Charmed baryons with $J = 3/2$

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(Received 11 August 1995)

The width of a recently discovered excited charmed-strange baryon, a candidate for a state Ξ_c^* with spin $\frac{3}{2}$, is calculated. In the absence of configuration mixing between the ground-state (spin-$\frac{1}{2}$) charmed-strange baryon $\Xi_c^{(a)}$ and the spin-$\frac{1}{2}$ state $\Xi_c^{(s)}$ lying about 95 MeV above it, one finds $\tilde{\Gamma}(\Xi_c^* \to \Xi_c^{(a)}\pi) = \frac{3}{4}\tilde{\Gamma}(\Xi^* \to \Xi\pi)$ and $\tilde{\Gamma}(\Xi_c^* \to \Xi_c^{(s)}\pi) = \frac{1}{4}\tilde{\Gamma}(\Xi^* \to \Xi\pi)$, where the tilde denotes the partial width with kinematic factors removed. Assuming a kinematic factor for P-wave decay of $p_{\text{c.m.}}^3$, one predicts $\Gamma(\Xi_c^* \to \Xi_c^{(a)}\pi) = 2.3$ MeV, while the $\Xi_c^* \to \Xi_c^{(s)}\pi$ channel is closed. Some suggestions are given for detecting the Σ_c^*, the spin-$\frac{3}{2}$ charmed nonstrange baryon, and the Ω_c^*, the spin-$\frac{3}{2}$ charmed doubly strange baryon.

PACS number(s): 12.39.Hg, 12.39.Jh, 13.30.Eg, 14.20.Lq

I. INTRODUCTION

Candidates for all the ground-state baryons with a single charmed quark and total spin equal to $\frac{1}{2}$ have now been observed. These consist of the isosinglet $\Lambda_c(2285) = udc$, isotriplet $\Sigma_c(2453) = (uuc, udc, ddc)$, and isodoublet $\Xi_c(2468) = usc, dsc$ states listed by the Particle Data Group [1], the isosinglet $\Omega_c(2704) = css$ [2], and an excited Ξ_c lying about 95 MeV/c^2 above the lowest Ξ_c and decaying to it by photon emission[1] [3]. These states are depicted as the solid lines in Fig. 1. However, until recently the only candidate for a spin-$\frac{3}{2}$ state was a cluster of six events produced by neutrinos in a heavy-liquid bubble chamber [4], corresponding to a Σ_c^* state at 2530±5±5 MeV/c^2 not yet confirmed in other experiments.

The CLEO Collaboration has now presented evidence [5] for a narrow state decaying into $\Xi_c^+ \pi^-$. The state lies $178.2 \pm 0.5 \pm 1.0$ MeV/c^2 above the Ξ_c^+. It has a width less than 5.5 MeV (90% C.L.), and has been identified by the authors as a candidate for the Ξ_c^* shown by the dashed line in Fig. 1, a spin-$\frac{3}{2}$ charmed baryon.

In the present article we predict the Ξ_c^* to have a total width of 2.3 MeV (or less, if symmetry breaking effects are important), narrower than the experimental resolution in the CLEO experiment. This small width may be the reason for the prominence of the signal. By contrast, the Σ_c^* is expected to have a larger total width as a result of a larger matrix element and a larger phase space for its $\Lambda_c\pi$ decay mode. Nonetheless, its predicted partial width is not expected to be so large that it should be unobservable. We shall argue that the Σ_c^* should be no heavier than 2552 MeV/c^2 and its total width should not exceed 35 MeV. We also predict the mass of the Ω_c^* to be at least 2771 MeV/c^2.

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[1]The numbers in parentheses denote the masses in MeV/c^2.

We introduce notation and calculate decay matrix elements in Sec. II. The decays of noncharmed baryons are discussed in Sec. III, while charmed baryon decays are described in Sec. IV. We conclude in Sec. V.

II. NOTATION AND CALCULATION OF MATRIX ELEMENTS

A. Representation of baryon states

We describe pion emission using a quark model language [6] which sums the amplitudes for transitions of individual u or d quarks. We represent baryon states by the
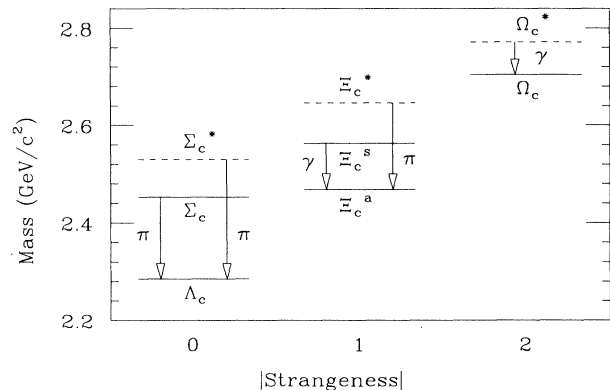

FIG. 1. Lowest-lying S-wave states of a single charmed quark and two light (u, d, s) quarks. Solid and dashed lines correspond to states with total quark spin equal to $\frac{1}{2}$ and $\frac{3}{2}$, respectively. Masses of the spin-$\frac{1}{2}$ states and the Σ_c^* and Ξ_c^* correspond to observed values (see text), while mass of the Ω_c^* is the lower limit predicted in the present work. Superscripts on the spin-$\frac{1}{2}$ Ξ_c states denote antisymmetry (a) and symmetry (s) with respect to interchange of light-quark spins. Transitions are denoted by arrows.

action of three bosonic quark creation operators on the vacuum, thereby taking account of antisymmetry with respect to color. We denote the operator which creates a quark q with $J_z = +1/2$ by $q^+ \uparrow$. A baryonic state with $J_z = +1/2$ is denoted by $|B \uparrow\rangle$, while one with $J_z = 3/2$ will be denoted by $|B \Uparrow\rangle$. Thus, for example, a Δ^{++} with $J_z = 3/2$ would be written $|\Delta^{++} \Uparrow\rangle = (6)^{-1/2}(u^+ \uparrow u^+ \uparrow u^+ \uparrow)|0\rangle$, where the factor is the usual one $(n!^{-1/2})$ associated with n identical Bose particles. The spin-lowering operator S_- may then be used to construct $|\Delta^{++} \uparrow\rangle = (2)^{-1/2}(u^+ \uparrow u^+ \uparrow u^+ \downarrow)|0\rangle$. The isospin-lowering operator I_- gives us $|\Delta^+ \uparrow\rangle = (6)^{-1/2}(u^+ \uparrow u^+ \uparrow d^+ \downarrow + 2u^+ \uparrow d^+ \uparrow u^+ \downarrow)|0\rangle$. We may then construct the proton with $J_z = 1/2$ as the state orthogonal to this: $|p \uparrow\rangle = (3)^{-1/2}(u^+ \uparrow u^+ \uparrow d^+ \downarrow - u^+ \uparrow d^+ \uparrow u^+ \downarrow)|0\rangle$.

The quark model states needed for the present calculations are given in Table I. Other states may be obtained by applying isospin raising or lowering operators. We shall need only states with $J_z = 1/2$ since we will be concerned only with emission of (spinless) pions, so we denote the states $|B \uparrow\rangle$ merely by B in the table. The full set of noncharmed states has been given in Ref. [6], whose sign conventions we adopt here.

The charmed $(C = 1)$ states may be obtained from the noncharmed $(C = 0)$ ones by simple substitutions. For example, the $\Lambda_c = udc$ is obtained from the $\Lambda = uds$ by the replacement $s \to c$. A similar replacement converts a $\Sigma^+ = uus$ to a $\Sigma_c^{++} = uuc$. The state $\Xi_c^{+(a)} = usc$, in which the u and s quarks are coupled to $J = 0$, is obtained from the $\Lambda = uds$ by the replacements $d \to s, s \to c$. Similarly, the state $\Xi_c^{+(s)}$, in which the u and s quarks are coupled to $J = 1$, is obtained from the Σ^0 by the same replacements. The hyperfine interaction between the light quarks is attractive in the $\Xi_c^{(a)}$ and repulsive in the $\Xi_c^{(s)}$, leading to $M(\Xi_c^{(a)}) < M(\Xi_c^{(s)})$. We shall ignore configuration mixing [7] between the $\Xi_c^{(a)}$ and

$\Xi_c^{(s)}$ states. Similar types of substitutions may be applied to the $J = 3/2$ states. For example, we obtain Ξ_c^{*+} from Σ^{*0} by replacing $d \to s, s \to c$.

B. Representation of pion emission

Pion emission is represented by a linear combination of products of one annihilation and one creation operator. We evaluate the matrix elements of the following operators between baryon states:

$$\mathcal{O}^{(\pi^-)} = u^+ \uparrow d \uparrow - u^+ \downarrow d \downarrow,$$

$$\mathcal{O}^{(\pi^0)} = (2)^{-1/2}(u^+ \uparrow u \uparrow - u^+ \downarrow u \downarrow - d^+ \uparrow d \uparrow + d^+ \downarrow d \downarrow),$$

$$\mathcal{O}^{(\pi^+)} = -(d^+ \uparrow u \uparrow - d^+ \downarrow u \downarrow). \tag{1}$$

The signs are chosen in accord with standard Clebsch-Gordan coefficient conventions.

C. Calculation of matrix elements

We factor matrix elements for specific transitions $A(B \uparrow \to \pi B' \uparrow)$ into isospin Clebsch-Gordan coefficients $(I_B I_{3B}|1 I_{3\pi} I_{B'} I_{3B'})$ and isoscalar factors $(\pi B'|B)$:

$$A(B \uparrow \to \pi B' \uparrow) = (\pi B'|B)(I_B I_{3B}|1 I_{3\pi} I_{B'} I_{3B'}). \tag{2}$$

The isoscalar factors are shown in Table II. The partial widths $\Gamma(B \to \pi B')$ are just proportional to the squares of these isoscalar factors, since the squares of Clebsch-Gordan coefficients for respective charge states sum to

TABLE I. Quark model baryon states with $J_z = 1/2$ in terms of bosonic creation operators acting upon the vacuum.

Multiplet	State	Configuration
$J = 1/2$	p	$(3)^{-1/2}(u^+ \uparrow u^+ \uparrow d^+ \downarrow - u^+ \uparrow u^+ \downarrow d^+ \uparrow)|0\rangle$
$(C = 0)$	Λ	$(2)^{-1/2}(u^+ \uparrow d^+ \downarrow s^+ \uparrow - u^+ \downarrow d^+ \uparrow s^+ \uparrow)|0\rangle$
	Σ^+	$(3)^{-1/2}(u^+ \uparrow u^+ \downarrow s^+ \uparrow - u^+ \uparrow u^+ \uparrow s^+ \downarrow)|0\rangle$
	Σ^0	$(6)^{-1/2}(u^+ \uparrow d^+ \downarrow s^+ \uparrow + u^+ \downarrow d^+ \uparrow s^+ \uparrow - 2u^+ \uparrow d^+ \uparrow s^+ \downarrow)|0\rangle$
	Ξ^0	$(3)^{-1/2}(s^+ \uparrow s^+ \uparrow u^+ \downarrow - s^+ \uparrow s^+ \downarrow u^+ \uparrow)|0\rangle$
$J = 1/2$	Λ_c^+	$(2)^{-1/2}(u^+ \uparrow d^+ \downarrow c^+ \uparrow - u^+ \downarrow d^+ \uparrow c^+ \uparrow)|0\rangle$
$(C = 1)$	Σ_c^{++}	$(3)^{-1/2}(u^+ \uparrow u^+ \downarrow c^+ \uparrow - u^+ \uparrow u^+ \uparrow c^+ \downarrow)|0\rangle$
	$\Xi_c^{+(a)}$	$(2)^{-1/2}(u^+ \uparrow s^+ \downarrow c^+ \uparrow - u^+ \downarrow s^+ \uparrow c^+ \uparrow)|0\rangle$
	$\Xi_c^{+(s)}$	$(6)^{-1/2}(u^+ \uparrow s^+ \downarrow c^+ \uparrow + u^+ \downarrow s^+ \uparrow c^+ \uparrow - 2u^+ \uparrow s^+ \uparrow c^+ \downarrow)|0\rangle$
$J = 3/2$	Δ^{++}	$(2)^{-1/2}(u^+ \uparrow u^+ \uparrow u^+ \downarrow)|0\rangle$
$(C = 0)$	Σ^{*+}	$(6)^{-1/2}(u^+ \uparrow u^+ \uparrow s^+ \downarrow + 2u^+ \uparrow u^+ \downarrow s^+ \uparrow)|0\rangle$
	Σ^{*0}	$(3)^{-1/2}(u^+ \uparrow d^+ \uparrow s^+ \downarrow + u^+ \uparrow d^+ \downarrow s^+ \uparrow + u^+ \downarrow d^+ \uparrow s^+ \uparrow)|0\rangle$
	Ξ^{*0}	$(6)^{-1/2}(s^+ \uparrow s^+ \uparrow u^+ \downarrow + 2s^+ \uparrow s^+ \downarrow u^+ \uparrow)|0\rangle$
$J = 3/2$	Σ_c^{*++}	$(6)^{-1/2}(u^+ \uparrow u^+ \uparrow c^+ \downarrow + 2u^+ \uparrow u^+ \downarrow c^+ \uparrow)|0\rangle$
$(C = 1)$	Ξ_c^{*+}	$(3)^{-1/2}(u^+ \uparrow s^+ \uparrow c^+ \downarrow + u^+ \uparrow s^+ \downarrow c^+ \uparrow + u^+ \downarrow s^+ \uparrow c^+ \uparrow)|0\rangle$

TABLE II. Isoscalar factors $(\pi B'|B)$ for decays of $J = 1/2$ or $J = 3/2$ baryons to a pion and a $J = 1/2$ baryon.

Decay $B \to \pi B'$	Value of $(\pi B'|B)$	$p_{\text{c.m.}}$ (MeV/c)	Partial width (MeV)
$\Delta \to \pi N$	$2\sqrt{2/3}$	227	120 ± 5
$\Sigma^* \to \pi \Lambda$	$2/\sqrt{3}$	208	31.5 ± 1.0
$\Sigma^* \to \pi \Sigma$	$2\sqrt{2}/3$	127	4.3 ± 0.7
$\Xi^* \to \pi \Xi$	$2/\sqrt{3}$	152	9.1 ± 0.5
$\Sigma_c \to \pi \Lambda_c$	$\sqrt{2/3}$	91	
$\Sigma_c^* \to \pi \Lambda_c$	$2/\sqrt{3}$	a	
$\Xi_c^* \to \pi \Xi_c^{(a)}$	-1	107	$< 5.5^{\text{b}}$
$\Xi_c^* \to \pi \Xi_c^{(s)}$	$-1/\sqrt{3}$	c	

$^{\text{a}}$(168, 192, 213) MeV/c for $M(\Sigma_c^*)$ =(2510, 2530, 2550) MeV/c^2.
$^{\text{b}}$90% c.l. limit [5].
$^{\text{c}}$Unphysical decay.

unity. Specifically, we have

$$\Gamma(B \to \pi B') = C|(\pi B'|B)|^2 p_{\text{c.m.}}^3, \qquad (3)$$

where C is a universal constant and the factor $p_{\text{c.m.}}^3$ is appropriate for P-wave decays. The value of this quantity for each decay is also shown in Table II, as is the observed partial width. Unless otherwise indicated, we quote the best-known partial width [1] for a given isospin multiplet.

III. NONCHARMED BARYON DECAYS

We may test the relations implied by Table II for SU(3) breaking using the decays [1] of the charmless $J = 3/2$ baryons (the first four rows).

A. Prediction for $\Sigma^* \to \pi \Lambda$

The observed partial width for $\Delta \to \pi N$ implies

$$\Gamma(\Sigma^* \to \pi \Lambda)_{\text{pred}} = \frac{1}{2}\left(\frac{208}{227}\right)^3 (120 \pm 5) \text{ MeV}$$
$$= 46 \pm 2 \text{ MeV}. \qquad (4)$$

The observed value of 31.5 ± 1.0 MeV is about 0.68 ± 0.05 times the prediction.

B. Prediction for $\Sigma^* \to \pi \Sigma$

The observed partial width for $\Sigma^* \to \pi \Lambda$ implies

$$\Gamma(\Sigma^* \to \pi \Sigma)_{\text{pred}} = \frac{2}{3}\left(\frac{127}{208}\right)^3 (31.5 \pm 1.0) \text{ MeV}$$
$$= 4.8 \pm 0.2 \text{ MeV}. \qquad (5)$$

The observed value of 4.3 ± 0.7 MeV is in satisfactory agreement with the prediction.

C. Prediction for $\Xi^* \to \pi \Xi$

The observed partial width for $\Sigma^* \to \pi \Lambda$ implies

$$\Gamma(\Xi^* \to \pi \Xi)_{\text{pred}} = \left(\frac{152}{208}\right)^3 (31.5 \pm 1.0) \text{ MeV}$$
$$= 12.3 \pm 0.4 \text{ MeV}. \qquad (6)$$

The observed value of 9.1 ± 0.5 MeV is about 0.74 ± 0.05 times the prediction.

D. Systematics of SU(3) breaking

It appears that the replacement of a nonstrange by a strange quark multiplies the decay width by a factor of approximately 0.7. We will bear this factor in mind when discussing possible violations of the symmetry which involves replacing a strange quark by a charmed quark. First-order symmetry breaking in the above decays has been discussed, for example, in Ref. [8].

IV. CHARMED BARYON DECAYS

A. $\Sigma_c \to \pi \Lambda_c$

This decay is kinematically allowed, in contrast to the decay $\Sigma \to \pi \Lambda$. The small c.m. momentum leads to a small predicted width:

$$\Gamma(\Sigma_c \to \pi \Lambda_c) = \frac{1}{2}\left(\frac{91}{208}\right)^3 (31.5 \pm 1.0) \text{ MeV}$$
$$= 1.32 \pm 0.04 \text{ MeV}, \qquad (7)$$

narrower than the experimental resolution with which this state is seen. Here we have related $\Sigma_c \to \pi \Lambda_c$ to $\Sigma^* \to \pi \Lambda$; both processes involve baryons with two nonstrange quarks.

B. $\Sigma_c^* \to \pi \Lambda_c$

This decay is the analogue of $\Sigma^* \to \pi \Lambda$ under the replacement $s \to c$. The isoscalar factors are the same for the two decays, so the ratio of partial widths in the limit of exact symmetry under $s \leftrightarrow c$ should simply scale according to the ratio of the values of $p_{\text{c.m.}}^3$.

We may estimate the mass of Σ_c^* by means of a simple hyperfine splitting calculation [9–11]. In the $\Sigma^{(*)+}$ and $\Sigma_c^{(*)++}$ states, the two u quarks are coupled to a total spin of 1, so that one expects the splitting between the $J = 1/2$ and $J = 3/2$ baryonic states to scale as $1/m_Q$, where $Q = s$ or c. Thus if the wave function of the $J = 1$ diquark is the same at the positions of the s quark in the

$\Sigma^{(*)}$ and the c quark in the $\Sigma_c^{(*)}$, we expect

$$M(\Sigma_c^*) = M(\Sigma_c) + (m_s/m_c)[M(\Sigma^*) - M(\Sigma)]$$
$$\approx 2514 \text{ MeV}, \tag{8}$$

where we have used constituent-quark masses [11] $m_s = 538$ MeV/c^2 and $m_c = m_s + M(\Lambda_c) - M(\Lambda) = 1707$ MeV/c^2. A similar attempt to relate the hyperfine splitting $M(D_s^*) - M(D_s)$ to $M(D^*) - M(D)$ underestimates the former [12]; reduced-mass effects apparently cannot be ignored. Similarly, we expect that the hyperfine splitting between Σ_c^* and Σ_c will, if anything, exceed the naive estimate. Hence (8) should be regarded as a lower bound. Other theoretical estimates for charmed baryon masses (see, e.g., [10,11,13,14]) lead one to expect $M(\Sigma_c^*)$ between about 2.50 and 2.55 GeV/c^2.

In Fig. 2 we have plotted the total width of (Σ_c^*), approximately equal to the partial width for $\Sigma_c^* \to \pi\Lambda_c$ aside from small electromagnetic transitions, as a function of $M(\Sigma_c^*)$. Since these predictions were obtained from $\Gamma(\Sigma^* \to \pi\Lambda)$ via the substitution $s \to c$, and we have seen that substituting heavier spectator quarks reduces partial widths in the case of noncharmed baryons, it is reasonable to expect the predictions of Fig. 2 to be upper bounds. These widths probably exceed available mass resolutions in CLEO or various fixed-target Fermilab experiments, so that optimum signal-to-noise advantages with respect to combinatorial backgrounds are not being achieved in the search for a Σ_c^*. Nevertheless, the widths in Fig. 2 are sufficiently modest that it should not be too hard to find this state.

C. Decays of the Ξ_c^*

The state discovered by CLEO [5] at a mass of 2643 MeV/c^2 lies 30 MeV/c^2 above a naive estimate [14] which was based on assuming a universal hyperfine interaction proportional to the inverse of products of quark masses. Thus, the $\Xi_c^* - \Xi_c^{(s)}$ splitting appears to be about $178 - 95 = 83$ MeV/c^2 instead of the 53 MeV/c^2 estimated in Ref. [14]. Nonetheless, the phase space for the
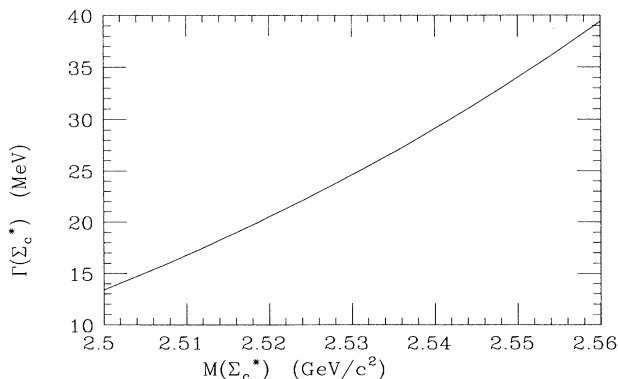

FIG. 2. Predicted total width $\Gamma(\Sigma_c^*) \approx \Gamma(\Sigma_c^* \to \pi\Lambda_c)$ as a function of the mass of Σ_c^*.

decay $\Xi_c^* \to \pi\Xi_c^{(a)}$ remains small enough that we predict a small partial width. The process $\Xi^* \to \pi\Xi$ involves two strange-quark spectators, whereas the spectators in $\Xi_c^* \to \pi\Xi_c^{(a)}$ are one strange and one charmed quark. Thus we expect $\Xi^* \to \pi\Xi$ to provide the best reference amplitude; if anything, the partial width for $\Xi_c^* \to \pi\Xi_c^{(a)}$ will be no larger than the following prediction:

$$\Gamma(\Xi_c^* \to \pi\Xi_c^{(a)}) = \frac{3}{4}\left(\frac{106}{152}\right)^3 (9.1 \pm 0.5) \text{ MeV}$$
$$= 2.3 \pm 0.1 \text{ MeV}. \tag{9}$$

The decay $\Xi_c^* \to \pi\Xi_c^{(s)}$ is kinematically forbidden. The square of its isoscalar factor is only 1/3 of that for the allowed decay $\Xi_c^* \to \pi\Xi_c^{(a)}$.

D. Relations between hyperfine splittings

An elementary calculation along the lines of Ref. [11] leads to the relation

$$\frac{M(\Xi_c^*) - M(\Xi_c^{(s)})}{M(\Sigma_c^*) - M(\Sigma_c)} = \frac{1}{2}\left(1 + \frac{m_u}{m_s}\right) \tag{10}$$

in the limit of universal hyperfine interactions mentioned earlier. Given the likelihood that the $\Xi_c^{(*,s)}$ wave functions are spatially more compact than those of the $\Sigma_c^{(*)}$ states, this relation must be regarded as a lower bound, implying an upper bound on $M(\Sigma_c^*) - M(\Sigma_c)$. Taking [11] $m_u = 363$ MeV/c^2 and $m_s = 538$ MeV/c^2, we find $M(\Sigma_c^*) - M(\Sigma_c) \leq 99$ MeV/c^2, or $M(\Sigma_c^*) \leq 2552$ MeV/c^2. Referring to Fig. 2, we see that the width of this state should not exceed 35 MeV.

One can perform a similar calculation to estimate the hyperfine splitting between Ω_c^* and Ω_c. We find

$$\frac{M(\Omega_c^*) - M(\Omega_c)}{M(\Xi_c^*) - M(\Xi_c^{(s)})} = \frac{2}{1 + m_s/m_u}, \tag{11}$$

leading to the prediction $M(\Omega_c^*) - M(\Omega_c) = 67$ MeV/c^2, or $M(\Omega_c^*) = 2771$ MeV/c^2. For the same reasons as mentioned above, we expect symmetry breaking in the wave function to increase the hyperfine splitting and the Ω_c^* mass. Thus the figure we quote is a lower limit. The decay $\Omega_c^* \to \Omega_c\gamma$ will be the means for detecting the Ω_c^*.

An equal-spacing rule follows from the assumptions [15] of heavy-quark symmetry and lowest-order SU(3) symmetry breaking. In this approach the corrections due to chiral loops are found to be finite and small. We can also obtain such a rule by linearizing our hyperfine expressions in $m_s - m_d$. One obtains

$$M(\Xi_c^{(s)}) - M(\Sigma_c) = M(\Omega_c) - M(\Xi_c^{(s)})$$
$$= M(\Xi_c^*) - M(\Sigma_c^*)$$
$$= M(\Omega_c^*) - M(\Xi_c^*). \tag{12}$$

The relations between states with a given $J = 1/2$ or 3/2 follow from the fact that the product $\mathbf{6} \times \mathbf{6}^* =$

$1+8+27$ contains a single octet, but the relations between states with $J=1/2$ and states with $J=3/2$ are the consequence of the heavy-quark symmetry. Experimentally $M(\Xi_c^{(s)})-M(\Sigma_c)\approx110$ MeV$/c^2$, while $M(\Omega_c)-M(\Xi_c^{(s)})\approx141$ MeV$/c^2$. We have predicted 91 MeV$/c^2\leq M(\Xi_c^*)-M(\Sigma_c^*)\leq129$ MeV$/c^2$ and 125 MeV$/c^2\leq M(\Omega_c^*)-M(\Xi_c^*)$.

E. Production of the Σ_c^*

The failure of the Σ_c^* to be produced abundantly (in contrast to the Σ^* discussed in Sec. III) may be due in part to the difference between mass splittings in the strange and charmed sectors. The Σ^* can just barely be produced via the S-wave decay of the lowest-lying spin-$\frac{3}{2}$ excited Λ state, $\Lambda(1520)\to\pi\Sigma^*(1385)$. In contrast, a candidate for the lowest-lying spin-$\frac{3}{2}$ excited Λ_c at 2626 MeV$/c^2$ [1,14] lies too low in mass to decay to $\pi\Sigma_c^*(>2500)$.

V. CONCLUSIONS

We have discussed the pionic decays of noncharmed and charmed baryons in an attempt to understand the small width of the recently observed [5] candidate for

the spin-$\frac{3}{2}$ state Ξ_c^*. Relating the decay $\Xi_c^*\to\pi\Xi_c^{(a)}$ to the process $\Xi^*\to\pi\Xi$, we predict $\Gamma(\Xi_c^*\to\pi\Xi_c^{(a)})=2.3$ MeV in the limit in which strange and charmed spectator quarks are interchangeable. In fact, this prediction is more likely to be an upper bound.

We have shown that the Σ_c^*, so far claimed in only one experiment [4], should have a total width modestly exceeding the mass resolution of most present-day experiments but not more than 35 MeV, and a mass not exceeding 2552 MeV$/c^2$. Evidence for this state (or confirmation of the results of Ref. [4]) and a reliable width measurement would permit the recalibration of pionic decay widths of charmed baryons, for which present predictions rely on an extrapolation from the charmless sector. The detection of a state Ω_c^* with a mass of at least 2771 MeV$/c^2$ would then complete the picture of the singly charmed ground-state baryons.

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