Polarized strangeness in the nucleon

M.G. Sapozhnikov

Laboratory of Particle Physics, Joint Institute for Nuclear Research, P.O. Box 141980, Dubna, Russia

A large violation of the Okubo-Zweig-Iizuka rule was discovered in the annihilation of stopped antiprotons. The explanation of these experimental data is discussed in the framework of the model assumed that the nucleon strange sea quarks are polarized.

1. INTRODUCTION

According to the naive quark models the proton wave function contains just two $u$-quarks and one $d$-quark and the role of the strange quarks in the nucleon seems to be marginal. However there are experimental indications that the $\bar{s}s$ pairs in the nucleon are responsible for the number of non-trivial effects.

It was found that the magnitude of the strange quarks contribution varies for different nucleon matrix elements. Thus, the fraction of the nucleon momentum carried by the strange quarks is not large [1], [2]:

$$P_s = 4.6\% \text{ at } Q^2 = 20 \text{ GeV}^2$$

(1)

The contribution of the strange quarks to the proton electric form factor is also quite small. The HAPPEX Collaboration measurements allow to extract the combinations of strange electric and magnetic form factors at $Q^2 = 0.48 \text{ (GeV/c)}^2$ [3]

$$G^s_E + 0.39G^s_M = 0.023 \pm 0.034(stat) \pm 0.022(syst) \pm 0.026$$

(2)

(the last error is related with uncertainties in the neutron electric form factor).

However the contribution of the strange quarks in the nucleon mass may be substantial, according to the analysis of the $\pi N$ data for evaluation of the nucleon $\sigma$-term [4] it is:

$$m_s < N|\bar{s}s|N > \sim 130 \text{ MeV}$$

(3)

The strange quarks contribution to the nucleon magnetic moment, measured by the SAMPLE Collaboration [5], is not small

$$G^s_M(0.1 \text{ GeV}^2) = (+0.61 \pm 0.17 \pm 0.21 \pm 0.19)\mu_N$$

(4)

(where $\mu_N$ is the nuclear magneton and the last error is due to the uncertainty in the axial form factor $G^Z_A$ of $Z^0$ exchange) with a positive sign contrary to the predictions of many theoretical models.
Moreover, during the past decade the EMC and successor experiments with polarized lepton beams and nucleon targets \cite{6} gave indication that the $\bar{s}s$ pairs in the nucleon are polarized.

\[ \Delta s \equiv \int_0^1 dx[s^+(x) - s^-(x) + \bar{s}^+(x) - \bar{s}^-(x)] = -0.10 \pm 0.02. \tag{5} \]

The minus sign means that the strange quarks and antiquarks are polarized negatively with respect to the direction of the nucleon spin.

Experiments on elastic neutrino scattering \cite{7} have also provided an indication that the intrinsic nucleon strangeness is negatively polarized though within large uncertainties. It was obtained that \( \Delta s = -0.15 \pm 0.07 \).

Recent common analysis \cite{8} of the baryon magnetic moments with the data of the SAMPLE Collaboration \cite{4} leads to the conclusion that the best fit of these data gives \( \Delta s = -0.19 \pm 0.08 \).

The lattice QCD calculations also indicate of negative polarization of strange quarks in proton: \( \Delta s = -0.12 \pm 0.01 \) \cite{9} and \( \Delta s = -0.109 \pm 0.030 \) \cite{10}.

In \cite{11} it was proposed to use the assumption about polarization of nucleon strangeness to explain the large OZI violation seen in different reactions of $\bar{p}p$ annihilation at rest. The model was extended to the reaction $\bar{p}p \rightarrow \Lambda \bar{\Lambda}$ in \cite{12}, where arguments were given on the basis of chiral symmetry that the $s\bar{s}$ pair in the nucleon wave function might be in the $^3P_0$ state. Also the model of \cite{11} was applied in \cite{13} to make predictions for $\Lambda$ longitudinal polarization in the target fragmentation region for deep-inelastic lepton scattering.

The main aim of my talk is to summarize the present status of the polarized strangeness model in view of new experimental facts (for recent developments of the model, see \cite{14}).

2. STRONG VIOLATION OF THE OZI RULE

The OZI rule \cite{15} forbids creation of $s\bar{s}$ mesons in the interaction of non-strange particles. The production of, for instance, $\phi$ meson is allowed only via presence of the light quark component in the $\phi$ wave function. The amount of this component is determined by the deviation of mixing angle of the vector nonet from the ideal mixing angle, for the ideal mixing angle $\phi$ should be a pure $s\bar{s}$ state. The OZI rule predicts that in all hadron reactions the ratio between the cross sections of $\phi$ and $\omega$ production $R(\phi/\omega)$ should be:

\[ R(\phi/\omega) = 4.2 \cdot 10^{-3} f \tag{6} \]

where $f$ is a ratio of phase spaces of the reactions.

This prediction was tested many times in experiments using different hadron beams. The analysis \cite{14} of the experiments collected in the Durham reactions database has shown that in $\pi N$ interactions the weighted average ratio of cross sections of $\phi$ and $\omega$ production at different energies is

\[ \bar{R} = \frac{\sigma(\pi N \rightarrow \phi X)}{\sigma(\pi N \rightarrow \omega X)} = (3.30 \pm 0.34) \cdot 10^{-3} \tag{7} \]

without attempting to make a phase-space correction.
The weighted average ratio of cross sections of $\phi$ and $\omega$ production at different energies in nucleon-nucleon interactions is somewhat higher, but still qualitatively similar to the OZI value (8):

$$\bar{R} = \frac{\sigma(NN \rightarrow \phi X)}{\sigma(NN \rightarrow \omega X)} = (12.78 \pm 0.34) \cdot 10^{-3}$$

(8)

The corresponding value for antiproton annihilation in flight is:

$$\bar{R} = \frac{\sigma(\bar{p}p \rightarrow \phi X)}{\sigma(\bar{p}p \rightarrow \omega X)} = (14.55 \pm 1.92) \cdot 10^{-3}$$

(9)

These experiments indicate that the naive OZI rule for the vector meson production is generally valid within 10% accuracy. This is not so bad for a heuristic model, bearing in mind that the OZI prediction is based only on the value of the mixing angle derived from meson masses, and applied at different energies from 100 MeV till 100 GeV.

From the point of view of theory, it is realized that the OZI rule reflects important feature of the hadron interactions - suppression of the flavor mixing transitions. It reflects the absence of the processes with pure gluonic intermediate states. The value of the flavor mixing is channel-dependent. It is large for the pseudoscalar and scalar channels. For other channels the OZI rule is a nice approximation. As it was discussed in [17], the OZI limit of QCD is a more accurate approximation than the large $N_c$ limit, or the quenched approximation, or the topological expansion ($N_c \rightarrow \infty$ at fixed $N_f/N_c$).

In spite of this solid theoretical background and numerous experimental confirmations there was a surprise when experiments at LEAR (CERN) with stopped antiprotons showed large violations of the OZI rule (for a review, see [16,18,19]). The compilation of the data is shown in Fig. 1 where the ratio $R = (\phi X/\omega X) \cdot 10^3$ of yields for different reactions of $\bar{p}p \rightarrow \phi(\omega)X$ annihilation at rest is shown as a function of the momentum transfer to $\phi$.

![Graph showing the ratio $R = (\phi X/\omega X) \cdot 10^3$ of yields for different reactions of $\bar{p}p \rightarrow \phi(\omega)X$ annihilation at rest as a function of the momentum transfer to $\phi$.]

The solid line corresponds to the prediction of the OZI rule (8).

Fig. 1 demonstrates the following distinctive features revealed by the LEAR experiments:

1) There is an unusually strong deviation from the OZI-rule predictions. Thus in the $\bar{p}p \rightarrow \phi \gamma$ channel, the Crystal Barrel collaboration has found [18, 20] after phase space corrections:

$$R_\gamma = \frac{B(\bar{p}p \rightarrow \phi \gamma)}{B(\bar{p}p \rightarrow \omega \gamma)} = (294 \pm 97) \cdot 10^{-3},$$

(10)

which is about by 70 times larger than the OZI prediction (8).

Another very large apparent violation of the OZI rule was found by the OBELIX and Crystal Barrel collaborations in the $\bar{p} + p \rightarrow \phi(\omega) + \pi$ channel.

For the ratio of the phase space corrected branching ratios the Crystal Barrel measurement [18] in liquid hydrogen gives:

$$R_\pi = \frac{B(\bar{p}p \rightarrow \phi \pi)}{B(\bar{p}p \rightarrow \omega \pi)} = (106 \pm 12) \cdot 10^{-3}$$

(11)

It coincides with the ratio of the annihilation yields measured by the OBELIX Collaboration for annihilation in a liquid-hydrogen target [21]:

$$R_\pi = (114 \pm 10) \cdot 10^{-3}$$

(12)
The ratio $R = \phi X/\omega X \cdot 10^3$ of yields for different reactions of $\bar{p}p \rightarrow \phi(\omega)X$ annihilation at rest as a function of the momentum transfer to $\phi$. The solid line shows the prediction of the OZI rule (6).

The ratios (11) and (12) are about a factor of 30 higher than the OZI rule prediction.

2) The violation of the OZI-rule is not-universal for all annihilation channels of $\phi$ production but mystically occurs only in some of them. For instance, no enhancement of $\phi$ production is observed for the $\phi\omega$ ($R(\phi\omega/\omega\omega) = (19 \pm 7) \cdot 10^{-3}$) or $\phi\rho$ ($R(\phi\rho/\omega\rho) = (6.3 \pm 1.6) \cdot 10^{-3}$) channels.

3) There is a strong dependence of the OZI-rule violation on the quantum numbers of the initial $\bar{p}p$ state. It was clearly demonstrated by the OBELIX collaborations results:

$$\begin{align*}
R_\pi(\phi/\omega, 3S_1) &= (120 \pm 12) \cdot 10^{-3}, \\
R_\pi(\phi/\omega, 1P_1) &< 7.2 \cdot 10^{-3} \quad \text{with 95\% CL}
\end{align*}$$

4) There is a serious indication that the degree of the OZI rule violation depends on the momentum transfer.

To explain the huge violation of the OZI rule in the annihilation of stopped antiprotons and its strong dependence on the spin of the initial state, the model based on a nucleon wave function containing negatively polarized $s\bar{s}$ pairs was proposed [11].

The model claims that the observed OZI violation is only apparent because in these processes the $s\bar{s}$ meson is created via connected diagrams with participation of intrinsic
nucleon strange quarks. The strong dependence on the initial quantum numbers is due to polarization of the strange sea. Let us discuss these assumptions in more details.

3. Polarized strangeness model

Let us consider the production of $\bar{s}s$ strangeonia in $NN$ or $\bar{N}N$ interactions assuming that the nucleon wave function contains an admixture of $\bar{s}s$ pairs which are polarized negatively with respect to the direction of the nucleon spin.

Due to the interaction it is possible that these pairs could be shaken-out from the nucleon or strange quarks from different nucleons could participate in some rearrangement process similar to one shown in Fig. 2. Let us assume further that the quantum numbers of the $\bar{s}s$ pair is $J^{PC} = 0^{++}$ (later we will explain this choice).

![Figure 2. Production of the $\bar{s}s$ mesons in $NN$ interaction from the spin-triplet (a) and spin-singlet (b) states. The arrows show the direction of spins of the nucleons and strange quarks.](image)

Then the shake-out of such pairs will not create $\phi$ or tensor $f_2'(1525)$ meson, but a scalar strangeonium. The $\bar{s}s$ systems with other quantum numbers (like $\phi$ or $f_2'(1525)$) should produce due to the process where strange quarks from both nucleons are participating.

An example of this rearrangement diagram is shown in Fig. 2. If the nucleon spins are parallel (Fig. 2a), then the spins of the $\bar{s}$ and $s$ quarks in both nucleons are also parallel. If the polarization of the strange quarks does not change during the interaction, then the $\bar{s}$ and $s$ quarks will have parallel spins in the final state. The total spin of $\bar{s}s$ quarks will be $S = 1$ and if their relative orbital momentum is $L = 0$, it means that the strangeonium has the $\phi$ quantum numbers, if $L = 1$, it will correspond to the creation of tensor strangeonium, $f_2'(1525)$.

If the initial $NN$ state is a spin-singlet, the spins of strange quarks in different nucleons are antiparallel and the rearrangement diagrams like that in Fig. 2b may lead to the preferential formation of the $\bar{s}s$ system with total spin $S = 0$. It means that for $L = 0$
one should expect an additional production of strangeonia with the pseudoscalar quantum numbers $0^-$. There are two important aspects of this scheme: the choice of the quantum number of the $\bar{s}s$ pair in the nucleon and notion that it is just rearrangement rather than shake-out processes are responsible for the $\bar{s}s$ mesons production.

In principle there are different possibilities for the quantum numbers of the $\bar{s}s$ component in the nucleon wave function. It may have, for instance, pseudoscalar quantum numbers $J^{PC} = 0^-\pi$ or vector $J^{PC} = 1^{--}$ ones. Then the relative angular momentum $j$ between the $\bar{s}s$ and $uud$ cluster with $J^P = 1/2^+$ should be $j = 1$. However, it is also possible that the $\bar{s}s$ pair has quantum numbers of the vacuum $J^{PC} = 0^{++}$, then $j = 0$ to provide quantum numbers of proton. It is up to the experiment to determine which of these possibilities are realized in nature.

If the nucleon $\bar{s}s$ pair has quantum numbers of $\phi$-meson it will lead to serious problems. In this case one might expect some additional $\phi$ production due to the strangeness, stored in the nucleon. This quasi-$\phi$ pair could be easily shaken-out from the nucleon. Then it is not clear how to explain the strong dependence of the $\phi$ yield on quantum numbers of both nucleons, observed at LEAR experiments.

Moreover, the shake-out of the $\phi$’s stored in the nucleon should lead to an apparent violation of the OZI rule in all reactions of the $\phi$ production.

Similar arguments were provided in [22], where it was demonstrated that the experimental data on the production of $\eta$ and $\eta'$ mesons exclude the $0^-\pi$ quantum numbers for the $\bar{s}s$ admixture in the nucleon wave function.

In [12] it was argued that the strange nucleon sea may be negatively polarized due to the interaction of the light valence quarks with the QCD vacuum. Due to the chiral dynamics the interaction between quarks and antiquarks is most strong in the pseudoscalar $J^{PC} = 0^-\pi$ sector. This strong attraction in the spin–singlet pseudoscalar channel between light valence quark from the proton wave function and a strange antiquark from the QCD vacuum will result in the spin of the strange antiquark which will be aligned opposite to the spin of the light quark (and, finally, opposite to the proton spin). As strange antiquark comes from the vacuum, the corresponding strange quark to preserve the vacuum quantum numbers $J^{PC} = 0^{++}$ should also be aligned opposite to the nucleon spin.

From the QCD sum rules analysis [23], [24] it is known that the condensate of the strange quarks in the vacuum is not small and is comparable with the condensate of the light quarks:

$$<0|\bar{s}s|0> = (0.8 \pm 0.1) <0|\bar{q}q|0>, \quad q = (u,d)$$  \hspace{1cm} (15)

Thus, the density of $\bar{s}s$ pairs in the QCD vacuum is quite high and one may expect that the effects of the polarized strange quarks in the nucleon will be also non-negligible.

Therefore, we arrive to the picture of the negatively polarized $\bar{s}s$ pair with the vacuum quantum numbers $3P_0$. These strange quarks should not be considered like constituent quarks formed some five quarks configuration of the nucleon. Rather they are included in the components of a constituent quark. It is important to stress that the $\bar{s}s$ pair with the $3P_0$ quantum numbers itself is not polarized being a scalar. That is a chiral non-perturbative interaction which selects only one projection of the total spin of the $\bar{s}s$ pair on the direction of the nucleon spin.
Since the quantum numbers of the $\bar{s}s$ pair in nucleon are fixed to be $^3P_0$, it is clear that the shake-out of this state is not relevant for the $\phi$ meson production. The rearrangement diagrams like those in Fig. 2 are responsible for an additional source of $\phi$ production. So on top of the $\phi$ production via standard reaction of mixing with light quarks there is an additional source of $\bar{s}s$ meson production due to intrinsic nucleon strangeness. The rearrangement nature of this mechanism implies that two nucleon should participate in it. This means a dependence on quantum numbers of both nucleons as well as appearance of some minimal momentum transfer from which this additional mechanism becomes important.

It explains the $Q^2$ dependence of ratio $R = \phi X/\omega X$ for different reactions of $\bar{p}p \to \phi(\omega)X$ annihilation at rest shown in Fig. 1. Indeed, the largest OZI-violation has been observed for the reactions with the largest momentum transfer to $\phi$. That is Pontecorvo reaction $\bar{p}d \to \phi n$ and $\bar{p}p \to \phi\gamma, \phi\pi$ processes. The kinematics of antiproton annihilation at rest restricts the variation of momentum transfer. It is important to study the dependence of the violation of OZI rule on momentum transfer directly for annihilation in flight.

The rearrangement nature of additional $\phi$ production allows to make some interesting prediction concerning annihilation into the $\phi\eta$ final state. This channel was measured by the OBELIX collaboration [25] for the $\bar{p}p$ annihilation at rest in liquid hydrogen, gas at NTP and at low pressure of 5 mbar. The $\phi\eta$ final state has the same $J^{PC}$ as the $\phi\pi^0$ final state. So, one may expect to see the same selection rule as eqs. (13)-(14) and suppose that the $\phi$ production in the low pressure sample will be suppressed. However, absolutely unexpectedly, the reverse trend is seen: the yield of the $\bar{p}p \to \phi\eta$ channel grows with decreasing of the target density. The branching ratio for annihilation from the $^1P_1$ state turns out to be by 10 times higher than that of the $^3S_1$ state:

\begin{align}
B(\bar{p}p \to \phi\eta, ^3S_1) & = (0.76 \pm 0.31) \cdot 10^{-4} \\
B(\bar{p}p \to \phi\eta, ^1P_1) & = (7.72 \pm 1.65) \cdot 10^{-4}
\end{align}

Moreover, the Crystal Barrel measurements of annihilation in liquid give the ratio of the phase space corrected branching ratios [18]:

\begin{equation}
R_\eta = \frac{B(\bar{p}p \to \phi\eta)}{B(\bar{p}p \to \omega\eta)} = (4.6 \pm 1.3) \cdot 10^{-3}
\end{equation}

in a perfect agreement with the OZI–rule prediction for the vector mesons (6).

Polarized strangeness model treats these facts as demonstration of the momentum transfer dependence: the momentum transfer in the $\phi\eta$ reaction is too small for rearrangement diagrams start working. So no OZI rule violation should be neither for annihilation from the S-wave nor from the P-wave. The ratio $Y(\phi\eta)/Y(\omega\eta)$ should remain small in the P-wave. Therefore ten times increasing of the $\omega\eta$ yield for annihilation from the P-wave is predicted.

The rearrangement nature of the additional strangeness production implies strong consequences for the possible amount of strange quarks in the nucleon. Indeed, let us estimate how many additional $\phi$ are creating due to intrinsic nucleon strangeness. Assuming the validity of the OZI rule and starting from branching ratio $B.R.(\bar{p}p \to \omega\pi^0) = (63 \pm 4) \cdot 10^{-4}$
for the annihilation from the $^3S_1$ state, one may calculate the branching ratio of $\bar{p}p \to \phi\pi^0$ reaction via normal OZI-allowed mixing. It will give $B.R.(\phi\pi^0)_{OZI} = 2.6 \cdot 10^{-5}$, which should be compared with the experimental value of $B.R.(\phi\pi^0)_{exp} = (7.57 \pm 0.62) \cdot 10^{-4}$.

Let us assume that all additional $\phi$’s are coming from the nucleon intrinsic strangeness due to the two-nucleon rearrangement and try to estimate (in a rather crude manner) the amount of strange quarks admixture in the nucleon which is needed to create this surplus of $\phi$.

The proton wave function is decomposing in two parts:

$$|p> = a \sum_{X=0}^{\infty} |uudX> + b \sum_{X=0}^{\infty} |uud\bar{ss}X>$$

where $X$ stands for any number of gluons and light $\bar{q}q$ pairs. The normalization of the non-strange and strange parts of the wave function is $|a|^2 + |b|^2 = 1$ (neglecting the admixture of more than one $\bar{ss}$ pair). The amplitude of the $\bar{ss}$ meson production should be proportional to $b^2$ due to the rearrangement nature of the process where strange quarks from both nucleons should participate:

$$M(\bar{p}p \to \bar{ss} + X) \sim b^2 T(\bar{ss})$$

where the factor $T(\bar{ss})$ reflects the dependence on the initial and final state interactions.

Let us assume that $T(\bar{ss}) \sim T(\bar{qq})$. Then the ratio R of the amplitudes for the $\phi\pi$ and $\omega\pi$ final state is

$$R = \frac{M(\bar{p}p \to \phi\pi)}{M(\bar{p}p \to \omega\pi)} \sim \frac{b^2}{1 - b^2}$$

Using experimental data for the additional strangeness production, one could obtain that $R = 0.24 \pm 0.02$, it means that $b^2 = 0.20$.

Of course, one should not consider this estimation literally, as demonstration that the LEAR experiments found the 20% strangeness component in the nucleon. The approximation $T(\bar{ss}) \sim T(\bar{qq})$ is too crude and the reality may differ on some factor. But what is clear: the rearrangement diagrams mean the $b^2$ dependence of the $\phi$ production amplitude and degree of the observed OZI violation (10)-(12) is so high that indeed implies the contribution of the strange quarks in the nucleon at the level of 10-20%.

4. Polarized strangeness model - experimental verification

The predictions of the polarized strangeness model have been tested in different reactions. The detailed review of the present status of the model is given in [14]. Here I would like to comment only few recent experimental results:

- The Pontecorvo reactions

We already discussed that the ratio $R = Y(\bar{p}d \to \phi n)/Y(\bar{p}d \to \omega n)$ shown in Fig. 4 turns out to be unusually high. It is even greater than the corresponding ratio for the annihilation on a free nucleon $\bar{p}p \to \phi\pi^0$ in liquid hydrogen and twice as large as the ratio measured in hydrogen gas at NTP. Usually, the Pontecorvo reactions are considered as two-step processes [27, 28]. First, two mesons are created in the $\bar{p}$ annihilation on a single
nucleon of the deuteron and then one of them is absorbed by the spectator nucleon. In this approach, the OZI violation in the Pontecorvo reaction $\bar{p}d \rightarrow \phi n$ is simply a reflection of its violation in the elementary act $\bar{p}p \rightarrow \phi\pi^0$.

However recently the two-step model explanations are in serious doubts after measurements by the Crystal Barrel collaboration of the Pontecorvo reactions with open strangeness [29]:

\[
\begin{align*}
\bar{p} + d & \rightarrow \Lambda + K^0 \\
\bar{p} + d & \rightarrow \Sigma^0 + K^0
\end{align*}
\]

It was found [29] that the yields of these reactions are practically equal, $R_{\Sigma,\Lambda} = Y(\Sigma K)/Y(\Lambda K) = 0.92 \pm 0.15$, in a sheer discrepancy with two-step models prediction [27] that the $\Sigma$ production (23) should be about 100 times less than $\Lambda$ production. It was predicted [28] that $R_{\Sigma,\Lambda} = 0.012$. This hierarchy appears naturally in the two-step models due to the fact that the $\bar{K}N \rightarrow \Lambda X$ cross section is larger than the $\bar{K}N \rightarrow \Sigma X$ one.

The measured yields of the reactions (22)-(23) are also at least by a factor 10 over the two-step model prediction [27].

Therefore, experiments on Pontecorvo reactions clearly indicate opulent production of additional strangeness either in form of $\phi$ mesons or of $\Lambda K$ and $\Sigma K$ pairs.

- **Longitudinal polarization of $\Lambda$ in DIS**

It has been pointed out in [13] that the negative polarization of the strange sea should lead to the negative longitudinal polarization of the $\Lambda$ hyperons formed in the target fragmentation region in the lepton deep-inelastic scattering (DIS). The idea is that the polarization of the $s$ quark transfers to the final state polarization of the $\Lambda$ hyperon after an intermediate boson hits a valence quark of the nucleon. Recent NOMAD data on $\nu N$ DIS [30] have demonstrated that the $\Lambda$ longitudinal polarization in the target fragmentation region is indeed large and negative: $P(\Lambda) = -0.21 \pm 0.04 \pm 0.02$. Remarkably, in the current fragmentation region this polarization is significantly less: $P(\Lambda) = -0.09 \pm 0.06 \pm 0.03$. The measurements of $\Lambda$ polarization with significantly large statistics is planned at COMPASS experiment on $\mu N$ DIS.

- **Polarization transfer to $\Lambda$ in $pp$ and $\bar{p}p$**

The polarized strangeness model assumes an anticorrelation between spins of the proton and $s$-quarks. Then it is natural to predict a negative value for depolarization $D_{nn}$ measured in the $\Lambda$ production in polarized proton interactions $\bar{p}p \rightarrow \Lambda K^+ p$. Recent measurements of DISTO collaboration [31] indeed have confirmed this prediction. The same effect is expected for the depolarization of $\Lambda$ produced in antiproton interactions with polarized protons $\bar{p} + \bar{p} \rightarrow \Lambda + \bar{\Lambda}$. However preliminary results of the PS 185 experiment presented at this conference [32] show that $D_{nn}$ is quite small but the spin transfer to $\Lambda$ $K_{nn}$ is unusually high and positive.

There are versions of the polarized strangeness model where the spin of proton is indeed mainly transferred to $\bar{\Lambda}$ rather than to $\Lambda$. But in these modifications the $K_{nn}$ should be still negative. So, it is for the future to resolve this paradox.

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