Flavor Decomposition of Polarized Quark Distributions from E99-117 g_1^n/F_1^n Data

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This document describes how the polarized parton distribution functions (PDF) $\Delta u/u$ and $\Delta d/d$ are extracted from E99-117 g_1^n/F_1^n data.

1 Formalism

In the quark-parton model, the structure functions can be interpreted as

$$g_1(x,Q^2) = \frac{1}{2}\sum e_i^2 \Delta q_i(x,Q^2) \quad (1)$$

$$F_1(x,Q^2) = \frac{1}{2}\sum e_i^2 q_i(x,Q^2) \quad (2)$$

$$\text{therefore} \qquad \frac{g_1(x,Q^2)}{F_1(x,Q^2)} = \frac{\sum e_i^2 \Delta q_i(x,Q^2)}{\sum e_i^2 q_i(x,Q^2)} \quad (3)$$

1.1 In the valence quark region

Assuming the strange and charm quark distributions $s(x)$, $\bar{s}(x)$, $c(x)$, $\bar{c}(x)$, $\Delta s(x)$, $\Delta\bar{s}(x)$, $\Delta c(x)$ and $\Delta\bar{c}(x)$ be negligible in the near valence region $x > 0.3$, ignoring Q^2 dependence, and using the charge symmetry that $u^p = d^n$, $d^p = u^n$, one can extract polarized PDF as

$$\frac{\Delta u + \Delta\bar{u}}{u+\bar{u}} = \frac{4}{15}\frac{g_1^p}{F_1^p}(4+R^{du}) - \frac{1}{15}\frac{g_1^n}{F_1^n}(1+4R^{du}) \; ; \quad (4)$$

$$\frac{\Delta d + \Delta\bar{d}}{d+\bar{d}} = \frac{4}{15}\frac{g_1^n}{F_1^n}(4+\frac{1}{R^{du}}) - \frac{1}{15}\frac{g_1^p}{F_1^p}(1+\frac{4}{R^{du}}) \; , \quad (5)$$

where $u = u_{sea} + u_V$, $d = d_{sea} + d_V$ and $R^{du} = (d+\bar{d})/(u+\bar{u})$.

1.2 Uncertainty from strange and charm quark distributions

However, there is a small amount of s, $\bar{s}$ and c, $\bar{c}$ quarks in the kinematic region where our data were obtained, which introduces a correction. We estimate this correction and its uncertainty as follows:

We write the PDFs extracted from Eq. (4) and Eq. (5) as $[(\Delta u + \Delta\bar{u})/(u+\bar{u})]_{s=0,c=0}$ and $[(\Delta d + \Delta\bar{d})/(d+\bar{d})]_{s=0,c=0}$. In the region where s and c are not negligible, they are actually

$$\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}} \text{ and } \frac{\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}}{d+\bar{d}+s+\bar{s}}$$

We now estimate the difference between $\frac{\Delta u+\Delta\bar{u}+\Delta c+\Delta\bar{c}}{u+\bar{u}+c+\bar{c}}$ and $\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}$, and between $\frac{\Delta d+\Delta\bar{d}+\Delta s+\Delta\bar{s}}{d+\bar{d}+s+\bar{s}}$ and $\frac{\Delta d+\Delta\bar{d}}{d+\bar{d}}$:

$$\begin{aligned}
\frac{\Delta u + \Delta\bar{u}}{u+\Delta u} &= \Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}}\Big)(\frac{u+\bar{u}+c+\bar{c}}{u+\bar{u}})(\frac{\Delta u + \Delta\bar{u}}{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}) \\
&= \Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}++\bar{c}c}\Big)(1+\frac{c+\bar{c}}{u+\bar{u}})(\frac{1}{1+\frac{\Delta c+\Delta\bar{c}}{\Delta u+\Delta\bar{u}}}) \\
&= \Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}}\Big)(1+\frac{c+\bar{c}}{u+\bar{u}})(\frac{1}{1+\frac{\Delta c+\Delta\bar{c}}{u+\bar{u}}\frac{u+\bar{u}}{\Delta u+\Delta\bar{u}}}) \qquad (6)
\end{aligned}$$

Times both sides by $1+\frac{\Delta c+\Delta\bar{c}}{u+\bar{u}}\frac{u+\bar{u}}{\Delta u+\Delta\bar{u}}$, obtain

$$\frac{\Delta u + \Delta\bar{u}}{u+\Delta u} + \frac{\Delta c + \Delta\bar{c}}{u+\bar{u}} = \Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}}\Big)(1+\frac{c+\bar{c}}{u+\bar{u}})$$

Therefore

$$\frac{\Delta u + \Delta\bar{u}}{u+\bar{u}} = \Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}}\Big)(1+\frac{c+\bar{c}}{u+\bar{u}}) - \frac{\Delta c + \Delta\bar{c}}{u+\bar{u}} \qquad (7)$$

Next, one should use world fits for polarized PDFs and estimate the uncertainty due to c quarks. However, since all available fits only give Δu, Δd, $\Delta\bar{u}$, $\Delta\bar{d}$ and Δs, we will use the positivity constraint for c here: $|\Delta c| < c$. The error of $\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}$ from Eq. (7) is then

$$\delta\Big(\frac{\Delta u + \Delta\bar{u}}{u+\bar{u}}\Big) = \left\{\Big[1+\Big(\frac{\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c}}{u+\bar{u}+c+\bar{c}}\Big)^2\Big]\Big[\delta\Big(\frac{c+\bar{c}}{u+\bar{u}}\Big)\Big]^2 + \Big(\frac{c+\bar{c}}{u+\bar{u}}\Big)^2\right\}^{0.5} \qquad (8)$$

Similar to Eq. (7), one has

$$\frac{\Delta d + \Delta\bar{d}}{d+\bar{d}} = \Big(\frac{\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}}{d+\bar{d}+s+\bar{s}}\Big)(1+\frac{s+\bar{s}}{d+\bar{d}}) - \frac{\Delta s + \Delta\bar{s}}{d+\bar{d}} \qquad (9)$$

and the error is

$$\begin{aligned}
\delta\Big(\frac{\Delta d + \Delta\bar{d}}{d+\bar{d}}\Big) &= \left\{\Big[\frac{\delta(\Delta s + \Delta\bar{s})}{d+\bar{d}}\Big]^2 + \Big[\Big(\frac{\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}}{d+\bar{d}+s+\bar{s}}\Big)\Big(\frac{\delta(s+\bar{s})}{d+\bar{d}}\Big)\Big]^2\right. \\
&+ \left.\Big[\Big(\frac{\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}}{d+\bar{d}+s+\bar{s}}\Big)(s+\bar{s}) - (\Delta s + \Delta\bar{s})\Big]^2\Big[\frac{\delta(d+\bar{d})}{(d+\bar{d})^2}\Big]^2\right\}^{0.5} \qquad (10)
\end{aligned}$$

We will use world unpolarized PDF fits (MRST and CTEQ) and polarized PDF fits (AAC, LSS2001, BB and GRSV) to calculate the r.h.s. of Eq. (9) and (10), and take the variation among all PDF sets as the uncertainty.

1.3 Obtaining polarized valence quark distributions

Since the constituent quark model (CQM) gives the polarized valence quark distributions $\Delta u_V/u_V$ and $\Delta d_V/d_V$, one needs to estimate the effect due to sea quarks u_{sea}, d_{sea}, $\bar{u}$ and $\bar{d}$ when comparing $(\Delta u+\Delta\bar{u})/(u+\bar{u})$ and $(\Delta d+\Delta\bar{d})/(d+\bar{d})$ data with the CQM predictions. Assuming $u_{sea}=\bar{u}$ and $d_{sea}=\bar{d}$, and follow a similar manner as the sea quark treatment, we obtain:

$$\frac{\Delta u_v}{u_v} = \Big(\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}\Big)(1+\frac{2\bar{u}}{u_v})-\frac{2\Delta\bar{u}}{u_v}\ , \tag{11}$$

and the error is

$$\delta\Big(\frac{\Delta u_v}{u_v}\Big) = \Bigg\{\Big[\frac{\delta(2\Delta\bar{u})}{u_v}\Big]^2+\Big[\Big(\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}\Big)\Big(\frac{\delta(2\bar{u})}{u_v}\Big)\Big]^2 + \Big[\Big(\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}\Big)(2\bar{u})-(2\Delta\bar{u})\Big]^2\Big[\frac{\delta(u_v)}{(u_v)^2}\Big]^2\Bigg\}^{0.5}\ . \tag{12}$$

For the valence d quark,

$$\frac{\Delta d_v}{d_v} = \Big(\frac{\Delta d+\Delta\bar{d}}{d+\bar{d}}\Big)(1+\frac{2\bar{d}}{d_v})-\frac{2\Delta\bar{d}}{d_v}\ , \tag{13}$$

and the error is

$$\delta\Big(\frac{\Delta d_v}{d_v}\Big) = \Bigg\{\Big[\frac{\delta(2\Delta\bar{d})}{d_v}\Big]^2+\Big[\Big(\frac{\Delta d+\Delta\bar{d}}{d+\bar{d}}\Big)\Big(\frac{\delta(2\bar{d})}{d_v}\Big)\Big]^2 + \Big[\Big(\frac{\Delta d+\Delta\bar{d}}{d+\bar{d}}\Big)(2\bar{d})-(2\Delta\bar{d})\Big]^2\Big[\frac{\delta(d_v)}{(d_v)^2}\Big]^2\Bigg\}^{0.5}\ . \tag{14}$$

2 Inputs

2.1 Neutron data from E99-117

Neutron data g_1^n/F_1^n from E99-117 are given in Table 1. Also listed are the A_1^n results.

2.2 Proton world data

We fit to world g_1^p/F_1^p data using function $x^\alpha(a+bx)(1+\beta/Q^2)$ and obtain:

$$\frac{g_1^p}{F_1^p} = x^{0.8126}(1.2307-0.4128x)\Big(1+\frac{0.0303}{Q^2}\Big) \tag{15}$$

The world data set for the proton g_1^p/F_1^p includes those from HERMES [1], E143 [2] and E155 [3]. We obtain for the E99-117 kinematics: g_1^p/F_1^p=0.447 ± 0.014, 0.563 ± 0.017 and

Table 1: Results for A_1^n and g_1^n/F_1^n, errors are given as ± stat. ± syst.

x	Q^2	A_1^n	g_1^n/F_1^n
0.327	2.71	$-0.048 \pm 0.024^{+0.015}_{-0.016}$	$-0.043 \pm 0.022^{+0.009}_{-0.009}$
0.466	3.52	$-0.006 \pm 0.027^{+0.019}_{-0.019}$	$0.040 \pm 0.035^{+0.011}_{-0.011}$
0.601	4.83	$0.175 \pm 0.048^{+0.026}_{-0.028}$	$0.124 \pm 0.045^{+0.016}_{-0.017}$

0.654 ± 0.026, for $x = 0.327$, 0.466 and 0.601, respectively. The uncertainties are given by the error matrix of the fitting parameters, referred to as the uncertainties of the fit. However, they are not the real uncertainty of g_1^p/F_1^p since the model uncertainty caused by the certain choice of fitting function is not taken into account.

To be realistic, instead of using the uncertainties of the fit, we checked the world data in the region of $0.2 < x < 0.7$ and estimate the uncertainty in g_1^p/F_1^p from the experimental statistical and systematic uncertainties. We estimate this error to be $\delta(g_1^p/F_1^p) = 0.02$, 0.05 and 0.10 at $x = 0.327$, 0.466 and 0.601, respectively.

2.3 Ratio d/u

The R^{du} ratio was extracted from proton and deuteron structure function data, with nuclear corrections included [4]. We fit to their offshell results and take it as the nominal value, and fit to the onshell results and take it as the minimum value:

$$R^{du}{}_{nominal} = 0.9850 - 1.9075x + 1.3202x^2 - 0.2068x^3 \text{ , and} \quad (16)$$

$$R^{du}{}_{min} = 0.7122 - 0.8041x \text{ .} \quad (17)$$

We then estimated the maximum value as $R^{du}{}_{max} - R^{du}{}_{mean} = (R^{du}{}_{mean} - R^{du}{}_{min})/4$ (this is arbitrary). We obtain the ratio R^{du} at the three kinematics of E99-117 as listed in Table 2.

Table 2: Ratio R^{du} used for this work. Estimated from [4].

x	nominal	max	min
0.327	0.495	0.507	0.449
0.466	0.362	0.368	0.338
0.601	0.271	0.281	0.229

2.4 Unpolarized Parton Distribution Functions

We use MRST [5] and CTEQ [6] to estimate the unpolarized PDF. Results are given in Table 3 and 4. We choose the larger uncertainties between the two PDF sets.

Table 3: MRST PDF at E99-117 kinematics.

x	Q^2	u_v	d_v	u	d	s	c	$\bar{u}$	$\bar{d}$
0.327	2.71	1.8292	0.6551	1.8791	0.7152	0.0305	0.0012	0.0499	0.0601
0.466	3.52	0.7626	0.2188	0.7725	0.2235	0.0042	0.0003	0.0099	0.0048
0.601	4.83	0.2451	0.0558	0.2461	0.0561	0.0004	0.0000	0.0011	0.0002

Table 4: CTEQ PDF at E99-117 kinematics.

x	Q^2	u_v	d_v	u	d	s	c	$\bar{u}$	$\bar{d}$
0.327	2.71	1.8111	0.7121	1.8576	0.7564	0.0198	0.0027	0.0465	0.0444
0.466	3.52	0.7498	0.2321	0.7585	0.2343	0.0027	0.0009	0.0087	0.0022
0.601	4.83	0.2428	0.0525	0.2436	0.0528	0.0004	0.0002	0.0008	0.0003

Table 5: Averaged PDF values at E99-117 kinematics.

x	Q^2		u_v	d_v	u	d	s	c	$\bar{u}$	$\bar{d}$
0.327	2.71	$\langle f \rangle$	1.8202	0.6836	1.8684	0.7358	0.0251	0.0019	0.0482	0.0522
		δf	0.0128	0.0403	0.0152	0.0291	0.0076	0.0011	0.0024	0.0111
0.466	3.52	$\langle f \rangle$	0.7562	0.2254	0.7655	0.2289	0.0034	0.0006	0.0093	0.0035
		δf	0.0091	0.0094	0.0099	0.0076	0.0010	0.0004	0.0008	0.0018
0.601	4.83	$\langle f \rangle$	0.2439	0.0542	0.2449	0.0544	0.0004	0.0001	0.0009	0.0003
		δf	0.0016	0.0024	0.0018	0.0023	0.0000	0.0001	0.0002	0.0000

2.5 Polarized Parton Distribution Functions

We use AAC03 [7], LSS2001 [8], BB [9] and GRSV2000 [10] to estimate the polarized PDF. Results are given in Table 6. Since LSS2001 does not satisfy positivity constraints on sea quarks, we choose the other three to estimate the effect of sea quarks.

Table 6: Polarized PDF at E99-117 kinematics. The polarized PDF values for u, d and $\bar{u}$, $\bar{d}$ and s quarks are given, as well as the ratio $\Delta q/q$. The unpolarized PDFs in the denominator of $\Delta q/q$ are using MRST except the 2nd last column.

x $/Q^2$	POL PDF	Δu	Δd	$\Delta\bar{u}$	$\Delta\bar{d}$	Δs	$\Delta u/u$	$\Delta d/d$	$\Delta\bar{u}/\bar{u}$	$\Delta\bar{d}/\bar{d}$	$\Delta s/s$ (CTEQ)	$\Delta s/s$ (MRST)
0.327	LSS	1.062	-0.254	-0.0353	-0.0353	-0.0353	0.565	-0.355	-0.707	-0.587	-1.158	-1.783
/2.71	AAC	0.990	-0.311	-0.0002	-0.0002	-0.0002	0.527	-0.434	-0.0045	-0.004	-0.007	-0.0115
	BB	1.033	-0.301	-0.0076	-0.0076	-0.0076	0.549	-0.420	-0.151	-0.126	-0.248	-0.382
	GRSV	1.041	-0.314	-0.0024	-0.0024	-0.0024	0.554	-0.438	-0.048	-0.040	-0.079	-0.121
0.466	LSS	0.501	-0.083	-0.0073	-0.0073	-0.0073	0.648	-0.369	-0.735	-1.535	-1.755	-2.677
/3.62	AAC	0.483	-0.124	0.0010	0.0010	0.0010	0.625	-0.557	0.103	0.216	0.246	0.376
	BB	0.528	-0.148	-0.0007	-0.0007	-0.0007	0.684	-0.660	-0.066	-0.138	-0.158	-0.241
	GRSV	0.497	-0.115	0.0001	0.0001	0.0001	0.644	-0.515	0.008	0.016	0.018	0.028
0.601	LSS	0.164	-0.020	-0.0008	-0.0008	-0.0008	0.666	-0.351	-0.771	-3.571	-2.155	-2.214
/4.83	AAC	0.179	-0.036	0.0001	0.0001	0.0001	0.726	-0.642	0.110	0.511	0.309	0.317
	BB	0.209	-0.051	0.0000	0.0000	0.0000	0.851	-0.912	-0.020	-0.091	-0.055	-0.057
	GRSV	0.178	-0.031	0.0000	0.0000	0.0000	0.721	-0.549	-0.017	-0.086	-0.051	-0.052

3 Results

Results for $(\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c})/(u + \bar{u} + c + \bar{c})$ and $(\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s})/(d + \bar{d} + s + \bar{s})$ extracted from our g_1^n/F_1^n data are listed in Table 10. The error bars includes statistical, experimental systematic and the uncertainty due to g_1^p/F_1^p and d/u fit.

After correcting for the sea quark s and c contributions using Eqs. (7) and (9), results for $(\Delta u + \Delta\bar{u})/(u + \bar{u})$ and $(\Delta d + \Delta\bar{d})/(d + \bar{d})$ are given in Table 9.

To compare with CQM predictions, a correction should be made to results in Table 9. We found $\frac{\Delta u_v}{u_v} = (\frac{\Delta u+\Delta\bar{u}}{u+\bar{u}}) + 0.033 \pm 0.008$, $+0.016 \pm 0.005$ and $+0.005 \pm 0.002$, and $\frac{\Delta d_v}{d_v} = (\frac{\Delta d+\Delta\bar{d}}{d+\bar{d}}) - 0.044 \pm 0.014$, -0.013 ± 0.008 and -0.005 ± 0.002, for $x = 0.327$,0.466 and 0.601, respectively. These correction are shown as the light-shaded (green) error bands in Figure 1.

Figure 1 shows our results compared with the semi-inclusive data from HERMES [11], CQM predictions [12] and pQCD-based predictions incorporating hadron helicity conservation [13].

Table 7: Averaged POL PDF values at E99-117 kinematics, note that all pol PDF fits assume $\Delta s = \Delta\bar{u} = \Delta\bar{d}$

x	Q^2	$\langle\Delta f\rangle$	$\delta\Delta f$
0.327	2.71	$-.00339$	0.00266
0.466	3.52	0.00015	0.00060
0.601	4.83	0.00003	0.00006

Table 8: Results for the polarized quark distributions $(\Delta u + \Delta\bar{u} + \Delta c + \Delta\bar{c})/(u + \bar{u} + c + \bar{c})$ and $(\Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s})/(d + \bar{d} + s + \bar{s})$. The three errors are those due to the g_1^n/F_1^n statistical error, g_1^n/F_1^n systematic error and the uncertainties of g_1^p/F_1^p and R^{du} fits (added in quadrature), respectively.

x	Q^2	$\frac{\Delta u+\Delta\bar{u}+\Delta c+\Delta\bar{c}}{u+\bar{u}+c+\bar{c}}$	$\frac{\Delta d+\Delta\bar{d}+\Delta s+\Delta\bar{s}}{d+\bar{d}+s+\bar{s}}$
0.327	2.71	$0.544 \pm 0.004 \pm 0.002^{+0.024}_{-0.025}$	$-0.339 \pm 0.035 \pm 0.014^{+0.013}_{-0.030}$
0.466	3.52	$0.648 \pm 0.006 \pm 0.002^{+0.058}_{-0.058}$	$-0.380 \pm 0.063 \pm 0.020^{+0.041}_{-0.049}$
0.601	4.83	$0.727 \pm 0.006 \pm 0.002^{+0.114}_{-0.114}$	$-0.433 \pm 0.092 \pm 0.035^{+0.107}_{-0.142}$

Table 9: Results for the polarized quark distributions $(\Delta u + \Delta\bar{u})/(u + \bar{u})$ and $(\Delta d + \Delta\bar{d})/(d + \bar{d})$. Here the error bar is due to the uncertainty of sea quark unpolarized PDFs. They will NOT be added to the "model uncertainty" of the final results, instead they will be represented as a dark-shaded (blue) error band in the figure.

x	Q^2	$(\Delta u + \Delta\bar{u})/(u + \bar{u})$	$(\Delta d + \Delta\bar{d})/(d + \bar{d})$
0.327	2.71	0.545 ± 0.002	-0.352 ± 0.010
0.466	3.52	0.649 ± 0.002	-0.393 ± 0.006
0.601	4.83	0.728 ± 0.002	-0.440 ± 0.002

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Table 10: Final results for PRC. The three errors are those due to the g_1^n/F_1^n statistical error, g_1^n/F_1^n systematic error and the uncertainty due to g_1^p/F_1^p, R^{du} fit and sea quark corrections (added in quadrature), respectively.

x	Q^2	$(\Delta u + \Delta\bar{u})/(u+\bar{u})$	$(\Delta d + \Delta\bar{d})/(d+\bar{d})$
0.327	2.71	$0.545 \pm 0.004 \pm 0.002^{+0.024}_{-0.025}$	$-0.352 \pm 0.035 \pm 0.014^{+0.017}_{-0.031}$
0.466	3.52	$0.649 \pm 0.006 \pm 0.002^{+0.058}_{-0.058}$	$-0.393 \pm 0.063 \pm 0.020^{+0.041}_{-0.049}$
0.601	4.83	$0.728 \pm 0.006 \pm 0.002^{+0.114}_{-0.114}$	$-0.440 \pm 0.092 \pm 0.035^{+0.107}_{-0.142}$

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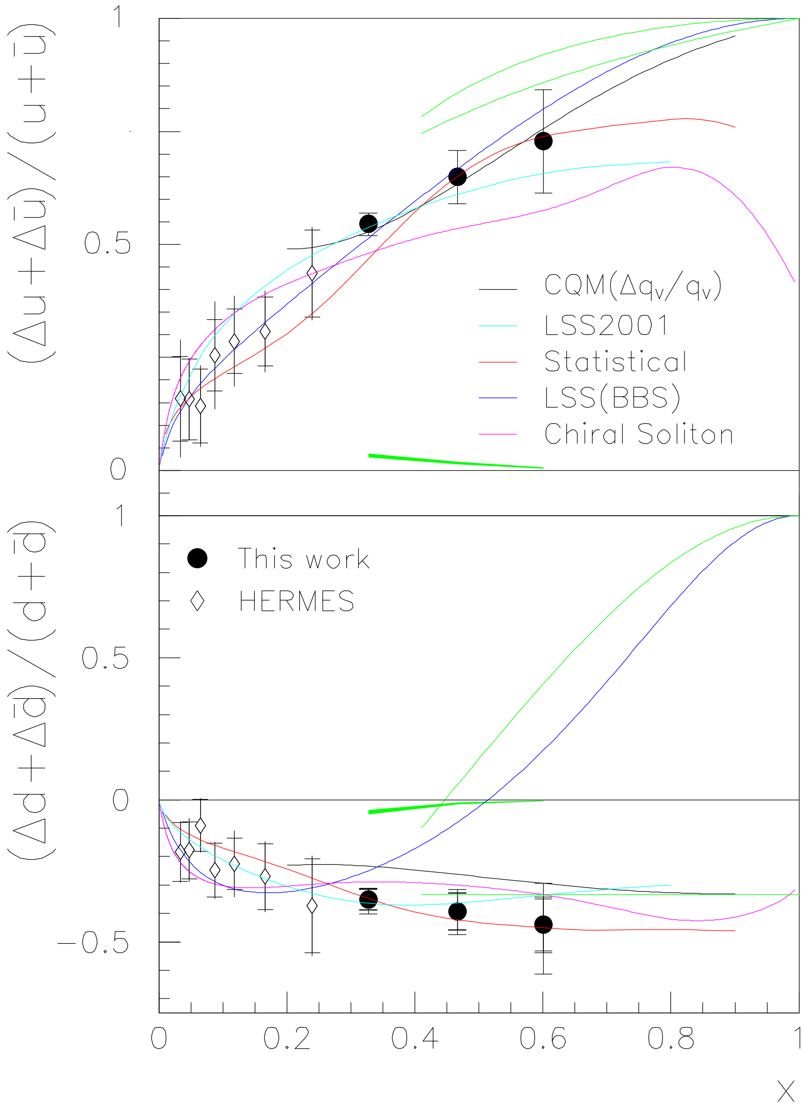

Figure 1: Results for $(\Delta u + \Delta\bar{u})/(u + \bar{u})$ and $(\Delta d + \Delta\bar{d})/(d + \bar{d})$ in the quark-parton model, compared with semi-inclusive data from HERMES [11] and CTEQ unpolarized PDF [6] as described in the text, the RCQM predictions (dash-dotted) [12], predictions from LSS 2001 NLO polarized parton densities at $Q^2 = 5$ (GeV/c)^2 (solid) [14], the statistical model at $Q^2 = 4$ (GeV/c)^2 (long-dashed) [15], the pQCD-based predictions with the HHC constraint (dashed) [13], the duality model using two different SU(6) breaking mechanisms (dash-dot-dotted and dash-dot-dot-dotted) [17], and predictions from chiral soliton model at $Q^2 = 4.8$ (GeV/c)^2 (dotted) [18]. The error bars of our data include the uncertainties given in Table 10. The shaded (green) band shows the difference between $\Delta q_V/q_V$ and $(\Delta q + \Delta\bar{q})/(q + \bar{q})$ that needs to be applied to the data when comparing with the RCQM calculation.