Distribution of quarks in chirality states oh the baryon The baryon has the two chirality states $\psi^{\pm}$. With $P^h_{q\pm}$ we denote the probability to find the quark q in the hadron h in the chirality $\pm$ state of the hadron. In the nonperturbative domain we have in the leading twist only valence quarks that is in this contribution we have $P^h_{\bar{q}\pm} = 0$, the occurence of antiquarks is quantitatively related to the higher Fock state admixture.

The relation between chirality of the hadron and helicity of the quarks is not unique. If $L_3 = 0$ and the spin of the diquark cluster is zero, in the chirality + state the active quark must have positive helicity and in the chirality − state the active quark must have negative helicity. If the active quark in the proton is a d, however, the diquark cluster must have $J = 1$ and the hadronic negative chirality component could well contain a positive helicity active d. Therefore in the following we make no asumptions on the helicity of the quarks inside the hadron and only consider the hadron chirality.

For the proton in the pure valence state we have the general result:

$$P^p_{u+} = 2 - r_2; P^p_{u-} = r_2; P^p_{d+} = 1 - r_1; P^p_{d-} = r_1 \tag{1}$$

From isospin symmetry follows for the neutron:

$$P^n_{d+} = 2 - r_2; P^n_{d-} = r_2; P^n_{u+} = 1 - r_1; P^n_{u-} = r_1 \tag{2}$$

For simplicity let us assume that the probabilities are not changed by higher Fock state contributions, that is the above expressions refer to the differences of quark and antiquark probabilities:

$$P^p_{u+} - P^p_{\bar{u}+} = 2 - r_2;\; P^p_{u-} - P^p_{\bar{u}-} = r_2;\; P^p_{d+} - P^p_{\bar{d}+} = 1 - r_1;\; P^p_{d-} - P^p_{\bar{d}-} = r_1 \tag{3}$$

In the follwing we shall therefore only refer to the simple notataion P^p_{u+} etc.

Consequences Positivity of probabiliy requires:

$$0 \le r_2 \le 2;\; 0 \le r_1 \le 1 \tag{4}$$

In PRD we had only one parameter, r with the relation

$$r = 3r_2 = \frac{3}{2} r_1 \tag{5}$$

which yields the limits

$$0 \le r \le \frac{3}{2} \tag{6}$$

This condition has been taken into account in the PRL.

If we identify the negative chirality with the quark down helicity and assume SU(6) wave functionsd we obtain $r = 1$

Phenomenology, e. m. FF In PRD we had used $r = 2.08$ which is in contradiction to (6). We therefore use the maximally allowed value $r = 1.5$ which leads to a quite serious dicreapancy of the neutron FF by 25 %. It also entails $r_1 = 1$ and hence $P^p_{d+} = 0$, $P^n_{u+} = 0$. In Fig. 1 the pubished value (green) and the result for the according to (6) corrected value (black) for the n FF are displayed.

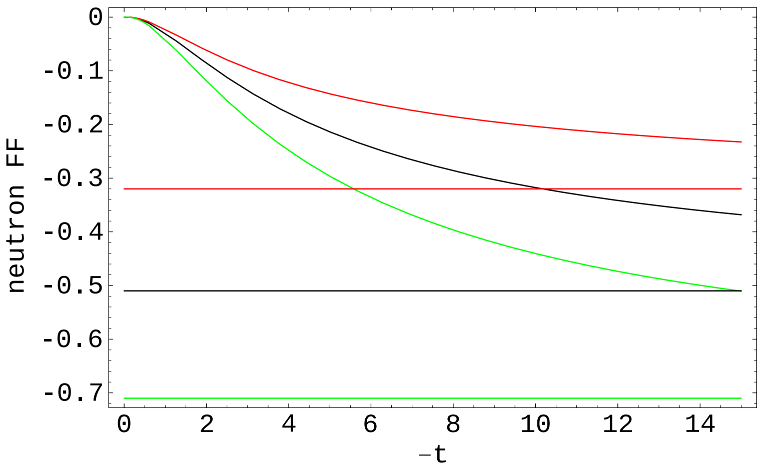

Figure 1: $t^2\times$ the neutron em FF F_1, Black: pure valence contribution, $r = 1.5$; Green: Published value with $r = 2.08$; Red: $r = 1.5$, $\quad \gamma_n = 0.38$. The horizontal lines are the asymptotic values

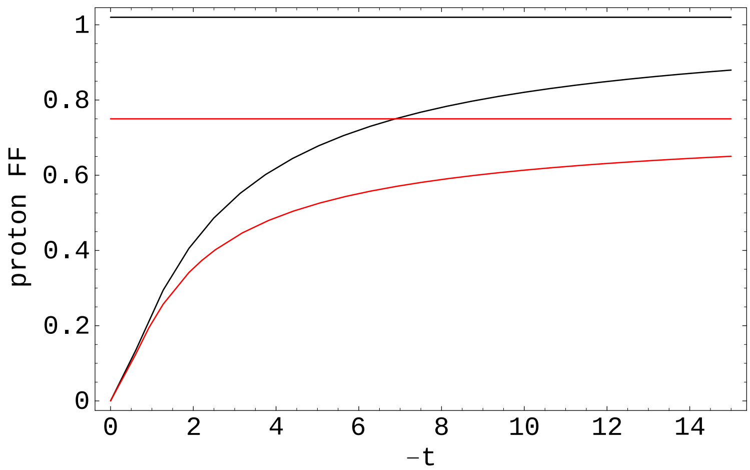

Figure 2: $t^2\times$ the proton em FF F_1, Black: pure valence contribution Red: $\gamma_p = 0.27$. The horizontal lines are the asymptotic values

Since the choice of different higher Fock state contributions for the same hadron has met justified criticism, also the result for a higher Fock state contribution $\gamma = 0.38$ obtained from the F_2 FF is displayed as red curve. The published (and unfortunately wrong) green curve agrees with the experiments, which extend to c. 3.5 GeV^2.

The proton FF, Fig. 2 needs no change (black), but we also display in red the result for the higher Fock state addition of $\gamma_p - 0.27.$, necessary for the spin flip. The experimental results agree well with the black curve up to c 7 GeV^2.

So we see the experimental values for F_1 both for neutron and proton do not allow for a higher Fock state contribution.

Phenomenology, axial FF Our previous result, $F_A(t) = B[3, 1 - t/(4\lambda)]/B[3, 1]$ has to be modified, since also $\tau = 4$ contributes to the charged axial FF.

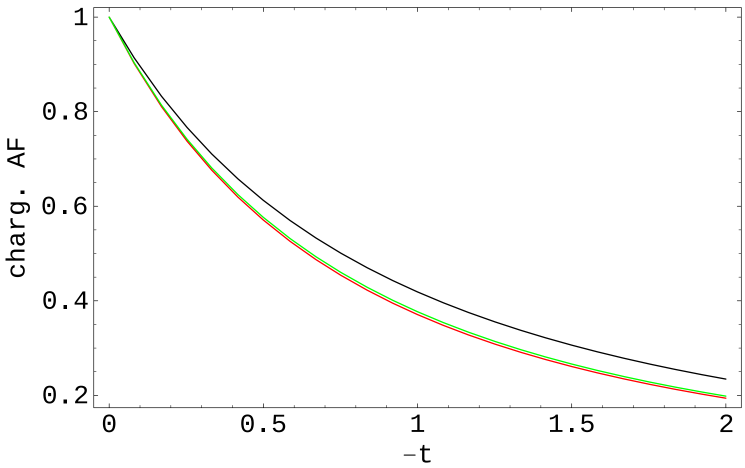

Figure 3: $t^2\times$ the charged axial FF F_1, Black: pure valence contribution, $r = 1.5$; Green: Older value, corresponding to r=0; Red: $r = 1.5, \quad \gamma_n = 0.30$.The green and red curve nearly overlap.

Since the old curve (green) gave a reasonable description of the data. here a higher Focj state contribution would improve a bit the theoretical result. If we give the vector and axual vector in the AdS_5 Lagrangian the charges G_V^5 and G_A^5 respectively, we obain as the relative g_A/g_V ratio for the charged weak gurrent

$$g_a/g_V = (1 - \frac{r}{3})\, G_A^5/G_V^5 \tag{7}$$

so the axial vector receives for $d = 4$ a smaller relative charge than the vector current.

Appendix

Let us consider only the helicity (chirality) nonflip term, and let $F_\tau^{V,A}(t)$ be the vector or axial FF of the chirality + state ($\tau = 3$) or chiralty − state ($\tau = 4$). From LFHQCD we have:

$$F_\tau^V(t) = 1/N_\tau B[\tau - 1, 1/2 - t/(4\lambda)], F_\tau^A(t) = 1/N_\tau B[\tau - 1, 1 - t/(4\lambda)]$$

The probabilities are given by (3), (2)

For the e.m. FF of the proton we obtain :

$$\begin{aligned} F_{em}^p(t)/e &= (P_{u,+}^p \frac{2}{3} + P_{d,+}^p \frac{-1}{3}) F_3^V(t) + (P_{u,-}^p \frac{2}{3} + P_{d,-}^p \frac{-1}{3}) F_4^V(t) && (8)\\ &= \frac{1}{3}(3 - 2r_2 + r_1) F_3^V(t) + \frac{1}{3}(2r_2 - r_1) F_4^V(t)] && (9) \end{aligned}$$

For the e.m. FF of the neutron we obtain :

$$\begin{aligned} F_{em}^n(t)/e &= (P_{d,+}^n \frac{-1}{3} + P_{u,+}^n \frac{2}{3}) F_3^V(t) + (P_{d,-}^n \frac{-1}{3} + P_{u,-}^n \frac{2}{3}) F_4^V(t) && (10)\\ &= \frac{1}{3}(r_2 - 2r_1) F_3^V(t) + \frac{1}{3}(2r_1 - r_2) F_4^V(t)] && (11) \end{aligned}$$

In the FF paper (PRD) we assumed:

$$r_1 = 2r_2; \quad r = 3r_2 \tag{12}$$

This yields for the P factors:

$$P^p_{u+} = 2 - \frac{r}{3}; \quad P^p_{u-} = \frac{r}{3}; \qquad P^p_{d+} = 1 - \frac{2r}{3}; \quad P^p_{d-} = \frac{2r}{3} \tag{13}$$

$$P^n_{d+} = 2 - \frac{r}{3}; \quad P^n_{d-} = \frac{r}{3}; \qquad P^n_{u+} = 1 - \frac{2r}{3}; \quad P^n_{u-} = \frac{2r}{3} \tag{14}$$

From $P \geq 0$ follows $r \leq \frac{3}{2}$, that is the choice $r = 2.08$ in PRD is not consistent.

We make the AdS ansatz for the charged current interaction:

$$\int d^4x dz \sqrt{g}\, \bar\Psi_{P'}(x,z) W^-_M e^M_A\, \Gamma^A (g^V_{cc}\, 1 + i\, g^A_{cc}\, \Gamma^5)\, \Psi_{P'}(x,z) \tag{15}$$

$$\to \qquad (2\pi)^4\, \delta^4(P' - P - q) W^-_\mu \bar u(P') \gamma^\mu (g^V_{cc}\, 1\, F^V_{cc} - \, g^A_{cc}\, \gamma_5\, F^A_{cc}) u(p) \tag{16}$$

This yields for the FF of the charged weak current vector and axial FF, $F^{V,A}_{cc}$ Here only the u-quark contributes.

$$\begin{aligned} F^V_{cc}/g &= \frac{g^V_{cc}}{2\sqrt{2}} [P^p_{u+}\, F^V_3 + P^p_{u-}\, F^V_4] & (17)\\ &= \frac{g^V_{cc}}{2\sqrt{2}} [(2 - \frac{r}{3})\, F^V_3 + \frac{r}{3} F^V_4] & (18)\\ F^A_{cc}/g &= \frac{g^A_{cc}}{2\sqrt{2}} [P^p_{u+}\, F^V_3 - P^p_{u-}\, F^V_4] & (19)\\ &= \frac{g^A_{cc}}{2\sqrt{2}} [(2 - \frac{r}{3})\, F^V_3 - \frac{r}{3} F^V_4] & (20) \end{aligned}$$

For completenes we give akso the FF of the neutral current with the interaction

$$(2\pi)^4\, \delta^4(P' - P - q) Z^-_\mu \bar u(P') \gamma^\mu (g^V_{nc}\, 1\, F^V_{nc} - \, g^A_{nc}\, \gamma_5\, F^A_{nc}) u(p). \tag{21}$$

Here u and d quark contribute with strength:

$$g^u_V = \frac{1}{2} - \frac{4}{3} \sin^2\theta_W; \qquad g^d_V = -\frac{1}{2} + \frac{2}{3} \sin^2\theta_W \tag{22}$$

$$g^u_A = \frac{1}{2}; \qquad g^d_A = -\frac{1}{2} \tag{23}$$

The FF are:

$$\begin{aligned} F^V_{nc}/g &= \frac{g^V_{nc}}{2\cos\theta_W} \Big[(P^p_{u+}\, g^u_V + P^p_{d+}\, g^d_V)\, F^V_3 + (P^p_{u-}\, g^u_V + P^p_{d-} g^d_V)\, F^V_4\Big] & (24)\\ &= \frac{g^V_{nc}}{2\cos\theta_W} \Big[(\frac{1}{2} + \frac{r}{6} - 2\sin^2\theta_W)\, F^V_3 - \frac{r}{6} F^V_4\Big] & (25)\\ F^A_{nc}/g &= \frac{g^A_{nc}}{2\cos\theta_W} \Big[(P^p_{u+}\, g^u_A + P^p_{d+}\, g^d_A)\, F^A_3 - (P^p_{u-}\, g^u_A + P^p_{d-} g^d_A)\, F^V_4\Big] & (26)\\ &= \frac{g^A_{nc}}{2\cos\theta_W} \Big[(\frac{1}{2} + \frac{r}{6})\, F^V_3 + \frac{r}{6} F^V_4\Big] & (27) \end{aligned}$$

At $t = 0$ the FF are:

$$F^{p}_{em}(0)/e = 1;\; F^{n}_{em}(0)/e = 0;\;\; F^{V}_{cc}(0)/g = 2\,\frac{g^{V}_{cc}}{2\sqrt{2}};\, F^{A}_{cc}(0)/g = 2(1-\frac{r}{3})\,\frac{g^{A}_{cc}}{2\sqrt{2}} \tag{28}$$

That is for $g^{A}_{cc} = g^{V}_{cc}$ we would ontain for the axial to vector coupling of the nucleon $G_A/G_V = 1 - \frac{r}{3}$ instead of the observed value 1.2