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QCD coupling constants and VDM

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Plan of the report

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2. Light cone sum rules
for the VBB coupling constants

3. VDM and QCD SR results

4. Conclusion

1 Unitary symmetry and VDM

We begin with the old story with octet baryon charges, magnetic moments and strong coupling constants of octet baryons with light vector mesons. And we try to relate all these quantities.

We begin from the Lagrangian for VBB couplings. (We mantain only unitary indices although we take in mind that there are two kinds of VBB couplings, electric $g^{(e)}_{VBB}$ and magnetic $g^{(m)}_{VBB}$ ones.)

$$\sqrt{2}\mathcal{L}^{VBB} = (F+D)\bar{B}^{\alpha}_{\beta}B^{\gamma}_{\alpha}V^{\beta}_{\gamma}$$
$$+(D-F)\bar{B}^{\beta}_{\alpha}B^{\alpha}_{\gamma}V^{\gamma}_{\beta} - (D-F)\cdot Tr(\bar{B}B)\cdot TrV \ , \qquad (1)$$

that is

$g(\rho^0 pp) = F + D$**,** $g(\omega pp) = 3F - D$**,** $g(\phi pp) = 0$**,**

$g(\omega\Lambda\Lambda) = \frac{2}{3}(3F - 2D$**,**

$g(\phi\Lambda\Lambda) = \sqrt{2}(F + \frac{1}{3}D)$ **etc.**

Also we write the Lagrangian for the direct $V\gamma$ interaction as

$$\mathcal{L}^{V\gamma} = \frac{\sqrt{2}}{g_{V\gamma}}(V_1^1 - \frac{1}{3}TrV) = \frac{1}{g_{V\gamma}}(\rho^0 + \frac{1}{3}\omega - \frac{\sqrt{2}}{3}\phi), \tag{2}$$

that is $g_{\rho^0\gamma} = g_{V\gamma}$,

$g_{\omega\gamma} = 3g_{\rho^0\gamma}$,

$g_{\phi\gamma} = -3g_{\rho^0 V\gamma}/\sqrt{2}$.

Unitary part of the electromagnetic current for the electric coupling in terms of proton charge e could be written in terms of the F-type structure as

$$J^e = J_1^1 = \bar{B}_1^\alpha B_\alpha^1 - \bar{B}_\alpha^1 B_1^\alpha \tag{3}$$

Electromagnetic current for the magnetic coupling can be written as

$$J^m = J_1^1 = (\mu_F + \mu_D)\bar{B}_1^\alpha B_\alpha^1$$
$$+(-\mu_F + \mu_D)\bar{B}_\alpha^1 B_1^\alpha - \frac{2}{3}\mu_D \cdot Tr\bar{B}B. \tag{4}$$

wherefrom standard unitary formules for baryon magnetic moments follows.

But instead we could construct electric charges and magnetic moments of the octet baryons in terms of the electric and magnetic BBV couplings and $V\gamma$ ones upon using formula

$$e_B, \mu_B = \frac{g^{(e,m)}_{\rho BB}}{g_{\rho\gamma}} + \frac{g^{(e,m)}_{\omega BB}}{g_{\omega\gamma}} + \frac{g^{(e,m)}_{\phi BB}}{g_{\phi\gamma}}. \tag{5}$$

We write it in some details below for magnetic moments upon using Eq.(2) and also put $SU(3)$ results in terms of μ_F and μ_D:

Magnetic moment of the proton

$$\mu_p = \frac{F^m + D^m}{g_{\rho\gamma}} + \frac{3F^m - D^m}{g_{\omega\gamma}}$$
$$= \frac{2}{g_{\rho\gamma}}(F^m + \frac{1}{3}D^m) = \mu_F + \frac{1}{3}\mu_D. \tag{6}$$

Magnetic moment of the neutron

$$\mu_n = -\frac{F^m + D^m}{g_{\rho\gamma}} + \frac{3F^m - D^m}{g_{\omega\gamma}}$$
$$= \frac{2}{g_{\rho\gamma}}(-\frac{2}{3}D^m) = -\frac{2}{3}\mu_D.$$

Magnetic moment of the Σ^+ hyperon

$$\mu_{\Sigma^+} = \frac{2F^m}{g_{\rho\gamma}} + \frac{2F^m}{g_{\omega\gamma}} + \frac{\sqrt{2}(-F^m + D^m)}{g_{\phi\gamma}}$$

$$= \frac{2}{g_{\rho\gamma}}(F^m + \frac{1}{3}D^m) = \mu_F + \frac{1}{3}\mu_D.$$

Magnetic moment of the Σ^- hyperon

$$\mu_{\Sigma^-} = -\frac{2F^m}{g_{\rho\gamma}} + \frac{2F^m}{g_{\omega\gamma}} + \frac{\sqrt{2}(-F^m + D^m)}{g_{\phi\gamma}}$$

$$= \frac{2}{g_{\rho\gamma}}(-F^m + \frac{1}{3}D^m) = -\mu_F + \frac{1}{3}\mu_D.$$

Magnetic moment of the Σ^0 hyperon

$$\mu_{\Sigma^0} = 0 + \frac{2F^m}{g_{\omega\gamma}} + \frac{\sqrt{2}(-F^m + D^m)}{g_{\phi\gamma}}$$

$$= \frac{2}{g_{\rho\gamma}}(\frac{1}{3}D^m) = \frac{1}{3}\mu_D.$$

Magnetic moment of the Ξ^0 hyperon

$$\mu_{\Xi^0} = -\frac{-F^m + D^m}{g_{\rho\gamma}} - \frac{-F^m + D^m}{g_{\omega\gamma}} + \frac{\sqrt{2}(-2F^m)}{g_{\phi\gamma}}$$
$$= \frac{2}{g_{\rho\gamma}}(-\frac{2}{3}D^m) = -\frac{2}{3}\mu_D.$$

Magnetic moment of the Ξ^- hyperon

$$\mu_{\Xi^-} = \frac{-F^m + D^m}{g_{\rho\gamma}} - \frac{-F^m + D^m}{g_{\omega\gamma}} + \frac{\sqrt{2}(-2F^m)}{g_{\phi\gamma}}$$
$$= \frac{2}{g_{\rho\gamma}}(-F^m + \frac{1}{3}D^m) = -\mu_F + \frac{1}{3}\mu_D.$$

Magnetic moment of the Λ hyperon

$$\mu_{\Lambda} = \frac{2(3F^m - 2D^m}{3g_{\omega\gamma}} - \frac{\sqrt{2}(3F^m + D^m)}{3g_{\phi\gamma}}$$
$$= \frac{2}{g_{\rho\gamma}}(-\frac{1}{3}D^m) = -\frac{1}{3}\mu_D.$$

We see that magnetic moments are of the same form as given by $SU(3)$ with renormalized F and D couplings

$$\mu_F = \frac{2F^m}{g_{\rho\gamma}}, \qquad \mu_D = \frac{2D^m}{g_{\rho\gamma}}.$$

Electric charges of baryons could also be obtained in this way, they are just read from magnetic mmoments by changing μ_F to e and putting μ_D=0.

The same electric charges are deduced from the formules in terms of D^e and F^e similar to those for magnetic moments with D^e=0 and $2F^e$=$g_{\rho\gamma}$.

This equality gives us some kind of criterium for distinguishing between the models if we beleive in VDM.

The electric couplings seems to be even more important as they impose the strict equality of $g_{\rho\gamma}$ to $2F^e$.

The following correlation function is considered:

$$\Pi^{B_1\to B_2 V} = i\int d^4x e^{ipx}\left\langle V(q)\left|\mathcal{T}\left\{\eta_{B_2}(x)\bar{\eta}_{B_1}(0)\right\}\right|0\right\rangle \tag{7}$$

The correlator can be calculated in terms of the hadrons, as well as in the deep Euclidean region $p^2 \to -\infty$, in terms of the quark and gluon degrees of freedom.

To construct the phenomenological part of the correlator we insert a complete set of intermediate states with the quantum numbers of current operators η_B. After isolating the ground state baryons:

$$\begin{aligned}\Pi^{B_1\to B_2 V}(p_1^2,p_2^2) = \frac{\left\langle 0\left|\eta_{B_2}\right|B_2(p_2)\right\rangle}{p_2^2-m_2^2}\times \\ \left\langle B_2(p_2)V(q)\mid B_1(p_1)\right\rangle \frac{\left\langle B_1(p_1)\left|\bar{\eta}_{B_1}\right|0\right\rangle}{p_1^2-m_1^2}+\cdots\ ,\end{aligned} \tag{8}$$

$p_1 = p_2 + q$, m_i **is the mass of baryon** B_i, **and** $\cdots$ **means contributions of the higher states and the continuum.**

Matrix elements are defined as:

$$\langle 0\,|\eta_{B_i}|\,B_i(p_i)\rangle=\lambda_{B_i}u(p_i)\ \ ,\langle B_2(p_2)V(q)\,|\,B_1(p_1)\rangle$$
$$=\bar{u}(p_2)[f_1\gamma_\mu - f_2\frac{i}{m_1+m_2}\sigma_{\mu\nu}q^\nu]u(p_1)\varepsilon^\mu\ \ , \tag{9}$$

λ_{B_i} **is the overlap amplitude for baryon** B_i**.**

Phenomenological part of the correlator reads

$$\Pi^{B_1\to B_2}=\frac{\lambda_{B_1}\lambda_{B_2}}{(p_1^2-m_1^2)(p_2^2-m_2^2)}\varepsilon^\mu(\not{p}_2+m_2)$$
$$\{f_1\gamma_\mu - f_2\frac{i}{m_1+m_2}\sigma_{\mu\nu}q^\nu\}(\not{p}_1+m_1)$$
$$= i\frac{\lambda_{B_1}\lambda_{B_2}}{(p^2-m_2^2)[(p+q)^2-m_1^2]}$$
$$\{\not{p}\not{\varepsilon}\not{q}(f_1+f_2)+2(\varepsilon\cdot p)\not{p}f_1+(m_1-m_2)\not{p}\not{\varepsilon}$$
$$+2m_2(\varepsilon\cdot p)+(m_1m_2-p^2)\not{\varepsilon}f_1$$

$$+\frac{f_2}{m_1+m_2}[\not{p}\not{\varepsilon}((p+q)^2-p^2)-2(\varepsilon\cdot p)\not{p}\not{q}$$
$$+(p^2+m_1m_2)\not{\varepsilon}\not{q}+m_2((p+q)^2-p^2)\not{\varepsilon}-2m_1(\varepsilon\cdot p)\not{q}]\}$$

Correlation function contains numerous structures and none of the structures has any apparent advantage over any other. So any of them can be used for QCD SR's. But our analysis shows that the structures $\not p \not\varepsilon \not q$ and $\not p(\varepsilon \cdot p)$ exhibit better convergence and we choose them.

Baryon interpolating currents are:

$$\eta^{\Sigma^0} = \sqrt{\frac{1}{2}}\epsilon^{abc}[(u^{aT}Cs^b)\gamma_5 d^c - (s^{aT}Cd^b)\gamma_5 u^c$$
$$+\beta(u^{aT}C\gamma_5 s^b)d^c - \beta(s^{aT}C\gamma_5 d^b)u^c] \ ,$$

where C is the charge conjugation operator, (a, b, c) are the color indices and β is an arbitrary parameter and $\beta = -1$ corresponds to the Ioffe current. All the currents except the Λ one can be derived from the Σ^0 current by making simple replacements.

Also Λ current can also be obtained from Σ^0 current with the help of following relations:

$$2\eta^{\Sigma^0}(d \leftrightarrow s) + \eta^{\Sigma^0} = \sqrt{3}\Lambda \ ,$$
$$2\eta^{\Sigma^0}(u \leftrightarrow s) - \eta^{\Sigma^0} = -\sqrt{3}\Lambda \ . \quad (10)$$

Correlation functions for VBB coupling constants can be written in terms of only two invariant functions for each coupling, of the electric and magnetic type.

It is clear that in the limit with all the parameters equal we should obtain only two functions of the D- and F- type. But otherwise it turns out to be rather strange.

First we have found 4 independent functions, then we have realized that they are only 3.

And finally we have proved with explicit calculation that there only are 2 independent functions which we have named Π_1, Π_3,

and Π_2 is instead

$$\Pi_2(u,d,s) = \Pi_1(u,d,s) + \Pi_1(u,s,d) + \sqrt{2}\Pi_3^{sym}(u,d,s)$$

We put the formula for $\Sigma^0\Sigma^0V$ channel

$$\Pi^{\Sigma^0\Sigma^0V}(u,d,s;M^2,s_0,\beta) = g_{Vuu}\Pi_1(u,d,s;M^2,s_0,\beta)$$

$$+g_{Vdd}\Pi_1(d,u,s;M^2,s_0,\beta) + g_{Vss}\Pi_2(u,d,s;M^2,s_0,\beta)$$

Some other channels are

$$
\begin{aligned}
\Pi^{n\to n\rho^0} &= \frac{1}{\sqrt{2}}\Pi_2(d,d,u) - \sqrt{2}\Pi_1(d,d,u)\ , \\
\Pi^{\Xi^0\to\Xi^0\rho^0} &= \frac{1}{\sqrt{2}}\Pi_2(s,s,u)\ , \\
\Pi^{\Xi^-\to\Xi^-\rho^0} &= -\frac{1}{\sqrt{2}}\Pi_2(s,s,d)\ .
\end{aligned} \tag{11}
$$

$$
\begin{aligned}
\Pi^{\Sigma^+\to\Sigma^+\omega} &= \sqrt{2}\Pi_1(u,u,s)\ , \\
\Pi^{\Sigma^-\to\Sigma^-\omega} &= \sqrt{2}\Pi_1(d,d,s)\ , \\
\Pi^{\Xi^0\to\Xi^0\omega} &= \frac{1}{\sqrt{2}}\Pi_2(s,s,u)\ , \\
\Pi^{\Xi^-\to\Xi^-\omega} &= \frac{1}{\sqrt{2}}\Pi_2(s,s,d)\ , \\
\Pi^{\Sigma^0\to\Sigma^0\phi} &= \Pi_2(u,d,s)\ , \\
\Pi^{\Sigma^+\to\Sigma^+\phi} &= \Pi_2(u,u,s)\ , \\
\Pi^{\Sigma^-\to\Sigma^-\phi} &= \Pi_2(d,d,s)\ , \\
\Pi^{\Xi^0\to\Xi^0\phi} &= 2\Pi_1(s,s,u)\ , \\
\Pi^{\Xi^-\to\Xi^-\phi} &= 2\Pi_1(s,s,d)\ ,
\end{aligned} \tag{12}
$$

QCD sum rules for vector-meson baryon couplings

Electric-type coupling

$$f_1 = \frac{\kappa}{\lambda_B^2} \Pi^{f_1}(u, d, s; M^2, s_0, \beta)$$

Magnetic-type coupling

$$f_{1+2} = f_1 + f_2 = \frac{\kappa}{\lambda_B^2} \Pi^{f_1+f_2}$$

$$\kappa = e^{-(m_B^2/M^2)-(m_V^2/M^2)}$$

El.coupl. $f_1^{channel}$	LC QCD AlievD80	$F^e = 3.2$, $D^e = -0.6$	QCD SR Zhu	QCD SR Erkol	QCD SR WangD75
$f_1^{pp\rho^0}$	2.5±1.1	2.6	2.5 ± 0.2	2.4 ± 0.6	3.2± 0.9
$f_1^{pp\omega}$	8.9±1.5	10.2	18 ± 8	7.2 ± 1.8	—
$f_1^{\Xi^0\Xi^0\rho^0}$	4.2±2.1	3.8	—	2.4 ± 0.6	1.5 ± 1.1
$f_1^{\Xi^0\Xi^0\omega}$	4.4±1.0	3.8	—	2.4	—
$f_1^{\Xi^0\Xi^0\phi}$	9.5±2.5	9.1	—	6.6*	—
$f_1^{\Sigma^+\Sigma^+\rho^0}$	7.2±1.2	6.4	—	4.8	4.0±1.0
$f_1^{\Sigma^+\Sigma^+\omega}$	6.6±1.0	6.4	—	4.8	—
$f_1^{\Sigma^+\Sigma^+\phi}$	6.0±0.8	5.4	—	3.3*	—
$f_1^{\Lambda\Lambda\omega}$	7.1±1.1	7.2	—	4.8 ± 1.2	—
$f_1^{\Lambda\Lambda\phi}$	5.3±1.5	4.2	—	3.3*	—
$f_1^{\Lambda\Sigma^0\rho^0}$	1.9±0.7	0.6	—	—	—

Magn. $f_{1+2}^{channel}$	Aliev D80	SU(3) VBB	$F^m = 9.1$, $D^m = 12.3$	SR Zhu	SR Erkol	SR WangD75
$f_{1+2}^{pp\rho^0}$	19.7 ±2.8	$F^m + D^m$	21.4	21.6 ± 6.6	10.1 ± 3.7	36.8 ± 13
$f_{1+2}^{pp\omega}$	14.5 ±2.6	$3F^m - D^m$	15.0	32.4 ± 14.4	5.0 ± 1.2	—
$f_{1+2}^{\Xi^0\Xi^0\rho^0}$	- 2.8 ±1.6	$F^m - D^m$	-3.2	—	-3.6 ± 1.6	- 5.3 ± 3.3
$f_{1+2}^{\Xi^0\Xi^0\omega}$		$F^m - D^m$	-3.2	—	2.5*	—
$f_{1+2}^{\Xi^0\Xi^0\phi}$	22.8 ±6.4	$2\sqrt{2}F^m$	25.7	—	-10.4*	—
$f_{1+2}^{\Sigma^+\Sigma^+\rho^0}$	17.8 ±2.2	$2F^m$	18.2	—	7.1 ± 1.0	53.5 ± 19
$f_{1+2}^{\Sigma^0\Sigma^0\omega}$		$2F^m$	18.2	—	7.5*	—
$f_{1+2}^{\Sigma^0\Sigma^0\phi}$	- 3.5 ±2.5	$\sqrt{2}(F^m - D^m)$	-4.5	—	3.6*	—
$f_{1+2}^{\Lambda\Lambda\omega}$	1.6 ±0.6	$\frac{2}{3}(3F^m - 2D^m)$	1.8	—	- 10.5*	—
$f_{1+2}^{\Lambda\Lambda\phi}$	19.3 ±5.0	$\sqrt{2}(F^m + \frac{1}{3}D^m)$	18.7	—	-1.5*	—
$f_{1+2}^{\Lambda\Sigma^0\rho^0}$	14.3 ±2.9	$\frac{2}{\sqrt{3}}D^m$	14.2	—	—	—

AlievD80 (F^e=3.2, D^e=-0.6)

$$f_1^{pp\rho^0} = \mathbf{2.5 \pm 1.1} \quad (\mathbf{2.6})$$

$$f_1^{pp\omega} = \mathbf{8.9 \pm 1.5} \quad (\mathbf{10.2})$$

$$f_1^{\Xi^0\Xi^0\rho^0} = \mathbf{4.2 \pm 2.1} \quad (\mathbf{3.8})$$

$$f_1^{\Xi^0\Xi^0\omega} = \mathbf{4.4 \pm 1.0} \quad (\mathbf{3.8})$$

$$f_1^{\Xi^0\Xi^0\phi} = \mathbf{9.5 \pm 2.5} \quad (\mathbf{9.1})$$

$$f_1^{\Sigma^+\Sigma^+\rho^0} = \mathbf{7.2 \pm 1.2} \quad (\mathbf{6.4})$$

$$f_1^{\Sigma^+\Sigma^+\omega} = \mathbf{6.6 \pm 1.0} \quad (\mathbf{6.4})$$

$$f_1^{\Sigma^+\Sigma^+\phi} = \mathbf{6.0 \pm 0.8} \quad (\mathbf{5.4})$$

$$f_1^{\Lambda\Lambda\omega} = \mathbf{7.1 \pm 1.1} \quad (\mathbf{7.2})$$

$$f_1^{\Lambda\Lambda\phi} = \mathbf{5.3 \pm 1.5} \quad (\mathbf{4.2})$$

$$f_1^{\Lambda\Sigma^0\rho^0} = \mathbf{1.9 \pm 0.7} \quad (\mathbf{0.6})$$

First we would see how VDM works deriving electric charges from the BBV couplings.

The idea is that there is should be some consistency between the strong couplings of the vector mesons to baryons and the corresponding electric charges.

As the first example we would present our results from T.M.Aliev, A.Ozpineci, M.Savci and V.Z., Phys.Rev. D80, 016010 (2009)
(AlievD80) along the same lines.

We start with the electric coupling constants.

It turns out that to make results consistent we should take the set of $V\gamma$ constants as $g_{\rho\gamma}$=6, $g_{\omega\gamma}$=18.0, $g_{\phi\gamma}$=16.4 and we get

$$G_E^p(q^2 = 0) = \frac{2.5^\rho}{6} + \frac{8.9^\omega}{18} = 0.912$$

$$G_E^n(0) = -\frac{2.5^\rho}{6} + \frac{8.9^\omega}{18} = -0.078$$

$$G_E^{\Sigma^+}(0) = \frac{7.2^\rho}{6} + \frac{6.6^\omega}{18} - \frac{6.0^\phi}{16.4} = 1.20$$

$$G_E^{\Sigma^-}(0) = -\frac{7.2^\rho}{6} + \frac{6.6^\omega}{18} - \frac{6.0^\phi}{16.4} = -1,20$$

$$G_E^{\Sigma^0}(0) = 0$$

$$G_E^{\Xi^0}(0) = \frac{4.2^\rho}{6} + \frac{4.4^\omega}{18} - \frac{9.5^\phi}{16.4} = 0.364$$

$$G_E^{\Xi^-}(0) = -\frac{4.2^\rho}{6} + \frac{4.4^\omega}{18} - \frac{9.5^\phi}{16.4} = -1.036$$

$$G_E^{\Lambda}(0) = 0 + \frac{7.1^\omega}{18} - \frac{5.3^\phi}{16.4} = 0.070.$$

The results for baryon electric charges are not brilliant but still rather reasonable.

Maybe we should consider only F-part of the charge disregarding that of D. We should for this purpose just to use only $\Pi_1(u,d,s)$ from AlievD80.

Really, our results are well reproduced by $F^{(e)}$=3.2 and $D^{(e)} = -$0.6,

so that $D^{(e)}/F^{(e)}$ ∼20%, which is just the declared percentage for the validity of the QCD SR's.

Now we consider magnetic moments and take values also from AlievD80.

With the same $V\gamma$ couplings we have:

$$G_M^p(q^2=0)=\frac{19.7^\rho}{6}+\frac{14.5^\omega}{18}=4.10(2.79exp)[2.74] \tag{13}$$

$$G_M^n(q^2=0)=-\frac{19.7^\rho}{6}-\frac{14.5^\omega}{18}$$
$$=-2.50(-1.91exp)[-1.87]$$

$$G_M^{\Sigma^+}(q^2=0)=\frac{17.8^\rho}{6}+\frac{18.2^\omega}{18}-\frac{3.5^\phi}{16.4}$$
$$=3.77(2.58exp)[2.51]$$

$$G_M^{\Sigma^-}(q^2=0)=-\frac{17.8^\rho}{6}+\frac{18.2^\omega}{18}-\frac{3.5^\phi}{16.4}=-2.17(-1.16exp)[-1.45]$$

$$G_M^{\Sigma^0}(q^2=0)=0+\frac{18.2^\omega}{18}-\frac{3.5^\phi}{16.4}=0.80;[0.53]$$

$$G_M^{\Xi^0}(q^2=0)=-\frac{2.8^\rho}{6}-\frac{3.2^\omega}{18}-\frac{22.8^\phi}{16.4}=$$
$$=-2.036(-1.250exp)[-1.36]$$

$$G_M^{\Xi^-}(q^2=0)=\frac{2.8^\rho}{6}-\frac{3.2^\omega}{18}-\frac{22.8^\phi}{16.4}=$$
$$=-1.100(-0.650exp)[-0.735]$$

$$G_M^{\Lambda}(q^2=0)=\frac{1.8^\omega}{18}-\frac{19.3^\phi}{16.4}=-1.080(-0.613exp)[-0.72]$$

We see that VDM in our case enlarge results for magnetic moments by factor 1.5.

Neither $SU(3)$ **pattern is seen here unambigously.**

We have seen this oversizing of the results of QCD sum rules in VDM already while discussing heavy-baryon gamma decays
in Aliev, Savci,V.Z.

Instead it is rather difficult to adjust similar quantities with the values given in, e.g., Zhi-Gang Wang, Phys.Rev. D75, 054020(2007) (WangD75).

Really, $f_1^{pp\rho}$=3.2 but $f_1^{\Sigma^+\Sigma^+\rho}$=4.0,

while it should be $\sim$ twice as great.

Also $f_1^{\Xi\Xi\rho}$=1.5 while it should be

of the same size as $f_1^{pp\rho}$.

The similar reasoning is valid for the magnetic-type constants.

Values $f_{1+2}^{pp\rho}$=36.8 and $f_{1+2}^{\Sigma^+\Sigma^+\rho}$=53.5,

do not permit to us even to try to apply VDM

From the other side the formulae of WangD75 shows perfect unitary pattern. Every some rule for octet baryons can be in fact written in terms of only two independent functions.

Let them be w and v. We put only those for electric-type couplings

$$w_V^e = -\frac{M^6}{12\pi^2}E_1(x)f_V m_V \phi_{||}(u_0) \tag{14}$$
$$+\frac{1}{16\pi^2}M^4 E_0(x)[A(u_0) + 16\int_0^{u_0} dt \int_0^t d\lambda C(\lambda)]f_V m_V^3$$
$$+(\frac{2}{3}\langle\langle\bar{q}q\rangle - \frac{1}{6}\frac{1}{M^2}\bar{q}g_s\sigma Gq\rangle)\, f_V^T m_V^2 h_{||}^{(s)}(u_0)$$
$$+\frac{1}{288M^2}\langle\frac{\alpha_s GG}{\pi}\rangle f_V m_V^3\,[-\frac{4M^2}{m_V^2}\phi_{||}(u_0) + A(u_0) + 24\int_0^{u_0} dt \int_0^t d\lambda C(\lambda)]$$

$$v_V^e = -\frac{M^6}{6\pi^2}E_1(x)f_V m_V \phi_{||}(u_0) \tag{15}$$
$$+\frac{1}{8\pi^2}M^4 E_1(x)[A(u_0) + 8\int_0^{u_0} dt \int_0^t d\lambda C(\lambda)]f_V m_V^3$$
$$+\frac{1}{144M^2}\langle\frac{\alpha_s GG}{\pi}\rangle f_V m_V^3\,[-\frac{4M^2}{m_V^2}\phi_{||}(u_0) + A(u_0)]$$

Analysis of these sum rules shows that the SU(3) breaking is mostly due to exponential factors coming from the Borel transformation and from suppression of the continuous spectrum and not from the terms containing corrections due to non-zero mass m_s.

We have tried to generalize them to include also couplings with ω and ϕ mesons. (If bad we cannot attribute it to Wang)

Our results are for ρ meson couplings $f_1^{pp\rho}$=2.8 (Wang 3.2), $f_1^{\Sigma^+\Sigma^+\rho}$=4.0 (Wang 4.0),
$f_1^{\Xi\Xi\rho}$=1.6 (Wang 1.5)

for ω and ϕ coupllings
$f_1^{pp\omega}$=6.5
$f_1^{\Sigma^+\Sigma^+\omega}$=4.0, $f_1^{\Sigma^+\Sigma^+\phi}$=1.0,
$f_1^{\Xi\Xi\omega}$=1.6, $f_1^{\Xi\Xi\phi}$=7.7

We have not obtain reasonable results for the baryon charges upon applying VDM.

We proceed with the work G.Erkol, R.G.E.Timmermans and Th.A.Rijken, Phys.Rev. C74, 045201(2006). (Erkol06.) The result with the exp values of $V\gamma$ constants is not very encouraging:

$$G_E^p(q^2=0) = \frac{2.4^\rho}{5.05} + \frac{7.2^\omega}{17.02} = 0.895$$

$$G_E^n(q^2=0) = -\frac{2.4^\rho}{5.05} + \frac{7.2^\omega}{17.02} = -0.055$$

$$G_E^{\Sigma^+}(q^2=0) = \frac{4.8^\rho}{5.05} + \frac{4.8^\omega}{17.02} - \frac{3.3^\phi}{12.89} = 1.17$$

.

$$G_E^{\Sigma^-}(q^2=0) = -\frac{4.8^\rho}{5.05} + \frac{4.8^\omega}{17.02} - \frac{3.3^\phi}{12.89} = -0.77$$

$$G_E^{\Sigma^0}(q^2=0) = 0 + \frac{4.8^\omega}{17.02} - \frac{3.3^\phi}{12.89} = 0.022$$

$$G_E^{\Lambda}(q^2=0) = 0 - \frac{4.8^\omega}{17.02} + \frac{3.3^\phi}{12.89} = -0.022$$

$$G_E^{\Xi^0}(q^2=0) = \frac{2.4^\rho}{5.05} + \frac{2.4^\omega}{17.02} - \frac{6.6^\phi}{12.89} = 0.103$$

$$G_E^{\Xi^-}(q^2=0) = -\frac{2.4^\rho}{5.05} + \frac{2.4^\omega}{17.02} - \frac{6.6^\phi}{12.89} = -0.847$$

But if we take now another set of $V\gamma$ constants that is the $g_{\phi\gamma}$ constant should be 9.9

(instead of 12.89),

other V-gamma constants should be

$g_{\rho\gamma}$**=4.8**

(the phenomenological value 5.05)

and $g_{\omega\gamma}$**=3x4.8=14.4**

(the phenomenological value 17.02)

the fit with a "click" became exact.

That is we reproduce exactly the charge pattern of the octet baryons through ρ, ω and ϕ contributions:

$$G_E^p(q^2=0) = \frac{2.4^\rho}{4.8} + \frac{7.2^\omega}{14.4} = 1$$

$$G_E^n(q^2=0) = -\frac{2.4^\rho}{4.8} + \frac{7.2^\omega}{14.4} = 0$$

$$G_E^{\Sigma^+}(q^2=0) = \frac{4.8^\rho}{4.8} + \frac{4.8^\omega}{14.4} - \frac{3.3^\phi}{9.9} = 1$$

.

$$G_E^{\Sigma^-}(q^2=0) = -\frac{4.8^\rho}{4.8} + \frac{4.8^\omega}{14.4} - \frac{3.3^\phi}{9.9} = -1$$

$$G_E^{\Sigma^0}(q^2=0) = 0 + \frac{4.8^\omega}{14.4} - \frac{3.3^\phi}{9.9} = 0$$

$$G_E^{\Lambda}(q^2=0) = 0 - \frac{4.8^\omega}{14.4} + \frac{3.3^\phi}{9.9} = 0$$

$$G_E^{\Xi^0}(q^2=0) = \frac{2.4^\rho}{4.8} + \frac{2.4^\omega}{14.4} - \frac{6.6^\phi}{9.9} = 0$$

$$G_E^{\Xi^-}(q^2=0) = -\frac{2.4^\rho}{4.8} + \frac{2.4^\omega}{14.4} - \frac{6.6^\phi}{9.9} = -1$$

Now with the same $V\gamma$ couplings of Erkol06 we go to the calculation of the magnetic moments:

$$G_M^p(q^2=0) = 1 + \frac{7.6^\rho}{4.8} - \frac{2.2^\omega}{14.4} = 2.49;$$

$$G_M^n(q^2=0) = -\frac{7.6^\rho}{4.8} - \frac{2.2^\omega}{14.4} = -1.81;$$

$$G_M^{\Sigma^+}(q^2=0) = 1 + \frac{2.7^\rho}{4.8} + \frac{2.7^\omega}{14.4} + \frac{6.9^\phi}{9.9} = 2.48;$$

•

$$G_M^{\Sigma^-}(q^2=0) = -1 - \frac{2.7^\rho}{4.8} + \frac{2.7^\omega}{14.4} + \frac{6.9^\phi}{9.9} = -0.69;$$

$$G_M^{\Lambda}(q^2=0) = -\frac{5.7^\omega}{14.4} - \frac{4.8^\phi}{9.9} = -0.90;$$

$$G_M^{\Xi^0}(q^2=0) = -\frac{4.9^\rho}{4.8} - \frac{4.9^\omega}{14.4} - \frac{3.8^\phi}{9.9} = -1.81;$$

$$G_M^{\Xi^-}(q^2=0) = -1 + \frac{4.9^\rho}{4.8} - \frac{4.9^\omega}{14.4} - \frac{3.8^\phi}{9.9} = -0.78;$$

We obtain in fact $SU(3)$ results which is reasonable as BBV couplings in Erkol06 are also given in the $SU(3)$ limit.

Our calculations show the inner consistency of the QCD results of AlievD80 and in a particular spectacular way those of Erkol06 and

prove our idea that upon using VDM hypothesis it could be possible to make conclusions as to the reliability of QCD sum rule results.

CONCLUSION

1. It is written explicitly relations between the VBB coupling constants and electromagnetic characteristics of baryons within VDM model in SU(3).

2. VBB coupling constants are derived within the QCD sum rules. Comparison with existing results are made.

3. VDM is applied to analyse consistency of the QCD SR's for several models.

4. Evaluation of the baryon electric charges seems to be convenient method for putting constraints on QCD SR parameters.

THANK YOU