^* - 2\,\Xi^{*-} \quad (6\,b)$$

$$(\Omega^- - \Delta^-) = 3(\Xi^* - \Sigma^{*-}) \quad (6\,c)$$

$$(\Omega_3^{*++} - \Omega^-) = 3(\Omega_2^{*+} - \Omega_1^{*0}) \quad (6\,d)$$

$$\Omega_2^{*+} + \Sigma^{*-} - 2\,\Xi_1^{*0} = \Xi_2^{*+} + \Delta^- - 2\Sigma_1^{*0} \quad (6\,e)$$

Relation (5 *a*) has been obtained in SU(3) symmetry consideration (Iwao 1965). We are unable to determine all the ten parameters for $3/2^+$ baryons as veiy less information exists concerning charmed isobars. Because of this masses of all the $3/2^+$ isobars cannot be calculated. In the absence of electromagnetic interactions, mass relations among various $3/2^+$ isomultiplets can be obtained simply by removing the charges in (6, *a–e*).

In case of $1/2^+$ baryons, second order effects predict the following relations:

$$3(\Lambda + \Sigma^0) = 2(\Sigma^- + P + \Xi^0) \quad (7\,a)$$

$$3(\Lambda'_1{}^+ + \Sigma_1^+) = 2(\Sigma_1^0 + P + \Xi_2^{++}) \quad (7\,b)$$

$$(\Omega_2^+ - \Xi_2^+) + (\Xi^- - \Sigma^-) = 2(\Xi_1^0 - \Sigma_1^0) \quad (7\,c)$$

$$\Omega_1^0 - \Xi_1^0 = \Xi_1^0 - \Sigma_1^0 \quad (7\,d)$$

$$2(\Sigma_1^0 - \Sigma^-) = 2\,\Xi_2^+ + \Xi_1^0 - 3\,\Xi'_1{}^0 \quad (7\,e)$$

$$\Xi^- - P = 2(\Sigma^- - N) \quad (7\,f)$$

$$\Xi_2^+ - P = 2(\Sigma_1^0 - N) \quad (7\,g)$$

$$\Xi^0 - \Xi^- - \Sigma^+ + \Sigma^- = N - P \quad (8\,a)$$

$$\Xi_2^{++} - \Xi_2^+ - \Sigma_1^{++} + \Sigma_1^0 = N - P \quad (8\,b)$$

$$\Sigma_1^{++} - \Sigma_1^+ = \Sigma_1^+ - \Sigma_1^0 = \Xi_1^+ - \Xi_1^0 \quad (8\,c)$$

$$\Sigma^+ - \Sigma^0 = \Sigma^0 - \Sigma^- \quad (8\,d)$$

$$3(\Xi'_1{}^+ - \Xi'_1{}^0) = 2(N - P) + 2(\Sigma^0 - \Sigma^-) + 3(\Lambda'_1{}^+ - \Sigma_1^0) \quad (8\,e)$$

In the absence of electromagnetic mass breaking we get:

$$(\Omega_2 - \Xi_2) + (\Xi - \Sigma) = 2(\Xi_1 - \Sigma_1) \tag{9 a}$$

$$\Omega_1 - \Xi_1 = \Xi_1 - \Sigma_1 \tag{9 b}$$

$$2(\Sigma_1 - \Sigma) = 2\,\Xi_2 + \Xi_1 - 3\,\Xi_1' \tag{9 c}$$

$$\Xi + N = 2\Sigma \tag{9 d}$$

$$\Xi_2 + N = 2\Sigma_1 \tag{9 e}$$

$$\Lambda'_1 = \Sigma_1 \text{ and } \Lambda = \Sigma \tag{9 f}$$

Relations (9 *a*) to (9 *e*) are already obtained in charmed quark models (Hendry and Lichtenberg 1975). (9 *f*) and (9 *g*) are collapsed forms of GMO relation (12 *b*) and its charmed analog (12 *c*). This happens because of relation (9 *f*) which is unsatisfied experimentally. The relation (9 *f*) exists, because in the absence of electromagnetic interactions, second order effects in SU(8) are unable to remove degeneracy between $\Lambda'_1\Sigma_1$ and Λ-Σ. This fact is also reflected in (14) where $m_{\Lambda_1'^+\Sigma_1^+} = m_{\Lambda\Sigma^0}$ *i.e.*, Λ'_1-Σ_1^+ mixing is purely electromagnetic in origin.

Relation (8 *a*) is the well known Coleman-Glashow relation and (8 *a*) is GMO mass sum rule modified electromagnetically. Second order effects also remove the mass degeneracy between the mixed states. Mixing masses are calculated to be

$$m_{\Lambda\Sigma^0} = \sqrt{3}/2\,(\Lambda - \Sigma^0);\; m_{\Lambda'_1{}^+\Sigma_1^+} = \sqrt{3}/2\,(\Lambda'_1{}^+ - \Sigma_1{}^+);\; m_{\Xi_1'\Xi_1} = \sqrt{3}/2\,(\Xi'_1 - \Xi_1)$$

so that

$$\theta_{\Lambda\Sigma^0} = \theta_{\Lambda_1{}^+\Sigma_1^+} = \theta_{\Xi_1'\Xi_1} = 30^\circ \tag{10}$$

which are too large.

2.2. (*Spin singlet* $\oplus$ *spin triplet*) *mass breaking interaction*

Spin triplet mass breaking Hamiltonian transforms like (15, 3) components of $\underline{63}$. In SU(4) sub group, it is taken as $a'_1T_1^1 + a'_2T_3^3 + a'_3T_4^4$ member of $\underline{15}$. Here the masses of $1/2^+$ baryons are expressed in terms of seven parameters which are evaluated to be

$$m_0 = 0{\cdot}930\text{ GeV},\; a_1 = -8{\cdot}6\text{ MeV}\; a_2 = 0{\cdot}345\text{ GeV},\; a_3 = 2{\cdot}250\text{ GeV}$$
$$a_1' = 5{\cdot}3\text{ MeV},\; a'_2 = -0{\cdot}127\text{ GeV},\; a'_3 = -0{\cdot}262\text{ GeV}.$$

With both the spin singlet and spin triplet mass breakings the following results are obtained,

(1) Relations (7, *a–e*), (8, *a–d*) are maintained.

(2) In addition we get:

$$\Sigma_1{}^+ - \Sigma_1{}^0 = \Sigma^+ - \Sigma^0 \tag{11 a}$$

$$\Xi_2{}^{++} - \Xi_2{}^+ = \Xi^0 - \Xi^- \tag{11 b}$$

$$3(\Xi'_1{}^+ - \Xi_1{}'^0) = 5(\Xi^0 - \Xi^-) + (P - N) \quad (11\,c)$$

$$2(\Xi_1{}^0 - \Sigma_1{}^0) = (\Xi^0 - N). \quad (11\,d)$$

Note that the Coleman-Glashow relation and the modified GMO sum rule are again obtained. In the absence of em interactions, relations (9 *a*) to (9 *c*) are repeated. In addition we get:

$$2(\Xi_1 - \Sigma_1) = (\Xi - N). \quad (12\,a)$$

$$3\Lambda + \Sigma = 2(N + \Xi) \quad (12\,b)$$

$$3\Lambda'_1 + \Sigma_1 = 2(N + \Xi_2). \quad (12\,c)$$

Inclusion of spin triplet interaction does not disturb equal spacing rule for $3/2^+$ isobars because spin triplet mass breaking contributions are not independent of that of spin singlet breaking. Masses of 20 isobars are expressed in terms of four parameters. Effective parameters are evaluated to be:

$$m_0 = 1\cdot232 \text{ GeV}, \; A_1 = 9 \text{ MeV}. \; A_2 = 0\cdot435 \text{ GeV}, \; A_3 = 3\cdot790 \text{ GeV}.$$

various mass relations are

$$\Omega_3{}^* - \Omega_2{}^* = \Omega_2{}^* - \Omega_1{}^* = \Omega_1{}^* - \Omega. \quad (13\,a)$$

$$\Omega - \Xi^* = \Xi^* - \Sigma^* = \Sigma^* - \Delta \quad (13\,b)$$

$$= \Xi_1{}^* - \Sigma_1{}^* = \Omega_1{}^* - \Xi_1{}^* = \Omega_2{}^* - \Xi_2{}^*$$

$$\Delta^{++} - \Delta^+ = \Delta^+ - \Delta^0 = \Delta^0 - \Delta^- = \Sigma^{*+} - \Sigma^{*0}$$

$$= \Sigma^{*0} - \Sigma^{*-} = \Xi^{*0} - \Xi^{*-} = \Sigma_1{}^{*++} - \Sigma_1{}^{*+}$$

$$= \Sigma_1{}^{*+} - \Sigma_1{}^{*0} = \Xi_1{}^{*+} - \Xi_1{}^{*0} = \Xi_2{}^{*++} - \Xi_2{}^{*+} \quad (13\,c)$$

Because mass relations are identical with or without the spin triplet mass breaking. Hence for both the cases we give the masses of $3/2^+$ isobars in a single column of table 2.

2.3. *Mixing angles*

In the $\underline{20'}$ multiplet of SU(4) Λ and Σ^0 of octet are mixed due to SU(2) breaking and $B(3^*)$ is mixed with the states of $B(6)$ *via* SU(3) breaking. SU(2) mixing is expected to be small (of the order of em breaking), while SU(3) mixing may be larger. These mixing effects are expected to be negligible therefore we have not considered them in determining mass relations. But for the sake of completeness we have calculated the mixing angles. Considering mass breaking due to both the spin singlet and spin triplet interactions, we get the following mixing masses:

$$m_{\Lambda\Sigma^0} = m_{\Lambda'_1{}^+\Sigma_1{}^+} = \frac{1}{\sqrt{12}}(P - N + \Xi^- - \Xi^0) = 1\cdot53 \text{ MeV}.$$

$$m_{\Xi'_1{}^0\Xi_1{}^0} = \frac{1}{\sqrt{12}}(\Xi^0 - N - 2(\Sigma^+ - P)) = -\,36\cdot71 \text{ MeV}.$$

$$m_{\Xi'_1{}^+\Xi_1{}^+} = \frac{1}{\sqrt{12}}(P - \Xi^- - 2(\Sigma^+ - \Xi^0)) = -\,38\cdot24 \text{ MeV} \quad (14)$$

using the mass values given in column 3 of table 1 we get:

$$\theta_{\Lambda\Sigma^0} = 1°,4'; \; \theta_{\Lambda_1'^+\Sigma_1^+} = 0°, 22'; \; \theta_{\Xi_1'\Xi_1} \sim 10° 6' \tag{15}$$

$\theta_{\Lambda\Sigma^0} = 1°, 4'$ has been obtained in the SU(3) symmetry framework (Carruthers 1966).

3. Discussions and conclusions

We see that SU(8) symmetry does not predict satisfactory results if mass breaking is attributed to spin singlet interaction alone. Relations for $1/2^+$ baryons are too strong to be true. Second order effects definitely seem to improve the results but predict very large mixing angles of the mixed states. When mass breaking due to spin triplet interaction is included in first order, SU(8) predicts well satisfied relations and small mixing angles. Hence we may expect mass relations among charmed baryons also to be true. Any discrepancies present in the relation can be removed by further considerations of second order effects. Knowledge of the mass of one charmed baryons in $\underline{20}$ and of the two in case of $\underline{20'}$ multiplet will provide the masses of all the other charmed baryons and isobars. Recently a charmed antibaryon state has been observed (Knapp 1976) at 2·26 GeV decaying to $\bar{\Lambda}\, \pi^-\pi^-\pi^+$. Another state decaying to the first one and a positive pion has also been observed at 2·5 GeV. Assuming first state to be $\bar{\Lambda}_1'^+$ and second one to be either $\bar{\Sigma}_1^{*0}$ $(3/2^+)$ or $\bar{\Sigma}_1^0$ $(1/2^+)$ we have calculated masses of charmed baryons given in tables 1 and 2.

Quark models (Hendry and Lichtenberg 1975; Franklin 1975) do not give well known Gell-Man Okubo octet mass sum rule and equal spacing rule for decimet without additional assumptions. Both the relations follow, when the two body interaction is assumed to satisfy:

$$D_{sp} = \tfrac{1}{2}(D_{ss} + D_{pp}) \tag{16}$$

where D_{ij} is the two body interaction energy between the i and j quark in triplet state. Extension of this assumption to

$$D_{ij} = \tfrac{1}{2}(D_{ii} + D_{jj}) \qquad i,j = p, n, s, c \tag{17}$$

leads to further relations among charmed baryons, *e.g.*, equal spacing rule for $\underline{20}$ multiplet and analog of GMO relation (12 *c*). No particular reason can be given to justify this assumption, except that it represents a simple form of symmetry breaking. In SU(8) symmetry framework, we have derived relations similar to those obtained in quark models, only by assuming a certain transformationc haracter of the mass breaking interaction. Our relations are modified electromagnetically since we have introduced em breaking also. If em breaking is neglected, the relations (9 *a*), (9 *b*), (9 *c*), (12 *b*) and (12 *c*), among isomultiplets of $\underline{20'}$ have been already obtained within the framework of quark model in broken SU(8) symmetry. The relation (12) is new. However this relation has been derived in quark-diquark model (Lichtenberg 1975 *b*).

In case of 20′ baryons, inclusion of second order effects also gives all the relations obtained in quark models. If em breaking is neglected it gives two relations:

$$\Xi + N = 2\Sigma$$
$$\Xi_2 + N = 2\Sigma_1 \qquad (18)$$

which are collapsed form of GMO relation (12 *b*) and its charmed analog (12 *c*). For 20-multiplet, second order effects relate the violations of the equal spacing rule. But inclusion of spin triplet interaction does not disturb equal spacing rule for 20 isobars.

If the mass breaking operator $M_B{}^A$ transforming as 63 of SU (8) is considered up to all orders, then it is seen that for arbitrary powers of $M_B{}^A$, we can at most have the following three distinct baryons contractions.

$$B^{ABC'}\, B_{ABC}\, M^C_{C'}\ ;\ B^{AB'C'}\, B_{ABC}\, M^B_{B'}\, M^C_{C'}\ ;\ B^{A'B'C'}\, B_{ABC}\, M^A_{A'}\, M^B_{B'}\, M^C_{C'}$$

These correspond to 63, 1232 and 13104 representations of SU (8), present in the direct product:

$$\underline{120^*} \otimes \underline{120} = \underline{1} \oplus \underline{63} \oplus \underline{1232} \oplus \underline{13104} \qquad (19)$$

We have not considered the contributions of 13104 as it will lead to the introduction of large number of additional parameters in the Hamiltonian. This definitely does not lead to any useful mass relations to compare with experiment.

Like em mass splitting (Sakita 1964), if we assume general mass breaking Hamiltonian to be of the current ⊗ current form, which transforms like

$$\underline{63} \otimes \underline{63} = \underline{1} \oplus \underline{63_S} \oplus \underline{63_A} \oplus \underline{720} \oplus \underline{945} \oplus \underline{945^*} \oplus \underline{1232} \qquad (20)$$

Then representations common in the two direct products (19) and (20) will contribute to the mass splitting terms of the baryons. Natural candidates then are 1, 63 and 1232. Hence 13104 is neglected.

In summary we have extended the usual SU (6) (Pais 1966) to SU (8), thereby incorporating new quantum number charm. We see that mass relations obtained in the framework of SU (8) are well satisfied even though the SU (8) is very badly broken symmetry. Yet one may feel that breaking mechanism is systematic and there may be some deeper reason which explains why perturbation theory works well in such a badly broken higher symmetries (Hendry and Lichtenberg 1975). If a few charmed baryons are found, mass relations obtained can be employed to confirm whether SU (8) symmetry is a worthwhile symmetry scheme.

Acknowledgement

One of us (RCV) would like to thank CSIR, New Delhi, for the financial support.

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