Expected Polarization of Λ particles produced in deep inelastic polarized lepton scattering†

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Abstract

We calculate the polarization of Λ and Λ particles produced in deep inelastic polarized lepton scattering. We use two models: the naïve quark model and a model in which SU(3)_F symmetry is used to deduce the spin structure of SU(3) octet hyperons from that of the proton. We perform the calculations for Λ and Λ produced directly or as decay products of Σ⁰ and Σ*.

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The spin structure function of the nucleon has been studied extensively during the past several years. Very different experimental systems utilizing polarized muon \([1]\), electron \([2]\) and positron \([3]\) beams and covering different kinematic regions obtained results which are consistent with each other. This effort led to precise measurements of the nucleon spin structure functions \(g^N_1(x)\) (\(N = n,p\)) and their integrals \(\Gamma^N_1 = \int g^N_1(x)dx\). Here \(x \equiv x_{Bj} = Q^2/2M\nu\) is the Bjorken scaling variable, \(-Q^2\) is the four-momentum transfer to the target nucleon squared, \(\nu\) is the energy loss of the lepton in the laboratory frame, and \(M\) is the nucleon mass. The interpretation of these results is that quarks in the nucleon carry only \(\sim 30\%\) of the nucleon spin and that the strange (and non-strange) sea is polarized opposite to the polarization of the valence quarks. This interpretation leads to the question of where is the rest of the nucleon spin is coming from which will not be addressed here. Other open questions are: 1) how sensitive are the conclusions to the SU(3) symmetry assumed in the process of interpretation of the experimental data? 2) what is the mechanism that polarizes the strange sea? 3) how well do we understand the spin structure of other hadrons? 4) are the quarks and antiquarks in the sea equally polarized?

These questions may be addressed through measurement of the polarization of \(\Lambda\) and \(\bar{\Lambda}\) produced in polarized lepton Deep Inelastic Scattering (pDIS) on unpolarized targets. Having the strange quark as valence rather than sea quark, the polarization of \(\Lambda\) particles is sensitive to its contribution to the \(\Lambda\) spin. By measurements of both \(\Lambda\) and \(\bar{\Lambda}\) polarisation both \(s\) and \(\bar{s}\) roles can be studied. Recently some experimental results became available \([4]\) and more are expected in the future \([4, 5]\). As an illustration, a simple mechanism that can produce \(\Lambda\) polarization in pDIS is when the polarized virtual photon is absorbed by a strange quark in the target nucleon sea. The struck quark emerges with helicity in the direction of that of the photon. When it hadronizes into a \(\Lambda\) (in the current fragmentation region), it is likely to become a valence quark in the \(\Lambda\) and the naïve quark model predicts that the polarization of the \(\Lambda\) will be the same as that of the strange quark. An experiment that can probe the low \(x_{Bj}\) region will have a significant fraction of the \(\Lambda\) and \(\bar{\Lambda}\) originating from this mechanism and will have sensitivity to the strange sea in the target nucleon. The transfer of polarization from the beam to the produced \(\Lambda\) and \(\bar{\Lambda}\) is controlled by their helicity difference fragmentation functions \(\Delta \hat{q}\) \([6]\). In recent measurements at LEP \(\Delta \hat{q}\) was measured from \(\Lambda\) polarization near the \(Z\) pole and was found to be consistent with the naïve quark model expectations \([4, 5]\). It is not unreasonable, therefore, to expect that in the current fragmentation region of pDIS the polarization will follow the same expectations. An alternative approach is presented in \([3]\) where SU(3)\(_F\) symmetry is assumed and the spin structure of SU(3) octet hyperons is deduced from that of the proton. Other mechanisms exist and are discussed in \([4, 5, 11, 12]\).
A difficulty present in most experiments is that they cannot distinguish between $\Lambda$ and $\bar{\Lambda}$ produced directly from hadronization of a struck quark or as decay products. The main contributions from decays are the $\Sigma^0 \to \Lambda \gamma$ and $\Sigma^* \to \Lambda \pi$. The purpose of the present work is to calculate the expected polarization of $\Lambda$ and $\bar{\Lambda}$ produced directly or as decay products. The relative amount of each component depends on the experimental conditions. We carry out the calculations using two models. One is the naïve quark model where all baryons are three-quark states with wave functions having zero orbital angular momentum and all the spin of the baryon comes from quark spins. In the other, which we will refer to as the SU(3)$_F$ symmetry model, the spin structure of SU(3) octet hyperons can be deduced from that of the proton [6]. As we show, introduction of SU(3)$_F$ symmetry breaking does not affect the calculated $\Lambda$ polarization. In both models we calculate the polarization of $\Lambda$ and $\bar{\Lambda}$ produced directly or as decay products. Earlier calculations ignored the $\Lambda$ and $\bar{\Lambda}$ produced as decay products except for [13] where their polarization is calculated for the naïve quark model only.

The inclusion of the contribution of $\Lambda$’s produced in $\Sigma^*$ decay has been questioned because the quark-gluon fragmentation process should already include the production and decay via strong interactions of the $\Sigma^*$. Clearly the $\Sigma^*$ intermediate state must be already included in any fragmentation function which takes into account all strong interactions in the description of a process in which a struck quark turns into a $\Lambda$ plus anything else. But a precise value for such a fragmentation function must also include the precise value of small quantities like the $\Lambda - \Sigma$ mass difference, calculated from first principles, in order to take into account the effect of this mass difference on the relative branching ratios of the $\Sigma^*$ into different final states. Such fragmentation functions are not available at this time and there is some question whether they will ever be realistically available.

The existing Monte Carlo programs for producing such fragmentation functions do not go into such details and rely instead on a number of free parameters which are adjusted to fit vast quantities of data. These give separately the numbers of $\Lambda$’s produced directly and those via decay of $\Sigma^*$’s. We therefore use these Monte Carlo calculations and consider the two contributions separately. The $\Sigma^0$ decays electromagnetically. Its decay is never included in any strong interaction fragmentation function and the $\Lambda$’s produced via its production and decay must be considered separately in all fragmentation models. We note that the measured results of $\Lambda$ polarization at the Z pole [7] were reproduced by Monte Carlo simulations which included a contribution from $\Sigma^*$ decay of about 8% out of a total of 39%.
We are interested in describing the process in which a polarized struck quark $q$ with spin projection $m = +1/2$ picks up two quarks with two other flavors and fragments into a baryon denoted by $B$ with spin projection $M$ and valence quark constituents (uds). The baryon $B$ is either a $\Lambda$, or it is a $\Sigma^0$ or $\Sigma^*$ which decays into a $\Lambda$. We wish to calculate the polarization of this $\Lambda$. Antiquarks and antibaryons are handled in the same way.

Our basic assumptions are:

1. The polarization of the struck quark is maintained during the fragmentation process.
2. All polarization states of the additional two quarks are equally probable.
3. The relative amounts of $\Lambda$, $\Sigma^0$ and $\Sigma^*$ are changed during the fragmentation process. They cannot be calculated from theory, but are determined by some Monte Carlo model of the fragmentation process [4, 7, 8, 13, 14].
4. The relative amounts of the different $M$ states of the same baryon are maintained during the fragmentation process, which is rotationally invariant and is not correlated with the direction of the incident beam.
5. The measured $\Lambda$ polarization is obtained by averaging the polarization obtained for a given process over all the $M$ states relevant to this process.

In performing calculations with angular momentum algebra and Clebsch-Gordan coefficients, one must note that the coefficients for a given $M$ state give the relative probabilities for producing a $\Lambda$, $\Sigma^0$ or $\Sigma^*$ in this $M$ state and the sum of these probabilities is normalized to unity. However, these relative probabilities are not relevant to the experimental results because of the differences in fragmentation. The relative probabilities of producing different $M$ states of the same baryon can be calculated using these same Clebsch-Gordan coefficients, because the different $M$ states of the extra two quarks are equally populated. However these relative probabilities are not normalized to unity and must be explicitly normalized.

With these assumptions the calculation of the $\Lambda$ polarization is straightforward if we know the wave function of the $\Lambda$ or have sufficient spin information on its spin structure. In the simple quark model the spin wave function is given. However, we know from deep inelastic scattering that the simple quark model does not adequately explain the spin structure of the proton. The question then arises how information on the spin structure of the $\Lambda$ can enable us to go beyond the simple quark model.

We first consider the probabilities that a struck quark $q$ with spin up, denoted by $q \uparrow$, will fragment into a spin-1/2 Baryon with spin up or spin down, denoted
respectively by $B \uparrow$ and $B \downarrow$. The ratio of these probabilities under the above assumptions is

$$\frac{W(q \uparrow \rightarrow B \uparrow)}{W(q \uparrow \rightarrow B \downarrow)} = \frac{q \uparrow (B \uparrow)}{q \uparrow (B \downarrow)} = \frac{q \uparrow (B \uparrow)}{q \downarrow (B \uparrow)}$$

(1)

where $q \uparrow (B \uparrow)$ and $q \uparrow (B \downarrow)$ denote the distribution of quark $q$ with spin up in a baryon $B$ with spin up and spin down respectively. We have used rotational invariance to obtain the last equality.

The polarization of a baryon from a polarized struck quark $q$ is then given by

$$P(q \uparrow \rightarrow B) = \frac{W(q \uparrow \rightarrow B \uparrow) - W(q \uparrow \rightarrow B \downarrow)}{W(q \uparrow \rightarrow B \uparrow) + W(q \uparrow \rightarrow B \downarrow)} = \frac{q \uparrow (B \uparrow) - q \downarrow (B \uparrow)}{q \uparrow (B) + q \downarrow (B)}$$

(2)

This can be rewritten in terms of the conventional notation for the contribution of quark $q$ to the spin of baryon $B$, $\Delta q(B)$.

$$P(q \uparrow \rightarrow B) = \frac{\Delta q(B)}{q \uparrow (B) + q \downarrow (B)}$$

(3)

Expression (3) illustrates the main problems in going beyond the simple quark model to obtain the $\Lambda$ polarization. First one needs to know the contribution of the quark $q$ to the spin of the $\Lambda$. This is not known directly and needs a symmetry or model to use the measured values for the proton to obtain the information on the $\Lambda$. A more serious difficulty is the normalization factor which is the total number of quarks of flavor $q$ in the $\Lambda$. This is trivial for the valence quarks but is completely unknown for the sea quarks.

We now consider the process in which a polarized struck quark $q$ with spin projection $m = +1/2$ fragment into a $\Lambda$, $\Sigma^o$ or $\Sigma^*$. In the naïve quark model the lowest (uds) states with arbitrary spin couplings are linear combinations of $\Lambda$, $\Sigma^o$ and $\Sigma^*$. The strange quark in the $\Lambda$ carries the full $\Lambda$ polarization and the nonstrange quarks are coupled to spin zero. The $\Sigma^o$ and $\Sigma^*$ both decay into a $\Lambda$ and we are interested in the polarization of the $\Lambda$'s produced in all three ways. In both the $\Sigma^o \rightarrow \Lambda \gamma$ and the $\Sigma^* \rightarrow \Lambda \pi$ decays, the nonstrange diquark emits the boson in a $J=1$ state and changes its spin from one to zero, while the strange quark is a spectator and its polarization is unchanged. Thus in the simple quark model the $\Lambda$ polarization is the same as the strange quark polarization for all three baryons. In the general case the polarization of the $\Lambda$ from decay is still determined by the angular momentum couplings in the decays and must therefore give the same result for any model. The value of the polarization for any model is thus:

$$P_\Lambda (B, M) = P_s(B, M) = 2M \cdot \Delta s(B)_{NQM}$$

(4)
where $\Delta s(B)_{NQM}$ denotes the value of $\Delta s$ given by the naïve quark model for baryon $B$. To obtain the value of the observed polarization it is necessary to average the result \(^{(4)}\) over all relevant $M$ states. Since all $M$ states of the $uds$ system are expected to be produced equally, we need to find the relative probability $W(B,M)_q$ that a given $M$ state of baryon $B$ contains a quark $q$ with $m=+1/2$. This is simply given in terms of the contribution of a quark of flavor $q$ to the total spin of baryon $B$.

$$W(B,M)_q = (1/2) + M \cdot \Delta q(B)$$  \hspace{1cm} (5)

Combining eqs. \((4)\) and \((5)\) and averaging over $M$ then gives

$$P_{\Lambda}(B)_q = P_s(B)_q = \sum_M \frac{M^2 \cdot \Delta s(B)_{NQM} \cdot [M + 2M^2 \cdot \Delta q(B)]}{\sum_M (1/2) + M \cdot \Delta q(B)} = \sum_M \frac{M^2}{2J+1} \cdot \Delta s(B)_{NQM} \cdot \Delta q(B)$$  \hspace{1cm} (6)

where we have noted that $\sum_M M = 0$ and $\sum_M (1/2) = (2J+1)/2$.

For the $\Lambda$ and $\Sigma^o$, with $J=1/2$

$$P_{\Lambda}(B)_q = \Delta s(B)_{NQM} \cdot \Delta q(B)$$  \hspace{1cm} (7)

For the $\Sigma^*$, with $J = 3/2$,

$$P_{\Lambda}(\Sigma^*)_q = 5\Delta s(\Sigma^*)_{NQM} \cdot \Delta q(\Sigma^*)$$  \hspace{1cm} (8)

The naïve quark model values of $\Delta q(B)$ are:

$$\Delta u(\Lambda) = \Delta d(\Lambda) = 0; \quad \Delta s(\Lambda) = 1$$  \hspace{1cm} (9)

$$\Delta u(\Sigma^o) = \Delta d(\Sigma^o) = 2/3; \quad \Delta s(\Sigma^o) = -1/3$$  \hspace{1cm} (10)

$$\Delta u(\Sigma^{*o}) = \Delta d(\Sigma^{*o}) = \Delta s(\Sigma^{*o}) = 1/3$$  \hspace{1cm} (11)

We then obtain for a general model:

$$P_{\Lambda}(\Sigma^*)_{u,d,s} = (5/3) \cdot \Delta q(\Sigma^*)$$  \hspace{1cm} (12)

$$P_{\Lambda}(\Sigma^o)_{u,d,s} = -(1/3) \cdot \Delta q(\Sigma^o)$$ \hspace{1cm} (13)

$$P_{\Lambda}(\Lambda)_{u,d,s} = \Delta q(\Lambda)$$ \hspace{1cm} (14)

We can write the $\Lambda$ polarization as proportional to the polarization of the struck quark $q$: $P_{\Lambda} = c \cdot P_q$. For the naïve quark model which is expected to be
Table 1: The coefficients $c$ in the equation $P_{\Lambda} = c \cdot P_q$ for $q = u,d,s$ derived for the naïve quark model. The parent noted as $q, \bar{q}$ is a fragmentation in which the struck quark does not participate.

| Parent \ struck | u | d | s |
|----------------|---|---|---|
| $q, \bar{q}$  | 0 | 0 | 0 |
| $s$            | 0 | 0 | 1 |
| $\Sigma^0$    | $-\frac{2}{9}$ | $-\frac{2}{9}$ | $\frac{1}{9}$ |
| $\Sigma^*$    | $\frac{5}{9}$ | $\frac{5}{9}$ | $\frac{5}{9}$ |

correct for large $x$ [7, 8], we can use the values cited above. The proportionality coefficients $c$ are summarized in table 1. In the hadronization process the struck quark may hadronize directly to a $\Lambda$, in which case it is also the “Parent”, or it may hadronize to a Hyperon that decays to the $\Lambda$ and then that Hyperon is the parent. It may also happen that a $\Lambda$ was produced without carrying the struck quark at all and in this hadronization the $\Lambda$ is described in the table as having a “$q, \bar{q}$” parent.

An alternative approach is to assume that the spin structure of SU(3) octet hyperons can be deduced from that of the proton as measured in polarized DIS experiments. Now baryons consist of three valence quarks and a sea. In order to get the spin structure of the $\Lambda$, $\Sigma^0$ and $\Sigma^*$ from that of the nucleon we assume that the quark wave functions for the hyperons are obtained from the nucleon wave functions by using SU(3) symmetry. The $\Sigma^*$, which is not member of the octet is treated separately. We follow the notations of [6] defining $\Delta Q = \Delta q + \Delta \bar{q}$. SU(3) symmetry gives the following relations:

$$\Delta U(p) = \Delta D(n) = \Delta U(\Sigma^+) = \Delta D(\Sigma^-) = \Delta S(\Xi^o) = \Delta S(\Xi^-)$$  \hspace{1cm} (15)
$$\Delta D(p) = \Delta U(n) = \Delta S(\Sigma^+) = \Delta S(\Sigma^-) = \Delta S(\Sigma^o) = \Delta U(\Xi^o) = \Delta D(\Xi^-)$$  \hspace{1cm} (16)
$$\Delta S(p) = \Delta S(n) = \Delta D(\Sigma^+) = \Delta U(\Sigma^-) = \Delta D(\Xi^o) = \Delta U(\Xi^-)$$  \hspace{1cm} (17)
$$\Delta U(\Sigma^o) = \Delta D(\Sigma^o) = (1/2) \cdot [\Delta U(\Sigma^+) + \Delta D(\Sigma^+)]$$  \hspace{1cm} (18)
$$\Delta Q(\Sigma^o) + \Delta Q(\Lambda) = (2/3) \cdot [\Delta U(n) + \Delta D(n) + \Delta S(n)]$$  \hspace{1cm} (19)
Table 2: The contributions from quarks and antiquarks to the Baryon Spin Structures from Nucleon Data and SU(3) Symmetry. The values for the proton are taken from reference [2].

| Baryon | $\Delta U$   | $\Delta D$   | $\Delta S$   |
|--------|--------------|--------------|--------------|
| p      | 0.83 ± 0.03  | -0.43 ± 0.03 | -0.10 ± 0.03 |
| n      | -0.43 ± 0.03 | 0.83 ± 0.03  | -0.10 ± 0.03 |
| $\Sigma^+$ | 0.83 ± 0.03  | -0.10 ± 0.03 | -0.43 ± 0.03 |
| $\Sigma^-$ | -0.10 ± 0.03 | 0.83 ± 0.03  | -0.43 ± 0.03 |
| $\Xi^0$ | -0.43 ± 0.03 | -0.10 ± 0.03 | 0.83 ± 0.03  |
| $\Xi^-$ | -0.10 ± 0.03 | -0.43 ± 0.03 | 0.83 ± 0.03  |
| $\Sigma^0$ | 0.37 ± 0.03  | 0.37 ± 0.03  | -0.43 ± 0.03 |
| $\Lambda$ | -0.17 ± 0.03 | -0.17 ± 0.03 | 0.63 ± 0.03  |

These relations allow the values of $\Delta U$, $\Delta D$ and $\Delta S$ for all the octet baryons to be obtained from the values for the proton. The results are summarized in table 2.

Lambda from struck quarks and from $\Sigma^0 \rightarrow \Lambda \gamma$. In DIS the produced $\Lambda$ or $\bar{\Lambda}$ is associated with the photon being absorbed on a quark or antiquark, respectively. The struck quark or antiquark then hadronizes into the $\Lambda$ or $\bar{\Lambda}$ (or another parent hyperon which subsequently decays to a $\Lambda$ or $\bar{\Lambda}$). It is therefore necessary to have the separate contributions from the quarks and antiquarks to the spin structure functions. Following [6] we calculate these values assuming that the sea quark polarization distributions is the same in all the octet members. We then make the calculations assuming that the sea is SU(3) flavor symmetric. For the $\Lambda$ this assumption means: $\Delta s_N = \Delta \bar{s}_N = \Delta \bar{u}_\Lambda = \Delta \bar{d}_\Lambda = \Delta \bar{s}_\Lambda = \ldots$. In particular $\Delta \bar{u}_\Lambda = \Delta \bar{s}_N = \frac{1}{2} \Delta S_N = -0.05 \pm 0.015$. Similarly for $\Sigma^0$. In order to get the contributions from the valence quarks only, the sea $\Delta Q$ are assumed to be $-0.1 \pm 0.03$. By subtracting this value from the total $\Delta Q$ we obtain the value of the valence $\Delta q$ (no antiquarks here). The resulting values for the valence quarks are listed in table 3. An analogous table would have antibaryons and antiquarks replacing the baryons and the quarks.

It is known experimentally that SU(3) symmetry is broken for the sea, the polarized s-quark contribution being suppressed by a factor of 2 compared with that of the non-strange quarks [13]. However, the manner in which the spin constr-
Table 3: The contributions from only quarks to the baryon spin structures assuming the sea is SU(3) symmetric

| Distribution | all quarks       | valence quarks |
|--------------|------------------|----------------|
| $\Delta u_p$ | $0.88 \pm 0.03$  | $0.93 \pm 0.03$ |
| $\Delta d_p$ | $-0.38 \pm 0.03$ | $-0.33 \pm 0.03$ |
| $\Delta s_p$ | $-0.05 \pm 0.03$ | $0.0 \pm 0.03$ |
| $\Delta u_\Lambda$ | $-0.12 \pm 0.03$ | $-0.07 \pm 0.04$ |
| $\Delta d_\Lambda$ | $-0.12 \pm 0.03$ | $-0.07 \pm 0.04$ |
| $\Delta s_\Lambda$ | $0.68 \pm 0.03$  | $0.73 \pm 0.04$ |
| $\Delta u_{\Sigma^0}$ | $0.42 \pm 0.03$  | $0.47 \pm 0.04$ |
| $\Delta d_{\Sigma^0}$ | $0.42 \pm 0.03$  | $0.47 \pm 0.04$ |
| $\Delta s_{\Sigma^0}$ | $-0.38 \pm 0.03$ | $-0.33 \pm 0.04$ |
| $\Delta u_{\Sigma^*}$ | $0.23 \pm 0.02$  | $0.23 \pm 0.02$ |
| $\Delta d_{\Sigma^*}$ | $0.23 \pm 0.02$  | $0.23 \pm 0.02$ |
| $\Delta s_{\Sigma^*}$ | $0.33 \pm 0.04$  | $0.33 \pm 0.04$ |

Contributions are divided between valence and sea quarks is model dependent. We follow the model in which the sea is assumed to be an SU(3) singlet \cite{16}; i.e. that it is not polarized in flavor space by the valence quarks. In this case the sea is the same for all octet baryons and the valence quarks satisfy SU(3) symmetry. Thus equations \cite{13} - \cite{15} also apply only to the valence quarks. In this model the breaking of SU(3) symmetry by suppressing the strange quark contribution to the sea does not affect the valence quarks and the sea is still assumed to be the same for all octet baryons. This assumption is justified in detail in ref. \cite{16}. Consequently, the values listed in table 2 will change but those of table 3 will not. For calculation of the polarization of $\Lambda$ hyperons produced in the current fragmentation region we need only the values of $\Delta q$ for valence quarks as listed in table 3. Thus the results are not sensitive to SU(3) symmetry breaking.

The polarization of the $\Lambda$ and $\bar{\Lambda}$ is now computed according to eq. \cite{3}. For direct $\Lambda$ production the polarization will be equal to the contribution of the struck quark as given in table 3. If the $\Lambda$ is detected with a relatively large $x_F$ it is likely that the struck quark is a valence quark in the $\Lambda$ resulting from its hadronization. For example, if a 100% polarized photon strikes out a $s$-quark, the quark will also be 100% polarized. However, when it hadronizes into a $\Lambda$ there will be contributions from the $u$- and $d$-quarks, the sea and relativistic corrections that will cause the $\Lambda$ polarization to be only about 70%. For $\Lambda$ from
\( \Sigma^0 \rightarrow \Lambda \gamma \) we compute the polarization of the \( \Lambda \) from eq. 7 and table 3. Again, we write \( P_{\Lambda} = c \cdot P_q \) and the proportionality coefficients \( c \) are summarized in table 4.

**\( \Lambda \) from \( \Sigma^* \rightarrow \Lambda \pi \).** In order to get the contributions from the valence quarks of the \( \Sigma^* \) to its spin we cannot use SU(3) symmetry because the \( \Sigma^* \) is not member of the octet. We assume that the contribution from valence quarks of the hyperons is proportional to the contributions expected from the quark model. We therefore relate the quark model expectations for the \( \Sigma^0 \) and \( \Sigma^* \) and use the values for the former from table 3 to calculate the values for the latter. For \( \Sigma^0 \) we have from the quark model: \( \Delta u = \Delta d = \frac{2}{3} \) and \( \Delta s = -\frac{1}{3} \) (eq. 11). For \( \Sigma^* \) we have: \( \Delta u = \Delta d = \Delta s = \frac{1}{3} \) (eq. 11). This gives us ratios of the contributions from \( \Sigma^* \) to those of \( \Sigma^0 \) to be: 0.5, 0.5 and −1.0 for \( \Delta u, \Delta d \) and \( \Delta s \), respectively. Using these ratios and the values for \( \Sigma^0 \) listed in table 3 we calculate the values expected for \( \Sigma^* \). We do not estimate contributions from the sea in the \( \Sigma^* \). The results are listed in table 3. The polarization of \( \Lambda \) from \( \Sigma^* \rightarrow \Lambda \pi \) is computed using eq. 8 and the values of \( \Delta q(\Sigma^*) \) are taken from table 3. The proportionality coefficients \( c \) in \( P_{\Lambda} = c \cdot P_q \) are summarized in table 4.

Table 4: The coefficients \( c \) in the equation \( P_{\Lambda} = c \cdot P_q \) for \( q = u, d, s \) derived using SU(3) symmetry for valence quarks. The parent noted as \( q, \bar{q} \) is a fragmentation in which the struck quark does not participate.

| Parent \ struck | u   | d   | s   |
|----------------|-----|-----|-----|
| \( q, \bar{q} \) | 0   | 0   | 0   |
| \( s \)         | −0.07 | −0.07 | 0.73 |
| \( \Sigma^0 \)  | −0.16 | −0.16 | 0.11 |
| \( \Sigma^* \)  | 0.38  | 0.38  | 0.55 |

As an illustration we present some predictions for the polarization of \( \Lambda \) and \( \bar{\Lambda} \) produced in DIS. We use a Lund Monte Carlo simulation based on LEPTO generator to predict the number of \( \Lambda \) and \( \bar{\Lambda} \) produced either directly or as decay products as a function of \( x_F \). We then use the values presented in tables 3 and 4 to calculate the polarization predicted by the quark model and the SU(3)\(_F\) symmetry model, respectively. The results for \( \Lambda \) are presented in figure 1 showing the contributions from direct production and the two decay modes (Fig. 1a) and comparing the two models (Fig. 1b). The results depend on the Monte Carlo
structure such as the parton distributions and hadronization parameters as well as the particular DIS kinematics. The results in Figure 1 were calculated for the conditions of Fermilab experiment E665 [4]. It also should be noted that all the calculations presented in this work are justified only for the current fragmentation region. Therefore they should not be reliable for low $x_F$ values.

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Figure 1: Polarization of Λ hyperons. (a) Contributions from direct production (dashed line), from decays of Σ^0 (dotted line), of Σ^* (dash-dotted line) and the total polarization (solid line). All are calculated using the naïve quark model. (b) The Λ polarization from all components calculated using the naïve quark model (solid line) and the SU(3) symmetry model (dashed line).