Theoretical Analysis of Static Hyperon Data for HYPERON99

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Abstract

We consider all hyperon data relevant to spin and flavor structure of hyperons. In addition to masses and magnetic moments considered as static properties in Hyperon99 we include also relevant data from hyperon decays and spin structure determined from deep inelastic scattering. Any theoretical model for the hyperons with parameters to be determined from experiment should use input from all these data. Of particular interest are new data from $\Xi^0$ decay and the polarization of $\Lambda$'s produced in $Z^0$ decays and deep inelastic scattering.

I. INTRODUCTION - WHAT IS MEANT BY STATIC PROPERTIES

In the context of this meeting, hyperon masses and magnetic moments are considered static properties to be discussed in this talk, while hyperon decays and spin structure determined from deep inelastic scattering are not considered static properties. But all of them depend upon the spin and flavor structure of the hyperons. Any theoretical model for the hyperons with parameters to be determined from experiment should use input from all these data.

The masses and magnetic moments are very well measured, and they are well described by the simple constituent quark model. Going beyond this model is difficult without input
from other data, some of which are not so well measured. Thus progress in understanding hyperon structure will come from combining input from all relevant experimental data and improvements in the precision of data other than masses and magnetic moments.

A. New Data on $\Xi^0 \rightarrow \Sigma^+$ decays

The new data for the semileptonic decay $\Xi^0 \rightarrow \Sigma^+$ agrees with the SU(3) prediction

$$g_A(\Xi^0 \rightarrow \Sigma^+) = g_A(n \rightarrow p) \quad (1.1)$$

where we use the shortened form $g_A$ to denote $G_A/G_V$.

The essential physics of this prediction is that the spin physics in the nucleon system which is probed in the neutron decay is unchanged when the $d$ quarks in the nucleon are changed to strange quarks. This very striking result is completely independent of any fitting of weak decays using the conventional D/F parametrization. We can immediately carry this physics further by inserting the $d \leftrightarrow s$ transformation into the well-known prediction for the ratio of the proton ($uud$) to neutron ($udd$) magnetic moments and obtain a prediction for the ratio of the $\Sigma^+(uus)$ to $\Xi^0(uss)$ magnetic moments. It is convenient to write the prediction in the form:

$$\frac{\mu_p}{\mu_n} = -1.46 = \frac{4\xi_{ud} + 1}{4 + \xi_{ud}} = -1.5 \quad (1.2)$$

where $\xi_{ud}$ is the ratio of the quark magnetic moments

$$\xi_{ud} = \mu_u/\mu_d = -2 \quad (1.3)$$

This is easily generalized to give

$$\frac{\mu_{\Sigma^+}}{\mu_{\Xi^0}} = -1.96 = \frac{4\xi_{us} + 1}{4 + \xi_{us}} = -1.89 \quad (1.4)$$

where $\xi_{us}$ is the ratio of the quark magnetic moments,

$$\xi_{us} = \mu_u/\mu_s = (\mu_u/\mu_d) \cdot (\mu_d/\mu_s) = -3.11 \quad (1.5)$$
and we have determined \((\mu_d/\mu_s)\) by the ratio between the experimental value of \(\mu_\Lambda\) and the SU(3) prediction \(\mu_\Lambda = \mu_n/2\) which assumes that \(\mu_d = \mu_s\)

\[
\frac{\mu_d}{\mu_s} = \frac{\mu_n}{2\mu_\Lambda} = -3.11
\]

The fact that the prediction for this ratio (1.4) agrees with experiment much better than either moment agrees with the SU(6) quark model \([1]\) is very interesting.

B. New \(\Lambda\) polarization measurements from \(Z\) decays and DIS

When a \(\Lambda\) is produced either from \(Z^0\) decay or in deep inelastic scattering, the accepted mechanism is the production of a polarized quark produced in a pointlike vertex from a \(W\) boson or a photon, and the eventual fragmentation of this quark into the \(\Lambda\) directly or into a \(\Sigma^0\) or \(\Sigma^*\) which eventually decays into a \(\Lambda\). Now that experimental data on \(\Lambda\) polarization are becoming available in both processes \([2][3]\) a central theoretical question is which model to use for the spin structure of the \(\Lambda\). In the simple quark model, the strange quark carries the spin of the \(\Lambda\) and the \(u\) and \(d\) are coupled to spin zero. This model has been used \([7]\) in the first analysis of experimental data from \(Z\) decay \([4]\) and found to be consistent with the data. But the deep inelastic experiments have shown that the spin structure of the proton is different from that given by the simple quark model. An alternative approach is presented in \([8]\) where SU(3) symmetry is assumed and the spin structure of SU(3) octet hyperons is deduced from that of the proton. But SU(3) symmetry is known to be broken. Several approaches to this symmetry breaking have been proposed by theorists \([2][9]\), and other mechanisms are discussed in \([10][13]\). How to include the \(\Lambda\)’s produced by the fragmentation of a quark into \(\Sigma^*\) which eventually decays into a \(\Lambda\) remains controversial, since \([2][8]\) the decay via a strong interaction may be already included in the fragmentation function. The question of how to all this right remains open.

II. MASSES AND MAGNETIC MOMENTS
A. The Sakharov-Zeldovich 1966 Quark model (SZ66)

Andrei Sakharov was a pioneer in hadron physics who took quarks seriously already in 1966. He asked “Why are the Λ and Σ masses different? They are made of the same quarks!” [14]. His answer that the difference arose from a flavor-dependent hyperfine interaction led to relations between meson and baryon masses in surprising agreement with experiment [13]. Sakharov and Zeldovich anticipated QCD by assuming a quark model for hadrons with a flavor dependent linear mass term and hyperfine interaction,

\[ M = \sum_i m_i + \sum_{i>j} \vec{\sigma}_i \cdot \vec{\sigma}_j \cdot v_{ij}^{hyp} \]  

(2.1)

where \( m_i \) is the effective mass of quark \( i \), \( \vec{\sigma}_i \) is a quark spin operator and \( v_{ij}^{hyp} \) is a hyperfine interaction with different strengths but the same flavor dependence for \( qq \) and \( \bar{q}q \) interactions.

Hadron magnetic moments are are described simply by adding the contributions of the moments of these constituent quarks with Dirac magnetic moments having a scale determined by the same effective masses. The model describes low-lying excitations of a complex system with remarkable success.

Sakarov and Zeldovich already in 1966 obtained two relations between meson and baryon masses in remarkable agreement with experiment. Both the mass difference \( m_s - m_u \) between strange and nonstrange quarks and their mass ratio \( m_s/m_u \) have the same values when calculated from baryon masses and meson masses [15,16].

The mass difference between \( s \) and \( u \) quarks calculated in two ways from the linear term in meson and baryon masses showed that it costs exactly the same energy to replace a nonstrange quark by a strange quark in mesons and baryons, when the contribution from the hyperfine interaction is removed.

\[ \langle m_s - m_u \rangle_{Bar} = M_\Lambda - M_N = 177 \text{ MeV} \]  

(2.2)

\[ \langle m_s - m_u \rangle_{mes} = \frac{3(M_{K^*} - M_\rho) + M_K - M_\pi}{4} = 180 \text{ MeV} \]  

(2.3)

4
\begin{align*}
\left( \frac{m_s}{m_u} \right)_{\text{Bar}} &= \frac{M_\Delta - M_N}{M_{\Sigma^*} - M_\Sigma} = 1.53 \\
\left( \frac{m_s}{m_u} \right)_{\text{Mes}} &= \frac{M_\rho - M_\pi}{M_{K^*} - M_K} = 1.61
\end{align*}

Further extension of this approach led to two more relations for \( m_s - m_u \) when calculated from baryon masses and meson masses [17,18], and to three magnetic moment predictions with no free parameters [19,20]

\[ \langle m_s - m_u \rangle_{\text{mes}} = \frac{3M_\rho + M_\pi}{8} \cdot \left( \frac{M_\rho - M_\pi}{M_{K^*} - M_K} - 1 \right) = 178 \]  

\[ \langle m_s - m_u \rangle_{\text{Bar}} = \frac{M_N + M_\Delta}{6} \cdot \left( \frac{M_\Delta - M_N}{M_{\Sigma^*} - M_\Sigma} - 1 \right) = 190. \]

\[ \mu_\Lambda = -0.61 = \frac{\mu_p}{3} \cdot \frac{m_u}{m_s} = \frac{\mu_p}{3} \frac{M_{\Sigma^*} - M_\Sigma}{M_\Delta - M_N} = -0.61 \]

\[ -1.46 = \frac{\mu_p}{\mu_n} = -\frac{3}{2} \]

\[ \mu_p + \mu_n = 0.88 = \frac{M_p}{3m_u} = \frac{2M_p}{M_N + M_\Delta} = 0.865 \]

where masses are given in MeV and magnetic moments in nuclear magnetons.

**B. Problems in going beyond Sakharov-Zeldovich**

These successes and the success of the new relation (1.4) make it difficult to improve on the results of the simple constituent quark model by introducing new physics effects like higher order corrections. Any new effect also introduces new parameters. In order to keep any analysis significant, it is necessary to include large amounts of data in order to keep the total amount of data much larger than the number of parameters.

In contrast to the successes of the simple quark model in magnetic moments and hyperon decay, there are also failures. Pinpointing these failures and comparing them with the successes may offer clues to how to improve the simple picture.
Combining the experimental data for hyperon magnetic moments and semileptonic decays have provided some contradictions for models of hyperon structure. The essential difficulty is expressed in the experimental value of the quantity

\[
\frac{(g_a)_{\Lambda \to p}}{(g_a)_{\Sigma^- \to n}} \cdot \frac{\mu_{\Sigma^+} + 2\mu_{\Sigma^-}}{\mu_\Lambda} = 0.12 \pm 0.04
\] (2.11)

The theoretical prediction for this quantity from the standard SU(6) quark model is unity, and it is very difficult to see how this enormous discrepancy by a factor of $8 \pm 2$ can be fixed in any simple way.

The expression (2.11) is chosen to compare two ways of determining the ratio of the contributions of strange quarks to the spins of the $\Sigma$ and $\Lambda$. In the commonly used notation where $\Delta u(p)$, $\Delta d(p)$ and $\Delta s(p)$ denotes the contributions to the proton spin of the $u$, $d$ and $s$-flavored current quarks and antiquarks respectively to the spin of the proton the SU(6) model gives

\[
\Delta s(\Lambda)_{SU(6)} = 1 \quad (2.12)
\]

\[
\Delta s(\Sigma)_{SU(6)} = -\frac{1}{3} \quad (2.13)
\]

and

\[
\frac{\Delta s(\Sigma)_{SU(6)}}{\Delta s(\Lambda)_{SU(6)}} = \frac{(g_a)_{\Sigma^- \to n}}{(g_a)_{\Lambda \to p}} = \frac{\mu_{\Sigma^+} + 2\mu_{\Sigma^-}}{3\mu_\Lambda} = -\frac{1}{3}
\] (2.14)

whereas experimentally

\[
\frac{(g_a)_{\Sigma^- \to n}}{(g_a)_{\Lambda \to p}} = -0.473 \pm 0.026
\] (2.15)

\[
\frac{\mu_{\Sigma^+} + 2\mu_{\Sigma^-}}{3\mu_\Lambda} = -0.06 \pm 0.02
\] (2.16)

The semileptonic decays give a value which which is too large for the $\Sigma/\Lambda$ ratio; the magnetic moments give a value which is too low. Thus the most obvious corrections to the naive SU(6) quark model do not help. If they fix one ratio, they make the other worse. Furthermore,
the excellent agreement obtained by De Rujula, Georgi and Glashow [19] for \( \mu_\Lambda \) assuming that the strange quark carries the full spin of the \( \Lambda \) suggests that eq. (2.12) is valid, while the excellent agreement of the experimental value \(-0.340 \pm 0.017\) for \((g_\alpha)_{\Sigma^{-} \to n}\) with the prediction \(-(1/3)\) suggests that eq.(2.13) is valid.

The disagreement sharpens the paradox of other disagreements previously discussed because it involves only the properties of the \( \Lambda \) and \( \Sigma \) and does not assume flavor SU(3) symmetry or any relation between states containing different numbers of valence strange quarks. There is also the paradox that the magnetic moment of the \( \Lambda \) fits the value predicted by the naive SU(6) quark model, while the magnetic moments of the \( \Sigma \) are in trouble. In the semileptonic decays it is the opposite. It is the \( \Sigma \) which fits naive SU(6) and both the \( \Lambda \) and the nucleon are in trouble. If one assumes the obvious fix for the semileptonic decays by assuming a difference between constituent quarks and current quarks, one can fit the nucleon and \( \Lambda \) decays but then the \( \Sigma \) is in trouble.

The magnetic moments thus seem to indicate that the contribution of the strange quark to the spin of the \( \Sigma \) is smaller than any reasonable model can explain, when the scale is determined by the \( \Lambda \) moment. This result is far more general than the simple naive SU(6) quark model. But the new relation (1.4) between the \( \Sigma^+ \) and \( \Xi^o \) moments seems to indicate that the strange quark contributions to these moments are the same.

III. SEMILEPTONIC DECAYS

We now consider the semileptonic weak decays and begin by comparing the available data [21] for four semileptonic decays with several theoretical predictions. The \( \Xi^o \to \Sigma^+ \) decay considered above and equal to the neutron decay is omitted here.
TABLE 1. Theoretical Predictions and Experimental Values of $G_A/G_V$

| DECAY     | Simple $SU(6)$ | Constituent $SU(6)$ | Experiment |
|-----------|----------------|---------------------|------------|
| $n \rightarrow p$ | $5/3$ | $input$ | $input$ | $1.261 \pm 0.004$ |
| $\Lambda \rightarrow p$ | $1$ | $0.756 \pm 0.003$ | $0.727 \pm 0.007$ | $0.718 \pm 0.015$ |
| $\Xi^- \rightarrow \Lambda$ | $1/3$ | $0.252 \pm 0.001$ | $0.193 \pm 0.012$ | $0.25 \pm 0.05$ |
| $\Sigma^- \rightarrow n$ | $-1/3$ | $0.252 \pm 0.001$ | $input$ | $-0.340 \pm 0.017$ |
| $\Sigma^- \rightarrow n_{\Lambda \rightarrow p}$ | $-1/3$ | $-1/3$ | $noprediction$ | $-0.473 \pm 0.026$ |

The nucleon and $\Lambda$ data are seen to be in strong disagreement with simple $SU(6)$ but are smaller by about the same factor of about $5/4$. Thus they are both fit reasonably well by the $SU(6)$ constituent quark model which fixes $G_A/G_V$ for the constituent quark to fit the nucleon decay data and reduces the other simple $SU(6)$ predictions by the same factor. But the $\Sigma$ data agree with simple $SU(6)$ and therefore disagree with constituent $SU(6)$. The $SU(3)$ analysis fixes its two free parameters by using the nucleon and $\Sigma$ decays as input; its predictions for the $\Lambda$ and $\Xi$ fit the experimental data within two standard deviations. However the error on the $\Xi$ data is considerably larger than the other errors, and all three predictions fit the $\Xi$ data within two standard deviations. Thus the significance of this fit can be questioned.

Our $SU(3)$ fit deals directly with observable quantities rather than introducing $D$ and $F$ parameters not directly related to physical observables. This makes both the underlying physics and the role of experimental errors much more transparent. The neutron decay which has the smallest experimental error fixes one of the two free parameters. The $\Sigma^-$ decay provides the smallest error in fixing the remaining parameter, the spacing between
successive entries in Table I, required to be equal by the SU(3) “equal spacing rule” [22]. The success of this procedure is evident since the errors on the predictions introduced by using these two decays as input are much smaller than the experimental errors on the remaining decays.

The contrast between the good SU(6) fit of the Σ and the bad SU(6) fit of the others may give some clues to the structure of these baryons. The Σ data rule out the constituent SU(6) model which otherwise seems attractive as it preserves all the good SU(6) results for strong and electromagnetic properties at the price of simply renormalizing the axial vector couplings to constituent quarks. Any success of SU(3) remains a puzzle since no reasonable quark model has been proposed which breaks SU(6) without breaking SU(3).

IV. THE SPIN STRUCTURE OF BARYONS

A. Results from DIS experiments

Surprising conclusions about proton spin structure have arisen from an analysis [23] combining data from polarized deep inelastic electron scattering and weak baryon decays.

Polarized deep inelastic scattering (DIS) experiments provided high quality data for the spin structure functions of the proton, deuteron and neutron [24]-[30]. The first moments of the spin dependent structure functions can be interpreted in terms of the contributions of the quark spins ($\Delta \Sigma = \Delta u + \Delta d + \Delta s$) to the total spin of the nucleon. The early EMC results [24] were very surprising, implying that $\Delta \Sigma$ is rather small (about 10%) and that the strange sea is strongly polarized. More recent analyses [25,26], incorporating higher-order QCD corrections, together with most recent data, suggest that $\Delta \Sigma$ is significantly larger, but still less than $1/3$ of nucleon’s helicity, $\Delta \Sigma \approx 0.24 \pm 0.04$ and $\Delta s = -0.12 \pm 0.03$.

Conventional analyses to determine the quark contributions to the proton spin, commonly denoted by $\Delta u$, $\Delta d$ and $\Delta s$, use use three experimental quantities. The connection between two to proton spin structure is reasonably clear and well established. The third is
obtained from hyperon weak decay data rather than nucleon data via SU(3) flavor symmetry relations and its use has been challenged.

B. How should SU(3) be used in analyzing hyperon decays and relating data to baryon spin structure?

We first note that the Bjorken sum rule together with isospin tell us that the neutron weak decay constant

$$g_A(n \to p) = \Delta u(p) - \Delta d(p) = 1.261 \pm 0.004$$  \hspace{1cm} (4.1)

and that

$$\Delta u(p) - \Delta d(p) = \Delta d(n) - \Delta u(n) = 1.261 \pm 0.004$$  \hspace{1cm} (4.2)

Its SU(3) rotations give

$$g_A(\Sigma^- \to n) = \Delta u(n) - \Delta s(n) = -0.340 \pm 0.017$$  \hspace{1cm} (4.3)

and

$$\Delta u(n) - \Delta s(n) = \Delta d(p) - \Delta s(p) =$$

$$= \Delta s(\Sigma^-) - \Delta u(\Sigma^-) = -0.340 \pm 0.017$$  \hspace{1cm} (4.4)

as well as the prediction now satisfied by experiment

$$g_A(\Xi^o \to \Sigma^+) = \Delta s(\Xi^o) - \Delta u(\Xi^o) =$$

$$= g_A(n \to p) = 1.261 \pm 0.004$$  \hspace{1cm} (4.5)

The two independent linear combinations of $\Delta u(p)$, $\Delta d(p)$ and $\Delta s(p)$ obtained directly from the data without any assumptions about the $D$ and $F$ couplings commonly used can be combined to project out isoscalar component of eq.(4.2) and eq.(4.4),

$$\Delta u + \Delta d - 2\Delta s = g_A(n \to p) + 2g_A(\Sigma^- \to n) =$$

$$= 0.58 \pm 0.03$$  \hspace{1cm} (4.6)
The commonly used procedure to determine these two linear combinations includes the data for the $\Lambda \rightarrow p$ and $\Xi^{-} \rightarrow \Lambda$ decays, which do not directly determine any linear combination of but require an additional parameter, the $D/F$ ratio to give these quantities. Thus the standard procedure uses includes two more pieces of data at the price of an additional free parameter. Since the $\Xi^{-} \rightarrow \Lambda$ decay has a much larger error than all the other decays, there seems to be little point in introducing the D/F ratio.

C. How does SU(3) symmetry relate the valence and sea quarks in the octet baryons

We first note the following relations between the baryon spin structures following from SU(3) Symmetry

\[
\Delta u(p) = \Delta d(n) = \Delta u(\Sigma^+) = \Delta d(\Sigma^-) = \\
= \Delta s(\Xi^o) = \Delta s(\Xi^-) \tag{4.7}
\]

\[
\Delta d(p) = \Delta u(n) = \Delta s(\Sigma^+) = \Delta s(\Sigma^-) = \\
= \Delta s(\Sigma^o) = \Delta u(\Xi^o) = \Delta d(\Xi^-) \tag{4.8}
\]

\[
\Delta s(p) = \Delta s(n) = \Delta d(\Sigma^+) = \Delta u(\Sigma^-) = \\
= \Delta d(\Xi^o) = \Delta u(\Xi^-) \tag{4.9}
\]

\[
\Delta u(\Sigma^o) = \Delta d(\Sigma^o) = (1/2) \cdot [\Delta u(\Sigma^+) + \Delta d(\Sigma^+)] \tag{4.10}
\]

\[
\Delta q(\Sigma^o) + \Delta q(\Lambda) = (2/3) \cdot [\Delta u(n) + \Delta d(n) + \Delta s(n)] \tag{4.11}
\]

These relations allow all the baryon spin structures to be obtained from the values of $\Delta u(n)$, $\Delta d(n)$ and $\Delta s(n)$

However, we know that SU(3) symmetry is badly broken. This can be seen easily by noting that all these SU(3) relations apply separately to the valence quark and sea quark spin contributions. Thus SU(3) requires that the sea contributions satisfy eq.(4.4).
Since the strange contribution of the sea in the proton is known experimentally to be suppressed \cite{31}, this suggests that the strange sea in the Σ must be enhanced. This simply does not make sense in any picture where SU(3) is broken by the large mass of the strange quark. We are therefore led naturally to a model in which SU(3) symmetry holds for the valence quarks and is badly broken in the sea while the sea is the same for all octet baryons, is a spectator in weak decays and does not contribute to the magnetic moments. The sea thus does not contribute to the coupling of the photon or the charged weak currents to the nucleon. The one place where the sea contribution is crucial is in the DIS experiments, which measure the coupling of the neutral axial current to the nucleon.

The Bjorken sum rule and its SU(3) rotations relate the weak decays to the spin contributions of the active quarks to the baryon, without separating them into valence and sea contributions. The effects of the flavor symmetry breaking in the sea can be avoided by assuming that the flavor symmetry is exact for the algebra of currents, but the the hadron wave functions are not good SU(3) states but are broken in the sea. In this way one can obtain relations for the differences between spin contributions in which the sea contribution cancels out if the sea is the same for all octet baryons, even if SU(3) is broken in the sea.

V. WHERE IS THE PHYSICS? WHAT CAN WE LEARN?

A. How is SU(3) broken?

We now examine the underlying physics of some of these decays in more detail. The weak decays measure charged current matrix elements, in contrast to the EMC experiment which measures neutral current matrix elements related directly via the Bjorken sum rule to $\Delta u(p)$, $\Delta d(p)$ and $\Delta s(p)$. The charged and neutral current matrix elements have been related by the use of symmetry assumptions whose validity has been questioned \cite{32,33}.

We now examine the $\Sigma^- \to n$ decay and see how SU(3) breaking affects the relations

$$g_A(\Sigma^- \to n) = \Delta u(n) - \Delta s(n) = \Delta d(p) - \Delta s(p)$$  \hspace{1cm} (5.1)
\[ \Delta s(\Sigma^-) - \Delta u(\Sigma^-) = \Delta d(p) - \Delta s(p) \]  

(5.2)

\[ |G_V(\Sigma^- \rightarrow n)| = |G_V(n \rightarrow p)| \]  

(5.3)

The quantity denoted by \( g_A \) is a ratio of axial-vector and vector matrix elements. Although only the axial matrix element is relevant to the spin structure, breaking SU(3) in the baryon wave functions breaks both the relations between axial and vector couplings, as well as those from CVC for strangeness changing currents. Serious constraints on possible SU(3) breaking in the baryon wave functions are placed by the known agreement with Cabibbo theory of experimental vector matrix elements, uniquely determined in the SU(3) symmetry limit. On the other hand, the strange quark contribution to the proton sea is already known from experiment to be reduced roughly by a factor of two from that of a flavor-symmetric sea \[31\], due to the effect the strange quark mass. This suppression is expected to violate the \( \Sigma^- \leftrightarrow n \) mirror symmetry, since it is hardly likely that the strange sea should be enhanced by a factor of two in the \( \Sigma^- \). Yet Cabibbo theory requires retaining the relation between the vector matrix elements eq.(5.3).

**B. A model which breaks SU(3) only in the sea**

We now move to the discussion of the model described above mechanism for breaking SU(3) \[34\] which keeps all the good results of Cabibbo theory like eq.(5.3) by introducing a baryon wave function

\[ |B_{phys}\rangle = |B_{bare} \cdot \phi_{sea}(Q = 0)\rangle \]  

(5.4)

where \( |B_{bare}\rangle \) denotes a valence quark wave function which is an SU(3) octet satisfying the condition eq.(5.3) and \( \phi_{sea}(Q = 0) \) denotes a sea with zero electric charge which may be flavor asymmetric but is the same for all baryons. The wave function eq.(5.4) is shown \[3\] to satisfy eq.(5.3) and to give all charged current matrix elements by the valence quark component. This provides an explicit justification for the hand-waving argument \[34\] that the sea behaves as a spectator in hyperon decays.
Unlike the charged current, the matrix elements of the neutral components of the weak currents do have sea contributions, and these contributions are observed in the DIS experiments. The SU(3) symmetry relations eqs.(4.7-4.11) are no longer valid. However, the weaker relation obtained from current algebra [35] still holds.

\[
g_A(\Sigma^- \to n) = \frac{\langle n | \Delta u - \Delta s | n \rangle - \langle \Sigma^- | \Delta u - \Delta s | \Sigma^- \rangle}{2} \quad (5.5)
\]

SU(3) says

\[
\langle \Xi^o | \Delta s - \Delta u | \Xi^o \rangle = \langle p | \Delta u - \Delta d | p \rangle \quad (5.6)
\]

If the strange sea is suppressed, this is clearly wrong. However, Current Algebra relations require only that

\[
\langle \Xi^o | \Delta s - \Delta u | \Xi^o \rangle + \langle \Sigma^+ | \Delta u - \Delta s | \Sigma^+ \rangle = \\
= \langle p | \Delta u - \Delta d | p \rangle + \langle n | \Delta d - \Delta u | n \rangle \quad (5.7)
\]

This is immune to strange sea suppression in all baryons.

C. Getting \( \Delta u, \Delta d \) and \( \Delta s \) From Data

Breaking up the quark contributions into valence and sea contributions becomes necessary to treat SU(3) breaking and the suppression of the strange sea. Two ways of doing this have been considered [3], one using hyperon decay data and the other using the ratio of the proton and neutron magnetic moments.

What is particularly interesting is that each of the two approaches makes assumptions that can be questioned, but that although these assumptions are qualitatively very different, both give very similar results. The use of hyperon data requires a symmetry assumption between nucleon and hyperon wave functions, which is not needed for the magnetic moment method. But the use of magnetic moments requires that the sea contribution to the magnetic moments be negligible, which is not needed for the hyperon decay method.
VI. CONCLUSIONS

The question how flavor symmetry is broken remains open. Model builders must keep track of how proposed SU(3) symmetry breaking effects affect the good Cabibbo results for hyperon decays confirmed by experiment. The observed violation of the Gottfried sum rule remains to be clarified, along with the experimental question of whether this violation of $\bar{u} - \bar{d}$ flavor symmetry in the nucleon exists for polarized as well as for unpolarized structure functions. The question of how SU(3) symmetry is broken in the baryon octet can be clarified by experimental measurements of Λ polarization in various ongoing experiments.

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