Behavior of polarized light sea–quarks

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The experiment data by NMC, E866/NuSea and HERMES groups show a violation of the flavor symmetry of unpolarized light sea–quarks. However, for polarized ones, is the symmetry of polarized sea–quarks of $\Delta\bar{u}$ and $\Delta\bar{d}$ also violated at an initial Q_0^2 in the nonperturbative region? So far, several theoretical groups have presented excellent parametrization models by analyzing high precision data of polarized deep inelastic scatterings based on NLO of QCD[1]. From these analyses, we have now a good understanding on the polarized valence u and d quarks but knowledge of polarized sea–quarks and gluons are still poor. Usually people assume $\Delta\bar{u}(x) = \Delta\bar{d}(x)$ in their analyses without good reasoning. In order to understand the nucleon spin structure, it is very important to know if $\Delta\bar{u}(x)$ is equal to $\Delta\bar{d}(x)$ or not and further to determine their own values.

Here, we estimate the value of the difference between $\Delta\bar{u}$ and $\Delta\bar{d}$ from recent data of semi–inclusive processes with longitudinal polarized lepton beams and longitudinal polarized fixed targets measured by SMC at CERN[2] and HERMES at DESY[3].

Let us consider polarized semi–inclusive charged pion production processes off proton and neutron targets. The difference between $\Delta\bar{d}(x)$ and $\Delta\bar{u}(x)$ can be written by

$$\begin{aligned}\Delta\bar{d}(x,Q^2) - \Delta\bar{u}(x,Q^2) &= \frac{1}{6\{D(Q^2)+\widetilde{D}(Q^2)\}} \\ &\times[J_1(Q^2)\{\Delta N_p^{\pi^+}(x,Q^2) - \Delta N_n^{\pi^+}(x,Q^2)\} - J_2(Q^2)\ \{\Delta N_p^{\pi^-}(x,Q^2) - \Delta N_n^{\pi^-}(x,Q^2)\}]\ ,\end{aligned} \tag{1}$$

where $J_{1(2)}(Q^2) = \frac{3(D(Q^2)+\widetilde{D}(Q^2))}{5(D(Q^2)-\widetilde{D}(Q^2))} \mp 1$. D and $\widetilde{D}$ are called favored and unfavored fragmentation functions, respectively. $\Delta N_N^{\pi^\pm}(x,Q^2)$ is defined as $\Delta N_N^H(x,Q^2) = \frac{A_{1N}^H(x,Q^2)}{\{1+R(x,Q^2)\}} \times\{\sum_{q,H}\ e_q^2\ q(x,Q^2)\ D_q^H(Q^2)\}$ in terms of the measured value, $A_{1N}^H(x,Q^2)$. With this formula, we can estimate the difference of $\Delta\bar{d}(x)$ and $\Delta\bar{u}(x)$ from the data on semi–inclusive positive and negative charged hadron processes with proton and neutron targets. By using suitable unpolarized quark distributions[4] and fragemtation functions[5], we have calculated the values of $\Delta\bar{d}(x) - \Delta\bar{u}(x)$ through $\Delta N_N^H(x,Q^2)$ obtained from the present data set of ($A_{1p}^{h^\pm}$, $A_{1d}^{h^\pm}$) of SMC, ($A_{1p}^{h^\pm}$, $A_{1^3He}^{h^\pm}$) and ($A_{1p}^{\pi^\pm}$, $A_{1^3He}^{\pi^\pm}$) of HERMES. The results are shown in fig.1. To examine these results more deeply, we have made the χ^2–fit to them by using the parametrization

$$\Delta\bar{d}(x) - \Delta\bar{u}(x) = C\ x^\alpha\{\bar{d}(x) - \bar{u}(x)\} \tag{2}$$

at $Q^2 = 4\text{GeV}^2$. From the χ^2–fit to data, we have obtained $C = -1.00$ and $\alpha = 0.18$, respectively. Note that $C \neq 0$ suggests an asymmetry of $\Delta\bar{d}$ and $\Delta\bar{u}$. It is interesting to note that the negative value of C is consistent with instanton interaction predictions[6]. However, it must be premature to lay stress on this result because of too large errors of the present data, though this result might suggest a violation of the polarized light flavor sea–quark symmetry. We urge to have more data with high precision to confirm this result.

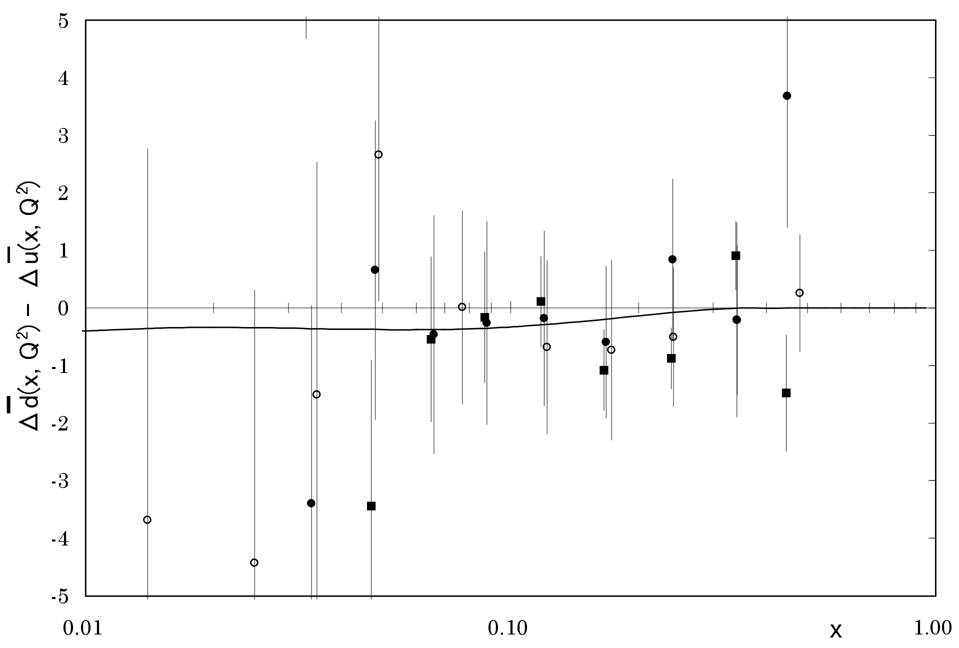

Figure 1: The x dependence of $\Delta\bar{d}(x,Q^2) - \Delta\bar{u}(x,Q^2)$ at $Q^2 = 4\mathrm{GeV}^2$ estimated by using the unpolarized quark distributions[4] and ratio R[7], respectively. Marks indicated by the solid circle, open circle and solid square denote the results calculated from the data set of SMC data, HERMES data for charged hadron productions and HEMRES data for charged pion productions, respectively. The solid line indicates the result of χ^2–fit by the parametrization of eq.(2).

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