Light Cone QCD Sum Rules for the Magnetic Moments of Baryons*

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Outline

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- Light Cone QCD Sum Rules (LCQSR) for the Magnetic Moments
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Introduction

- QCD sum rules [1] is a powerful tool for studying hadronic physics based on QCD.
- One of the important properties of hadrons is their magnetic moments.
- In QCDSR and its various extensions, non-perturbative contributions are parameterized in terms of vacuum condensates.
- In LCQSR the operator product is carried out in the light cone $x^2 \simeq 0$ and not at small distances.
- The non-perturbative dynamics are described by the so called light cone wave functions.

LCQSR for the Magnetic Moments

- In order to obtain an expression for the magnetic moments, one starts from the following correlation function:

$$\Pi = i \int d^4x \, e^{ipx} \, \langle \gamma(q) | T\{\eta_B(x) \bar{\eta}_B(0)\} | 0 \rangle \ , \tag{1}$$

  where B is the baryon under consideration and η^B is a current having the quantum numbers of the B hadron.

- For $p^2 > 0$ the correlator can be calculated by inserting a complete set of hadronic states between the currents:

$$\begin{aligned} \Pi &= \frac{\langle 0|\eta_B|B(p_1)\rangle}{p_1^2 - m_B^2} \langle \gamma(q) B(p_1)|B(p_2)\rangle \frac{\langle B(p_2)|\bar{\eta}_B|0\rangle}{p_2^2 - m_B^2} \\ &+ \sum_h \frac{\langle 0|\eta_B|h(p_1)\rangle}{p_1^2 - m_h^2} \langle \gamma(q) h(p_1)|h(p_2)\rangle \frac{\langle h(p_2)|\bar{\eta}_B|0\rangle}{p_2^2 - m_h^2} \ , \end{aligned} \tag{2}$$

  where $p_2 = p_1 + q$ and $\{|B\rangle\,,\ |h\rangle\}$ forms a complete set of hadronic states.

- The matrix elements appearing in the expression for the correlation can be expressed as:

$$\langle 0|\eta_B|B(p)\rangle = \lambda_B u_B(p) \ , \tag{3}$$

$$\langle \gamma(q) B(p_1)|B(p_2)\rangle = \bar{u}_B(p_1) \left[(f_1 + f_2)\gamma_\mu + \frac{(p_1+p_2)_\mu}{2m_B} f_2 \right] u_B(p_2) \varepsilon^\mu \ , \tag{4}$$

  where ε is the polarization vector of the photon and the form factors f_i are functions of q^2

- The value of $f_1 + f_2$ at $q^2 = 0$ gives the magnetic moment of the baryon in units of natural magneton, i.e., $e\hbar/2m_B c$

- Substituting these expressions back into the correlator, one obtains the following expression for the correlation function:

$$\Pi = -\lambda_B^2 \varepsilon^\mu \frac{\not{p}_1 + m_B}{p_1^2 - m_B^2} \left[(f_1 + f_2)\gamma_\mu + \frac{(p_1 + p_2)_\mu}{2m_B} f_2 \right] \frac{\not{p}_2 + m_B}{p_2^2 - m_B^2} + \cdots \ , \tag{5}$$

  where $\cdots$ represents contributions from the higher states and of the continuum.

- At $q^2 = 0$, rearranging the various Dirac structures and showing only the coefficient of the structure $\not{p}_1 \not{\varepsilon} \not{q}$, the correlation function can be written as:

$$\Pi = -\lambda_B^2 \frac{1}{p_1^2 - m_B^2} \mu \frac{1}{p_2^2 - m_B^2} + \cdots \tag{6}$$

$$= \int_0^\infty ds_1 ds_2 \frac{\rho^B(s_1, s_2)}{(s_1 - p_1^2)(s_2 - p_2^2)} + \int_0^\infty ds_1 ds_2 \frac{\rho^h(s_1, s_2)}{(s_1 - p_1^2)(s_2 - p_2^2)} + \textit{subtraction terms} \ , \tag{7}$$

  where $\mu = (f_1 + f_2)\,|_{q^2=0}$ and $\rho^B(s_1, s_2) = -\lambda_B^2 \mu \delta(s_1 - m_B^2)\delta(s_1 - s_2)$. This is the final expression for the correlation function in terms of the phenomenological parameters.

- In the other kinematical region, when $p^2 << 0$, the main contribution to the correlation function is from small distances and hence one can use the OPE.
- For this purpose, one needs explicit expression for the interpolating currents.
- For the octet baryons, there are two different currents for each baryon and the most general current is a linear combination of the two:

$$
\begin{aligned}
\eta_p &= 2\epsilon_{abc}\sum_{\ell=1}^{2}\left(u^{aT}CA_1^\ell d^B\right)A_2^\ell u^c \ , \\
\eta_n &= n_p\left(u^c \rightarrow d^c\right) \ , \\
\eta_{\Sigma^0} &= \frac{1}{\sqrt{2}}\epsilon_{abc}\sum_{\ell=1}^{2}\Big[\left(u^{aT}CA_1^\ell s^b\right)A_2^\ell d^c - \left(d^{cT}CA_1^\ell s^b\right)A_2^\ell u^a\Big] \ , \\
\eta_\Lambda &= \frac{2}{\sqrt{6}}\epsilon_{abc}\sum_{\ell=1}^{2}\Big[-2\left(u^{aT}CA_1^\ell d^c\right)A_2^\ell s^c + \left(u^{aT}CA_1^\ell s^b\right)A_2^\ell d^c + \left(d^{cT}CA_1^\ell s^b\right)A_2^\ell u^a\Big] \ , \\
\eta_{\Xi^0} &= -2\epsilon_{abc}\sum_{\ell=1}^{2}\left(s^{aT}CA_1^\ell u^b\right)A_2^\ell s^c \ , \\
\eta_{\Sigma^+} &= \eta_{\Sigma^0}\left(d \rightarrow u\right) \ , \\
\eta_{\Sigma^-} &= \eta_{\Sigma^0}\left(u \rightarrow d\right) \ , \\
\eta_{\Xi^-} &= \eta_{\Xi^0}\left(u \rightarrow d\right) \ ,
\end{aligned}
\tag{8}
$$

where $A_1^1 = 1$, $A_1^2 = t\gamma_5$, $A_2^1 = \gamma_5$, $A_2^2 = 1$ and t is arbitrary.

- Using these currents and the Wick theorem, one can write the correlation functions for the Λ and Σ^+ baryons as:

$$
\begin{aligned}
\Pi^{\Lambda} = & -\frac{2}{3}\epsilon_{abc}\epsilon_{def}\int d^4x e^{ipx}\langle\gamma|\sum_{\ell=1}^{2}\sum_{k=1}^{2}\Big\{4A_2^\ell S_s^{be}(x)A_2^k\,\mathrm{Tr}S_d^{cf}(x)CA_1^k S_u^{adT}(x)CA_1^\ell \\
+ & \; 2A_2^\ell S_s^{be}(x)CA_1^k S_u^{adT}(x)CA_1^\ell S_d^{cf}(x)A_2^k - 2A_2^\ell S_s^{be}(x)CA_1^k S_d^{cfT}(x)(CA_1^\ell)^T S_u^{ad}(x)A_2^k \\
+ & \; 2A_2^\ell S_d^{cf}(x)CA_1^k S_u^{adT}(x)CA_1^\ell S_s^{be}(x)A_2^k + A_2^\ell S_d^{cf}(x)A_2^k\,\mathrm{Tr}S_s^{be}(x)CA_1^k S_u^{adT}(x)CA_1^\ell \\
- & \; A_2^\ell S_d^{cf}(x)(CA_1^k)^T S_s^{beT}(x)(CA_1^\ell)^T S_u^{ad}(x)A_2^k - 2A_2^\ell S_u^{ad}(x)(CA_1^k)^T S_d^{cfT}(x)CA_1^\ell S_s^{be}(x)A_2^k \\
- & \; A_2^\ell S_u^{ad}(x)(CA_1^k)^T S_s^{beT}(x)(CA_1^\ell)^T S_d^{cf}(x)A_2^k + A_2^\ell S_u^{ad}(x)A_2^k\,\mathrm{Tr}S_s^{be}(x)CA_1^k S_d^{cfT}(x)CA_1^\ell\Big\}|0\rangle \;,
\end{aligned} \tag{9}
$$

$$
\begin{aligned}
\Pi^{\Sigma^+} = & -2\epsilon_{abc}\epsilon_{def}\int d^4x e^{ipx}\langle\gamma|\sum_{\ell=1}^{2}\sum_{k=1}^{2}\Big\{A_2^\ell S_u^{cf}(x)A_2^k\,\mathrm{Tr}S_s^{be}(x)CA_1^k S_u^{adT}(x)CA_1^\ell \\
+ & \; A_2^\ell\Big[S_u^{cf}(x)(CA_1^k)^T S_s^{beT}(x)(CA_1^\ell)^T S_u^{ad}(x)A_2^k + S_u^{ad}(x)(CA_1^k)^T S_s^{beT}(x)(CA_1^\ell)^T S_u^{cf}(x)A_2^k \\
+ & \; S_u^{ad}(x)A_2^k\,\mathrm{Tr}S_s^{be}(x)CA_1^k S_d^{cfT}(x)CA_1^\ell\Big]\Big\}|0\rangle \;,
\end{aligned} \tag{10}
$$

- The photon can be emitted by any one of the quarks either perturbatively

$$
S_{q\,\alpha\beta}^{\;ab} \rightarrow 2ee_q\left(\int dy\,\mathcal{F}^{\mu\nu}y_\nu S_q^{free}(x-y)\gamma_\mu S_q^{free}(y)\right)_{\alpha\beta}^{ab} \;, \tag{11}
$$

where the Fock–Schwinger gauge $x^\mu A_\mu(x)=0$ is used

- ...or non perturbatively

$$S_{q\,\alpha\beta}^{\,ab} \to -\frac{1}{4}\bar{q}^a A_j q^b (A_j)_{\alpha\beta}\ , \tag{12}$$

where $A_j \in \left\{1,\ \gamma_5,\ \gamma_\alpha,\ i\gamma_5\gamma_\alpha,\ \sigma_{\alpha\beta}/\sqrt{2}\right\}$ and sum over A_j is implied.

- The contributions of the non-perturbative contributions can be written in terms of photon wave functions defined as [2, 3]:

$$\begin{aligned}
\langle\gamma(q)|\bar{q}\gamma_\alpha\gamma_5 q|0\rangle &= \frac{f}{4} e_q \epsilon_{\alpha\beta\rho\sigma}\varepsilon^\beta q^\rho x^\sigma \int_0^1 du\, e^{iuqx}\psi(u)\ ,\\
\langle\gamma(q)|\bar{q}\sigma_{\alpha\beta} q|0\rangle &= ie_q\langle\bar{q}q\rangle \int_0^1 du\, e^{iuqx}\Bigg\{(\varepsilon_\alpha q_\beta - \varepsilon_\beta q_\alpha)\Big[\chi\phi(u) + x^2\Big(g_1(u) - g_2(u)\Big)\Big]\\
&+ \Big[qx(\varepsilon_\alpha x_\beta - \varepsilon_\beta x_\alpha) + \varepsilon x(x_\alpha q_\beta - x_\beta q_\alpha)\Big] g_2(u)\Bigg\}\ ,
\end{aligned} \tag{13}$$

where χ is the magnetic susceptibility of the quark condensate, $\phi(u)$ and $\psi(u)$ are the leading twist–2 photon wave functions, while $g_1(u)$ and $g_2(u)$ are the twist–4 functions, respectively.

- In our calculations the s-quark mass is considered only up to linear order, and as the quark propagator, we used:

$$
\begin{aligned}
S_q(x) &= \langle 0 \left| T \left\{ \bar{q}(x) q(0) \right\} \right| 0 \rangle \\
&= \frac{i \not{x}}{2\pi^2 x^4} - \frac{m_q}{4\pi^2 x^2} - \frac{\langle \bar{q} q \rangle}{12} \left(1 - \frac{i m_q}{4} \not{x} \right) - \frac{x^2}{192} m_0^2 \langle \bar{q} q \rangle \left(1 - \frac{i m_q}{6} \not{x} \right) \qquad (14) \\
&- i g_s \int_0^1 dv \left[\frac{\not{x}}{16\pi^2 x^2} G_{\mu\nu}(vx) \sigma^{\mu\nu} - v x^\mu G_{\mu\nu}(vx) \gamma^\nu \frac{i}{4\pi^2 x^2} - \frac{i m_q}{32\pi^2} G_{\mu\nu} \sigma^{\mu\nu} \left(\ln \frac{-x^2 \Lambda^2}{4} + 2\gamma_E \right) \right],
\end{aligned}
$$

- The expression for the coefficient of the structure $\sim \not{p}_1 \not{\varepsilon} \not{q}$ can be obtained after a straight forward but tedious calculation and then the spectral density can be extracted.

$$
\Pi^{OPE}(p_1^2, p_2^2) = \int_0^\infty ds_1 ds_2 \frac{\rho^{OPE}(s_1, s_2)}{(s_1 - p_1^2)(s_2 - p_2^2)} + subtraction\ terms \qquad (15)
$$

- Now we have two representations of the correlation function in two different kinematical regions. These can be matched using dispersion relations.

- In order to eliminate the subtraction terms, the correlation functions are Borel transformed after which the sum rules can be written in the form:

$$
-\lambda_B^2 \mu e^{-m_B^2 \left(\frac{1}{M_1^2} + \frac{1}{M_2^2} \right)} + \int_D \rho^h(s_1, s_2) e^{-\frac{s_1}{M_1^2}} e^{-\frac{s_2}{M_2^2}} = \int_0^\infty ds_1 ds_2 \rho^{OPE}(s_1, s_2) e^{-\frac{s_1}{M_1^2}} e^{-\frac{s_2}{M_2^2}} \qquad (16)
$$

- Besides eliminating the subtraction terms, Borel transformation also exponentially suppresses the contributions of the higher states and the continuum.

- The contribution of the higher states and continuum are modeled using the quark hadron duality, i.e.

$$\rho^h(s_1,s_2) = \rho^{OPE}(s_1,s_2)\theta(s_1-s_0)\theta(s_1-s_0') \tag{17}$$

- And the final sum rules are obtained from

$$-\lambda_B^2 \mu e^{-\frac{m_B^2}{M^2}} = \int_0^{s_0} ds_1 ds_2 \rho^{OPE}(s_1,s_2) e^{-\frac{s_1}{M_1^2}} e^{-\frac{s_2}{M_2^2}} \tag{18}$$

where $\frac{1}{M^2} = \frac{1}{M_1^2} + \frac{1}{M_2^2}$

- $\lambda_B^2 e^{-\frac{m_B^2}{M^2}}$ can be calculated similarly using the QCDSR starting from the correlation function:

$$\Pi = i\int d^4x\, e^{ipx}\, \langle 0|T\{\eta_B(x)\bar{\eta}_B(0)\}|0\rangle \ , \tag{19}$$

which has the phenomenological representation:

$$\Pi = i\lambda_B^2 \frac{\not{p}_B + m_B}{p_B^2 - m_B^2} + \cdots \tag{20}$$

which becomes

$$\Pi = i\lambda_B^2 e^{-\frac{m_B^2}{M^2}} \left(\not{p}_B + m_B\right) \tag{21}$$

after Borel transforming with respect to p_B^2.

$$
\begin{aligned}
\lambda_\Lambda^2 \mu_\Lambda e^{-M^2/M_\Lambda^2} = & \\
& \frac{1}{192\pi^4} M^6 E_2(x)\Big[(-1+t^2)(e_u+e_d)+(13+10t+13t^2)e_s\Big] \\
- & \frac{m_s}{48\pi^2} M^4 E_1(x)(-5+4t+t^2)\chi\varphi(u_0)\langle\bar{q}q\rangle(e_u+e_d) \\
- & \frac{1}{96\pi^2} M^4 E_1(x) f\psi(u_0)\Big[(-1+t)^2(e_u+e_d)+(13+10t+13t^2)e_s\Big] \\
+ & \frac{m_s}{12\pi^2} M^2 E_0(x)(-1-4t+5t^2)\langle\bar{q}q\rangle\left(\gamma_E-\ln\frac{M^2}{\Lambda^2}\right)e_s \\
- & \frac{m_s}{288\pi^2} m_0^2\langle\bar{q}q\rangle\Big[9(-1+t^2)(e_u+e_d)+(-3-12t+16t^2)e_s\Big]\left(\gamma_E-\ln\frac{M^2}{\Lambda^2}\right) \\
- & \frac{2}{9}\Big[g_1(u_0)-g_2(u_0)\Big]\langle\bar{q}q\rangle\Big[(-5+4t+t^2)\langle\bar{s}s\rangle+(-1+t)^2\langle\bar{q}q\rangle\Big](e_u+e_d) \\
+ & \frac{m_s}{6\pi^2}(-5+4t+t^2)\Big[g_1(u_0)-g_2(u_0)\Big]M^2E_0(x)\langle\bar{q}q\rangle(e_u+e_d) \\
+ & \frac{4}{9}(-1-4t-5t^2)\Big[g_1(u_0)-g_2(u_0)\Big]\langle\bar{s}s\rangle\langle\bar{u}u\rangle e_s \\
+ & \frac{m_s}{48\pi^2} M^2 E_0(x)\Big[(-1+t)^2\langle\bar{s}s\rangle-2(-5+4t+t^2)\langle\bar{u}u\rangle\Big](e_u+e_d) \\
+ & \frac{m_s}{12\pi^2} M^2\langle\bar{u}u\rangle(-1-4t+5t^2)e_s \\
+ & \frac{1}{18} M^2 E_0(x)\chi\varphi(u_0)\langle\bar{q}q\rangle\Big[(-5+4t+t^2)\langle\bar{s}s\rangle+(-1+t)^2\langle\bar{q}q\rangle\Big](e_u+e_d) \\
+ & \frac{1}{9} M^2 E_0(x)\chi\varphi(u_0)\langle\bar{s}s\rangle\langle\bar{q}q\rangle e_s \\
- & \frac{m_s}{72} f\psi(u_0)\Big[(-1+t)^2\langle\bar{s}s\rangle-2(-5+4t+t^2)\langle\bar{q}q\rangle\Big](e_u+e_d) \\
- & \frac{1}{144} m_0^2\chi\varphi(u_0)\langle\bar{u}u\rangle\Big[2(-5+4t+t^2)\langle\bar{s}s\rangle+(-3-2t+5t^2)\langle\bar{q}q\rangle\Big](e_u+e_d) \\
+ & \frac{1}{216} m_0^2(-3-12t+16t^2)\chi\varphi(u_0)\langle\bar{s}s\rangle\langle\bar{q}q\rangle e_s \\
+ & \frac{1}{19}\langle\bar{q}q\rangle\Big[(-5+4t+t^2)(e_u+e_d)+(-11-2t+13t^2)\langle\bar{q}q\rangle e_d\Big] \\
- & \frac{m_s}{288\pi^2} m_0^2\Big[(-1+t)^2\langle\bar{s}s\rangle-3(-5+4t+t^2)\langle\bar{q}q\rangle\Big](e_u+e_d)\ , \qquad (22)
\end{aligned}
$$

where

$$u_0 \ = \ \frac{M_2^2}{M_1^2 + M_2^2} \ . \tag{23}$$

In our calculations we set $M_1^2 = M_2^2 = 2M^2$, hence $u_0 = 1/2$.

$$\begin{aligned} M_\Lambda \lambda_\Lambda^2 e^{-M_\lambda^2/M^2} &= \\ & \frac{m_s}{192\pi^4}(-13+2t+11t^2)M^6 E_2(x) \\ &+ \ \frac{1}{48\pi^2}(1-t)\left\{(13+11t)\langle\bar{s}s\rangle + (1+5t)(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle)\right\} M^4 E_1(x) \\ &- \ \frac{m_0^2}{32\pi^2}(1-t^2)(4\langle\bar{s}s\rangle + \langle\bar{u}u\rangle + \langle\bar{d}d\rangle)M^2 E_0(x) \\ &+ \ \frac{m_s}{36}\left\{(1+4t-5t^2)\langle\bar{s}s\rangle(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle) + 6(5+2t+5t^2)\langle\bar{u}u\rangle\langle\bar{d}d\rangle\right\} \end{aligned} \tag{24}$$

$$\begin{aligned} \lambda_\Lambda^2 e^{-M_\Lambda^2/M^2} &= \\ & \frac{1}{256\pi^4}(5+2t+5t^2)M^6 E_2(x) \\ &+ \ \frac{1}{72}(1-t)m_0^2\left\{4(1+2t)\langle\bar{s}s\rangle(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle) + (25+23t)\langle\bar{u}u\rangle\langle\bar{d}d\rangle\right\}\frac{1}{M^2} \\ &+ \ \frac{m_s}{96\pi^2}\left\{3(5+2t+5t^2)\langle\bar{s}s\rangle + 2(1+4t-5t^2)(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle)\right\} M^2 E_0(x) \\ &+ \ \frac{m_s}{32\pi^2}m_0^2(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle)(1-t^2)\left\{\gamma_E - \ln\left(\frac{M^2}{\Lambda^2}\right)\right\} \\ &- \ \frac{1}{18}(1-t)\left\{(1+5t)\langle\bar{s}s\rangle(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle) + (13+11t)\langle\bar{u}u\rangle\langle\bar{d}d\rangle\right\} \\ &- \ \frac{m_s}{192\pi^2}m_0^2\left\{2(5+2t+5t^2)\langle\bar{s}s\rangle + (-5+4t+t^2)(\langle\bar{u}u\rangle + \langle\bar{d}d\rangle)\right\} \end{aligned} \tag{25}$$

Numerical Analysis

- In numerical calculations, the following forms of the photon wave functions are used [4, 3]:

$$\begin{aligned} \phi(u) &= 6u(1-u)~, \qquad \psi(u)=1~, \\ g_1(u) &= -\frac{1}{8}(1-u)(3-u)~, \qquad g_2(u)=-\frac{1}{4}(1-u)^2~. \end{aligned}$$

- The values of the other input parameters that are used in the numerical analysis are: $f=0.028~GeV^2$, $\chi=-4.4~GeV^{-2}$ [5](in [6] this quantity is estimated to be $\chi=-3.3~GeV^{-2}$), $\langle\bar{q}q\rangle(1~GeV)=-(0.243)^3~GeV^3$, $m_0^2=(0.8\pm0.2)~GeV^2$ [7], $m_s(1~GeV)=(150\pm50)~MeV$ and $\langle\bar{s}s\rangle(1~GeV)=0.8\langle\bar{q}q\rangle(1~GeV)$.

- The analysis should be carried out in several steps:

  * Find the region of the Borel parameter M^2 in which the sum rules for the magnetic moments are independent of M^2

  * Find the region of t where the mass sum rules make sense, i.e. the mass sum rule for $\lambda_B^2 e^{-\frac{m_B^2}{M^2}}$ is positive definite, and the predicted mass is stable with respect to the variations of this parameter.

  * Find the region of t where the predictions for the magnetic moments do not have a strong sensitivity on t

- The Borel mass parameter M^2 should be big enough to suppress the contributions of the higher dimensional operators in the OPE which are neglected and small enough to suppress the contributions of the higher states and the continuum.

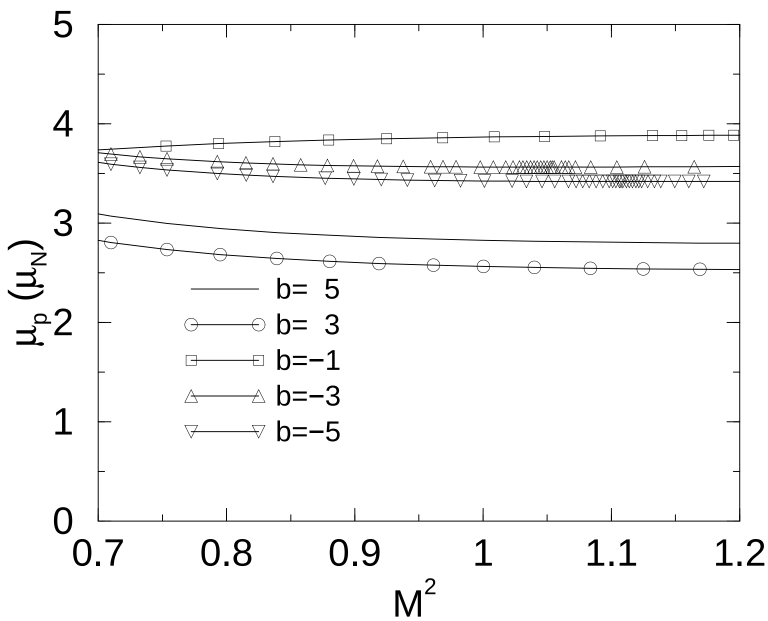

Figure 1: The dependence of μ_p on M^2 at $s_0 = 2\ GeV^2$.

- The working region for the Borel mass squared parameter for the members of octet baryons are found to be:
$0.9\ GeV^2 < M^2 < 1.3\ GeV^2$ for $p,\ n$;
$1.3\ GeV^2 < M^2 < 1.7\ GeV^2$ for $\Sigma^-,\ \Sigma^0,\ \Sigma^+$ and Λ;
$1.7\ GeV^2 < M^2 < 2.1\ GeV^2$ for Ξ^0 and Ξ^-

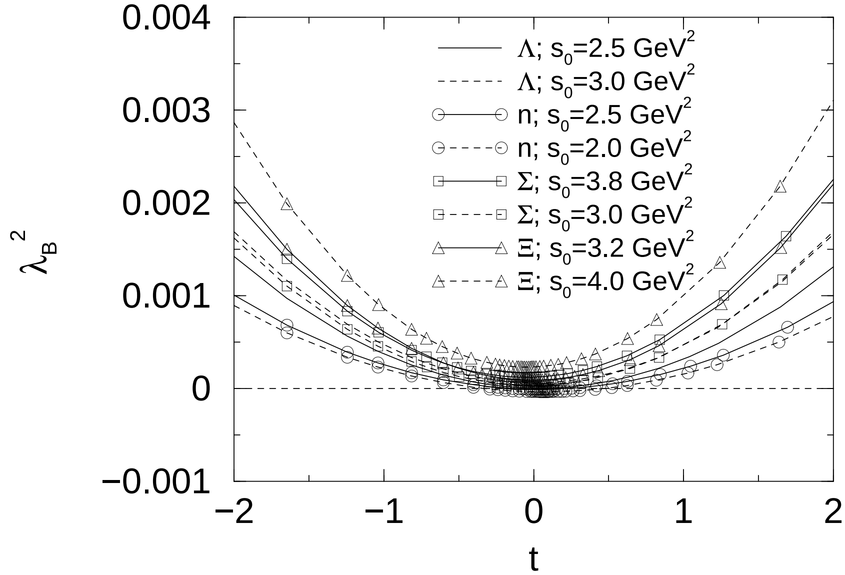

Figure 2: The dependence of λ_B on t for all the baryons.

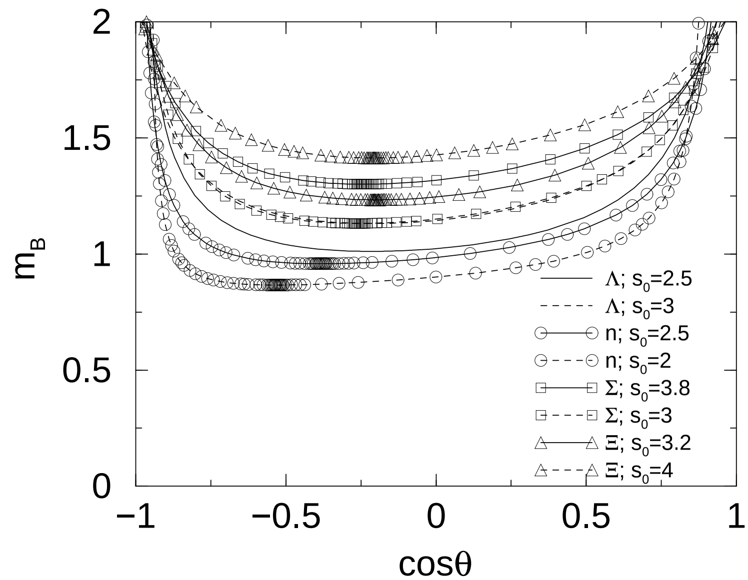

Figure 3: The dependence of m_B on $\cos\theta$, where $t = \tan\theta$, for all the baryons

- Both criteria on t are satisfied in the region $t < -1.7 (\cos\theta > -0.5)$ or $t > 2.3 (\cos\theta < 0.4)$. Ioffe current $(t = -1)$ is not in this region.

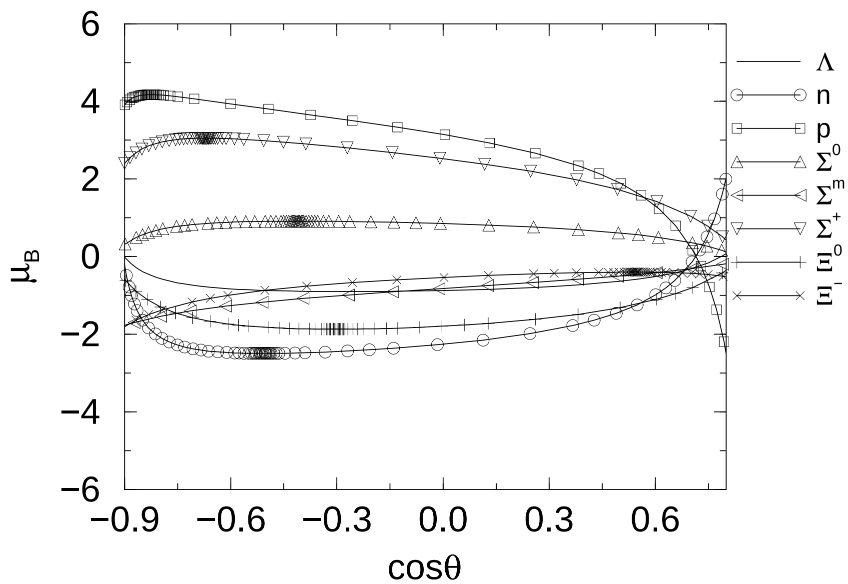

Figure 4: The dependence of μ_B on $\cos\theta$ at the continuum threshold $s_0 = 2.0\ GeV^2$ (for p and n), $s_0 = 2.5\ GeV^2$ (for Λ), $s_0 = 3.0\ GeV^2$ (for Σ), and at $M^2 = 1\ GeV^2$ (for p and n), $M^2 = 1.5\ GeV^2$ (for Σ and Λ) and $M^2 = 1.9\ GeV^2$ (for Ξ).

- The predicted magnetic moments are not sensitive to the precise value of t for $t > 3.2(\cos\theta < 0.3)$ or $t < -1.4$ $(\cos\theta > -0.6)$.
- Combining with the previous analysis of the mass sum rules, the working region of t is found to be $t < -1.7$ or $t > 3.2$.

	NQM	SQM	QCDSR		QCDSA	χPT	SKRM	LCQSR		EXP
			$\chi = -3.3$	$\chi = -4.4$				$\chi = -3.3$	$\chi = -4.4$	
μ_p	2.79	2.75	2.72	3.55	2.54	2.793	2.36	2.7 ± 0.5	3.5 ± 0.5	2.79
μ_n	-1.91	-1.84	-1.65	-2.06	-1.69	-1.913	-1.87	-1.8 ± 0.35	-2.3 ± 0.4	-1.91
μ_{Σ^+}	2.67	2.65	2.52	3.30	2.48	2.458	2.41	2.2 ± 0.4	2.9 ± 0.4	2.46 ± 0.01
μ_{Σ^0}	0.79	$--$	$--$	0.7[13]	0.8	0.649	0.66	0.5 ± 0.10	0.65 ± 0.15	$--$
μ_{Σ^-}	-1.09	-1.02	-1.13	-1.38	-0.90	-1.16	-1.10	-0.8 ± 0.2	-1.1 ± 0.3	-1.16 ± 0.03
μ_{Ξ^0}	-1.43	-1.44	-1.18	-1.27	-1.49	-1.25	-1.96	-1.3 ± 0.3	-1.3 ± 0.4	-1.25 ± 0.01
μ_{Ξ^-}	-0.53	-0.52	-0.89	-0.98	-0.63	-0.6531	-0.84	-0.7 ± 0.2	-1.0 ± 0.2	-0.65
μ_Λ	-0.61	-0.67	-0.50	-0.80	-0.69	-0.613	-0.60	-0.7 ± 0.2	-0.9 ± 0.2	-0.61

Table 1: Predictions of various approaches for the octet baryon magnetic moments: naive quark model (NQM, see ref. in [8]); static quark model (SQM) [9]; QCD sum rules (QCDSR) [10]; QCD string approach (QCDSA) [11]; chiral perturbation theory (χPT) [12]; skyrme model (SKRM) [13]; present work (LCQSR). For completeness we present the experimental values of the octet baryons. All the values in the table are given in units of nuclear magneton μ_N.

Conclusion

- The magnetic moments of the octet baryons are analyzed within the framework of LCQSR using the general form of the currents.
- It is shown that the predicted values for the magnetic moments are close to the experimental values for $\chi = -3.3\ GeV^2$
- It should be stressed that the predictions are not reliable for $t = -1$ which corresponds to the Ioffe current.

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