PREDICTION OF COUPLING CONSTANT RATIO VALUES IN THE OCTET HYPERON EM STRUCTURE *Unitary & Analytic* MODELS

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INTRODUCTION

UNITARY AND ANALYTIC MODELS OF OCTET BARYON EM STRUCTURE

NUMERICAL VALUES OF COUPLING CONSTANT RATIOS IN BARYON EM STRUCTURE MODELS

CONCLUSIONS
1/2⁺ octet baryon EM structure

According to SU(3) group classification of hadrons, 1/2⁺ baryon octet consists of 
p, n, Λ, Σ⁺, Σ⁰, Σ⁻, Ξ⁰, Ξ⁻,
every of which is compound of 3 quarks ⇒ they naturally have to manifest some space structure.

For the first time it was discovered for p in elastic scattering process \( e^- p \rightarrow e^- p \) almost 70 years ago in the last century, before the quark structure of hadrons has been revealed.

Because electrons are dominantly interacting with p electromagnetically ⇒ proton EM structure, which can be simply extrapolated also to all members of 1/2⁺ octet baryons.
The EM structure of every baryon from $1/2^+$-octet is completely described by two independent functions $F_1^B(t)$ and $F_2^B(t)$, the Dirac and Pauli FFs, which are naturally obtained in a decomposition of the baryon matrix element of the EM current $J_{EM}^\mu(0)$ into a maximal number of linearly independent covariants to be constructed from four-momenta, $\gamma$-matrices and Dirac bispinors of baryons.

$$< B | J_{EM}^\mu(0) | B > = e \bar{u}(p') \gamma_\mu F_1^B(t) + \frac{i}{2m_B} \sigma_{\mu \nu} (p' - p)_\mu F_2^B(t) u(p) \quad (1)$$

While Dirac and Pauli FFs are suitable for a theoretical description of the baryon EM structure, for an extraction of experimental information on it from the measured quantities, like cross sections and polarizations, the Sachs electric $G_E^B(t)$ and magnetic $G_M^B(t)$ FFs are more suitable.
Further, in a description of the EM structure of baryons it is useful to arrange calculations in such a way, that advantage can be taken of isospin-conservation. As EM current has mixed transformation properties under rotation in isospin space:
- part of it transforms as an isoscalar
- and part as a third component of an isovector.

As a consequence, every baryon matrix element of the EM current may be expressed in terms of the matrix elements of an isoscalar and of an isovector currents.

The sign between them depends on the value of the third component of isospin of the concrete baryon from the $1/2^+$ baryon octet to be found by $T_3 = Q - \frac{B}{2} - \frac{S}{2}$. 
Then the relations between baryon Sachs FFs and isoscalar and isovector parts of the baryon Dirac and Pauli FFs are:

for "nucleons"

\[
G_E^p(t) = [F_{1s}^N(t) + F_{1\nu}^N(t)] + \frac{t}{4m_p^2} [F_{2s}^N(t) + F_{2\nu}^N(t)] \\
G_M^p(t) = [F_{1s}^N(t) + F_{1\nu}^N(t)] + [F_{2s}^N(t) + F_{2\nu}^N(t)]
\]

(2)

\[
G_E^n(t) = [F_{1s}^N(t) - F_{1\nu}^N(t)] + \frac{t}{4m_n^2} [F_{2s}^N(t) - F_{2\nu}^N(t)] \\
G_M^n(t) = [F_{1s}^N(t) - F_{1\nu}^N(t)] + [F_{2s}^N(t) - F_{2\nu}^N(t)]
\]

(3)

with normalizations

\[
G_E^p(0) = 1; \quad G_M^p(0) = \mu_p; \quad G_E^n(0) = 0; \quad G_M^n(0) = \mu_n;
\]

(4)

\[
F_{1s}^N(0) = F_{1\nu}^N(0) = \frac{1}{2}; \quad F_{2s}^N(0) = \frac{1}{2}(\mu_p + \mu_n - 1); \quad F_{2\nu}^N(0) = \frac{1}{2}(\mu_p - \mu_n - 1);
\]

(5)
1/2\(^+\) octet baryon EM structure

for "\(\Lambda\)-hyperon"

\[
G_E^\Lambda(t) = F_{1s}^\Lambda(t) + \frac{t}{4m_\Lambda^2} F_{2s}^\Lambda(t) \quad (6)
\]

\[
G_M^\Lambda(t) = F_{1s}^\Lambda(t) + F_{2s}^\Lambda(t) \quad (7)
\]

with normalizations

\[
G_E^\Lambda(0) = 0; \quad G_M^\Lambda(0) = \mu_\Lambda; \quad (7)
\]

\[
F_{1s}^\Lambda(0) = 0; \quad F_{2s}^\Lambda(0) = \mu_\Lambda; \quad (8)
\]
1/2\(^+\) octet baryon EM structure

for "\(\Sigma\)-hyperons"

\[
G_E^{\Sigma^+}(t) = [F_{1s}^{\Sigma}(t) + F_{1v}^{\Sigma}(t)] + \frac{t}{4m_{\Sigma^+}^2} [F_{2s}^{\Sigma}(t) + F_{2v}^{\Sigma}(t)]
\]

\[
G_M^{\Sigma^+}(t) = [F_{1s}^{\Sigma}(t) + F_{1v}^{\Sigma}(t)] + [F_{2s}^{\Sigma}(t) + F_{2v}^{\Sigma}(t)]
\]

\[
G_E^{\Sigma^0}(t) = F_{1s}^{\Sigma}(t) + \frac{t}{4m_{\Sigma^0}^2} F_{2s}^{\Sigma}(t)
\]

\[
G_M^{\Sigma^0}(t) = F_{1s}^{\Sigma}(t) + F_{2s}^{\Sigma}(t)
\]

\[
G_E^{\Sigma^-}(t) = [F_{1s}^{\Sigma}(t) - F_{1v}^{\Sigma}(t)] + \frac{t}{4m_{\Sigma^-}^2} [F_{2s}^{\Sigma}(t) - F_{2v}^{\Sigma}(t)]
\]

\[
G_M^{\Sigma^-}(t) = [F_{1s}^{\Sigma}(t) - F_{1v}^{\Sigma}(t)] + [F_{2s}^{\Sigma}(t) - F_{2v}^{\Sigma}(t)]
\]
1/2⁺ octet baryon EM structure

with normalizations

\[ G_E^{Σ^+}(0) = 1 \quad G_M^{Σ^+}(0) = \mu_{Σ^+} \quad G_E^{Σ^0}(0) = 0 \quad G_M^{Σ^0}(0) = \frac{1}{2}(\mu_{Σ^+} + \mu_{Σ^-}) \quad G_E^{Σ^-}(0) = -1 \quad G_M^{Σ^-}(0) = \mu_{Σ^-} \] (12)

\[ F_{1s}(0) = 0 \quad F_{1v}(0) = 1 \quad F_{2s}(0) = \frac{1}{2}(\mu_{Σ^+} + \mu_{Σ^-}) \quad F_{2v}(0) = \frac{1}{2}(\mu_{Σ^+} - \mu_{Σ^-}) - 1 \] (13)

for ”Ξ-hyperons”

\[ G_E^{Ξ^0}(t) = [F_{1s}(t) + F_{1v}(t)] + \frac{t}{4m_{Ξ^0}^2}[F_{2s}(t) + F_{2v}(t)] \] (14)

\[ G_M^{Ξ^0}(t) = [F_{1s}(t) + F_{1v}(t)] + [F_{2s}(t) + F_{2v}(t)] \]

\[ G_E^{Ξ^-}(t) = [F_{1s}(t) - F_{1v}(t)] + \frac{t}{4m_{Ξ^-}^2}[F_{2s}(t) - F_{2v}(t)] \] (15)

\[ G_M^{Ξ^-}(t) = [F_{1s}(t) - F_{1v}(t)] + [F_{2s}(t) - F_{2v}(t)] \]
$1/2^+ \text{ octet baryon EM structure}$

with normalizations

$$
G_{E}^{\Xi^0}(0) = 0 \quad G_{M}^{\Xi^0}(0) = \mu_{\Xi^0} \quad G_{E}^{\Xi^-}(0) = -1 \quad G_{M}^{\Xi^-}(0) = \mu_{\Xi^-}
$$

$$
F_{1s}^{\Xi}(0) = -\frac{1}{2} \quad F_{1v}^{\Xi}(0) = \frac{1}{2} \quad F_{2s}^{\Xi}(0) = \frac{1}{2}(\mu_{\Xi^0} + \mu_{\Xi^-} + 1) \quad F_{2v}^{\Xi}(0) = \frac{1}{2}(\mu_{\Xi^0} - \mu_{\Xi^-} - 1)
$$

where $\mu_B$ are the magnetic moments of $1/2^+ \text{ octet baryons}$.

Next we construct 9 resonance $\text{Unitary & Analytic models}$ of the $1/2^+ \text{ octet baryon EM FFs}$, which represent an unification of the following three fundamental features (besides other known properties) of the baryon EM FFs.
1. The experimental fact of creation of unstable vector-meson resonances $\rho, \omega, \phi, \rho', \omega', \phi', \rho'', \omega'', \phi''$, with photon quantum numbers in $e^+e^-$-annihilation processes into hadrons

*M. Tanabashi et al.* (PDG),

2. Similar hypothetical analytic properties for all baryon EM FFs

3. The asymptotic behavior of baryon EM FFs

$G_E^B(t) = G_M^B(t) \sim \frac{1}{t^2}$ to be proved also in the framework of QCD.
U&A models of baryon EM structure

The most simple way to take into account creation of unstable vector-meson resonances in $e^+e^- \rightarrow \text{had}$ processes is the naive VMD model for isoscalar and isovector parts of the Dirac and Pauli baryon FFs

\[ F_{1s}^B(t) = \sum_{i=\omega} \frac{m_i^2}{m_i^2 - t} (f_{i\bar{B}B}^{(1)}/f_i) ; \quad F_{2s}^B(t) = \sum_{i=\omega} \frac{m_i^2}{m_i^2 - t} (f_{i\bar{B}B}^{(2)}/f_i) \] (18)

\[ F_{1v}^B(t) = \sum_{i=\rho} \frac{m_i^2}{m_i^2 - t} (f_{i\bar{B}B}^{(1)}/f_i) ; \quad F_{2v}^B(t) = \sum_{i=\rho} \frac{m_i^2}{m_i^2 - t} (f_{i\bar{B}B}^{(2)}/f_i) \] (19)

However, such model does not take into account not even, normalizations and the asymptotic behaviors of FFs

\[ F_{1s}^B(t) = F_{1v}^B(t) \sim \frac{1}{t^2} ; \quad F_{2s}^B(t) = F_{2v}^B(t) \sim \frac{1}{t^3} ; \] (20)
This problem has been solved on the price of a reduction of a number of coupling constant ratios as free parameters of the model in the paper


where for FF to be saturated by $n$ vector-mesons and possess the asymptotic behavior to be determined by the power $m$ and $n > m$ takes the following form

\[
F(t) = F_0 \frac{\prod_{j=1}^{m} m_j^2}{\prod_{j=1}^{m} (m_j^2 - t)} + \sum_{k=m+1}^{n} \left\{ \sum_{j=1}^{m} \frac{m_k^2}{(m_k^2 - t)} \frac{\prod_{j \neq i, j=1}^{m} m_j^2}{\prod_{j \neq k, j=1}^{m} (m_j^2 - t)} \frac{\prod_{j \neq i, j=1}^{m} (m_j^2 - m_k^2)}{\prod_{j \neq i, j=1}^{m} (m_j^2 - m_i^2)} - \right. \\
- \left. \frac{\prod_{j=1}^{m} m_j^2}{\prod_{j=1}^{m} (m_j^2 - t)} \right\} \left( f_{kB\bar{B}} / f_k \right) \tag{21}
\]
and for $n = m$ the form is found

$$F(t) = F_0 \frac{\prod_{j=1}^m m_j^2}{\prod_{j=1}^m (m_j^2 - t)} \quad (22)$$

for both the required asymptotical behavior $F(t)_{t \to \infty} \sim 1/t^m$ and for $t = 0$ the normalization $F(0) = F_0$ are fulfilled automatically.

So, for $m = 2$ and $n = 6$ isoscalar vector-meson resonances for $F_{1s}^B$ one finds

$$F_{1s}^B(t) = F_{1s}^B(0) \frac{m_{\omega''}^2 m_{\phi''}^2}{(m_{\omega''}^2 - t)(m_{\phi''}^2 - t)} +$$

$$+ \left\{ \frac{m_{\phi''}^2 m_{\omega'}^2}{(m_{\phi''}^2 - t)(m_{\omega'}^2 - t)} (m_{\phi''}^2 - m_{\omega'}^2) + \frac{m_{\omega'}^2 m_{\omega''}^2}{(m_{\omega'}^2 - t)(m_{\omega''}^2 - t)} (m_{\omega''}^2 - m_{\omega'}^2) - \right.$$

$$\left. - \frac{m_{\omega'}^2 m_{\phi''}^2}{(m_{\omega'}^2 - t)(m_{\phi''}^2 - t)} \right\} (f_{\omega'BB}/f_{\omega'}) +$$
**U&A models of baryon EM structure**

\[
\begin{align*}
+ \left\{ \frac{m_\phi^2 m_{\phi''}^2}{(m_\phi^2 - t)(m_{\phi''}^2 - t)} \frac{(m_{\phi''}^2 - m_\phi^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} + \frac{m_\omega^2 m_{\phi''}^2}{(m_\omega^2 - t)(m_{\phi''}^2 - t)} \frac{(m_{\phi''}^2 - m_\omega^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} - \frac{m_\omega^2 m_{\phi''}^2}{(m_\omega^2 - t)(m_{\phi''}^2 - t)} \right\} & (f_{\phi'}^{(1)}_{BB} / f_{\phi'}) + \\
+ \left\{ \frac{m_\phi^2 m_\omega^2}{(m_\phi^2 - t)(m_\omega^2 - t)} \frac{(m_{\phi''}^2 - m_\omega^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} + \frac{m_\omega m_{\phi''}^2}{(m_\omega^2 - t)(m_{\phi''}^2 - t)} \frac{(m_{\phi''}^2 - m_\omega^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} - \frac{m_\omega m_{\phi''}^2}{(m_\omega^2 - t)(m_{\phi''}^2 - t)} \right\} & (f_{\phi''}^{(1)}_{BB} / f_{\omega}) + \\
+ \left\{ \frac{m_\phi^2 m_{\phi'}^2}{(m_\phi^2 - t)(m_{\phi'}^2 - t)} \frac{(m_{\phi''}^2 - m_{\phi'}^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} + \frac{m_\omega m_{\phi'}^2}{(m_\omega^2 - t)(m_{\phi'}^2 - t)} \frac{(m_{\phi''}^2 - m_{\phi'}^2)}{(m_{\phi''}^2 - m_{\phi'}^2)} - \frac{m_\omega m_{\phi'}^2}{(m_\omega^2 - t)(m_{\phi'}^2 - t)} \right\} & (f_{\phi'}^{(1)}_{BB} / f_{\phi}).
\end{align*}
\]

where instead of 6 coupling constant ratios in VMD model, here only 4 of them appear.
The same is valid also for $m = 2$ and $n = 3$ isovector vector-meson resonances in $F_{1s}^B$

\[
F_{1v}^B(t) = F_{1v}^B(0) \frac{m_{\rho''}^2 m_{\rho'}^2}{(m_{\rho''}^2 - t)(m_{\rho'}^2 - t)} + \frac{m^2_{\rho''} m^2_{\rho'}}{(m_{\rho''}^2 - t)(m_{\rho'}^2 - t)} + \left\{ \frac{m^2_{\rho} m^2_{\rho'}}{(m_{\rho}^2 - t)(m_{\rho'}^2 - t)} + \frac{m^2_{\rho} m^2_{\rho''}}{(m_{\rho}^2 - t)(m_{\rho''}^2 - t)} - \frac{m^2_{\rho''} m^2_{\rho'}}{(m_{\rho''}^2 - t)(m_{\rho'}^2 - t)} \right\} (f_{\rho BB}^{(1)}/f_{\rho}) \quad (24)
\]

where instead of 3 coupling constant ratios in VMD model, here only 1 of them appears.
Similarly, with \( m = 3 \) and \( n = 6 \) isoscalar vector-meson resonances one finds for \( F^{B}_{2s} \)

\[
F^{B}_{2s}(t) = F^{B}_{2s}(0) \frac{m^2_{\phi''} m^2_{\phi'} m^2_{\phi}}{(m^2_{\phi''} - t)(m^2_{\phi'} - t)(m^2_{\phi} - t)} + \]

\[
\left\{ \frac{m^2_{\phi''} m^2_{\phi'} m^2_{\phi}}{(m^2_{\phi''} - t)(m^2_{\phi'} - t)(m^2_{\phi} - t)} \frac{(m^2_{\phi''} - m^2_{\phi}) (m^2_{\phi'} - m^2_{\phi})}{(m^2_{\phi''} - m^2_{\phi'}) (m^2_{\phi'} - m^2_{\phi})} \right. + \]

\[
\frac{m^2_{\omega''} m^2_{\omega'} m^2_{\phi'}}{(m^2_{\omega''} - t)(m^2_{\omega'} - t)(m^2_{\phi'} - t)} \frac{(m^2_{\omega''} - m^2_{\phi'}) (m^2_{\omega'} - m^2_{\phi'})}{(m^2_{\omega''} - m^2_{\phi}) (m^2_{\omega'} - m^2_{\phi})} + \]

\[
\frac{m^2_{\omega''} m^2_{\phi''} m^2_{\phi}}{(m^2_{\omega''} - t)(m^2_{\phi''} - t)(m^2_{\phi} - t)} \frac{(m^2_{\omega''} - m^2_{\phi}) (m^2_{\phi''} - m^2_{\phi})}{(m^2_{\omega''} - m^2_{\phi'}) (m^2_{\phi'} - m^2_{\phi})} - \]

\[
\left. \frac{m^2_{\omega''} m^2_{\phi''} m^2_{\phi}}{(m^2_{\omega''} - t)(m^2_{\phi''} - t)(m^2_{\phi} - t)} \left\{ (f^{(2)}_{\phi'' BB} / f_{\phi'}) \right. \right. \}
\]
U&A models of baryon EM structure

\[
\begin{align*}
\frac{m^2_{\phi''} m^2_{\omega} m^2_{\omega}}{(m^2_{\phi''} - t)(m^2_{\omega} - t)(m^2_{\omega} - t)} & + \frac{(m^2_{\phi''} - m^2_{\omega})(m^2_{\omega} - m^2_{\omega})}{(m^2_{\phi''} - m^2_{\omega})(m^2_{\omega} - m^2_{\omega})} + \\
\frac{m^2_{\omega} m^2_{\omega} m^2_{\omega}}{(m^2_{\omega} - t)(m^2_{\omega} - t)(m^2_{\omega} - t)} & + \frac{(m^2_{\omega} - m^2_{\omega})(m^2_{\omega} - m^2_{\omega})}{(m^2_{\omega} - m^2_{\omega})(m^2_{\omega} - m^2_{\omega})} + \\
\frac{m^2_{\omega} m^2_{\phi''} m^2_{\omega}}{(m^2_{\omega} - t)(m^2_{\phi''} - t)(m^2_{\omega} - t)} & - \frac{(m^2_{\omega} - m^2_{\omega})(m^2_{\phi''} - m^2_{\omega})}{(m^2_{\omega} - m^2_{\omega})(m^2_{\phi''} - m^2_{\omega})} - \\
\frac{m^2_{\omega} m^2_{\phi''} m^2_{\omega}}{(m^2_{\omega} - t)(m^2_{\phi''} - t)(m^2_{\omega} - t)} & \bigg\} \left( f^{(2)}_{\omega BB} / f_{\omega} \right) + 
\end{align*}
\]
\[ U\&A \text{ models of baryon EM structure} \]

\[
\left\{ \frac{m_{\phi''}^2, m_{\omega'}^2, m_{\phi}^2}{(m_{\phi''}^2 - t)(m_{\phi'}^2 - t)(m_{\phi}^2 - t)} \frac{(m_{\phi''}^2 - m_{\phi}^2)(m_{\omega'}^2 - m_{\phi}^2)}{(m_{\omega''}^2 - m_{\phi}^2)(m_{\omega}^2 - m_{\phi}^2)} + \right.
\]

\[
+ \frac{m_{\omega''}^2, m_{\phi''}^2, m_{\phi}^2}{(m_{\omega''}^2 - t)(m_{\phi''}^2 - t)(m_{\phi}^2 - t)} \frac{(m_{\omega''}^2 - m_{\phi}^2)(m_{\phi}^2 - m_{\phi''}^2)}{(m_{\phi''}^2 - m_{\phi}^2)(m_{\omega}^2 - m_{\phi''}^2)} + \right.
\]

\[
+ \frac{m_{\omega''}^2, m_{\phi''}^2, m_{\phi}^2}{(m_{\omega''}^2 - t)(m_{\phi''}^2 - t)(m_{\phi}^2 - t)} \frac{(m_{\omega''}^2 - m_{\phi}^2)(m_{\phi}^2 - m_{\phi''}^2)}{(m_{\phi''}^2 - m_{\phi}^2)(m_{\omega}^2 - m_{\phi''}^2)} - \right.
\]

\[
\left. - \frac{m_{\omega''}^2, m_{\phi''}^2, m_{\omega'}^2}{(m_{\omega''}^2 - t)(m_{\phi''}^2 - t)(m_{\omega'}^2 - t)} \right\} (f_{\phi \omega''}^{(2)}) (f_{\omega'' \omega'} / f_{\phi}).
\]

where instead of 6 coupling constant ratios in VMD model, here only 3 of them appear.
The same is valid also for $m = 3$ and $n = 3$ isovector vector-meson resonances in $F_{2v}^B$

$$F_{2v}^B(t) = F_{2v}^B(0) \frac{m_{\rho''}^2 m_{\rho'}^2 m_{\rho}^2}{(m_{\rho''}^2 - t)(m_{\rho'}^2 - t)(m_{\rho}^2 - t)}.$$  \hspace{1cm} (26)

where instead of 3 coupling constant ratios in VMD model, there is no free coupling constant ratio appearing as a free parameter of the model.

Nevertheless, the latter model still suffers from the unpleasant drawback of the naive VMD model - the $\sigma_{tot}(e^+e^- \rightarrow \text{had})$ at the mass squared values of vector-meson resonances are acquiring infinite values.

A removal of this unpleasant drawback is carried out by the unitarization of $F_{1s}^B(t), F_{1v}^B(t), F_{2s}^B(t), F_{2v}^B(t)$ FFs.
Unitarization of $F_{1s}^B(t)$, $F_{1v}^B(t)$, $F_{2s}^B(t)$, $F_{2v}^B(t)$ FFs is achieved by incorporation of the correct baryon EM FF analytic properties with the non-linear transformations

\[
\begin{align*}
    t &= t_0^s + \frac{4(t_{in}^{1s} - t_0^s)}{[1/V(t) - V(t)]^2}; \\
    t &= t_0^v + \frac{4(t_{in}^{1v} - t_0^v)}{[1/W(t) - W(t)]^2}; \\
    t &= t_0^s + \frac{4(t_{in}^{2s} - t_0^s)}{[1/U(t) - U(t)]^2}; \\
    t &= t_0^v + \frac{4(t_{in}^{2v} - t_0^v)}{[1/X(t) - X(t)]^2},
\end{align*}
\] (27)

respectively and then by subsequent inclusion of the nonzero values of vector-meson widths into them.

In non-linear transformations (27) $t_0^s = 9m_\pi^2$, $t_0^v = 4m_\pi^2$, $t_{in}^{1s}$, $t_{in}^{1v}$, $t_{in}^{2s}$, $t_{in}^{2v}$ are the square-root branch points, as it is transparent from the inverse transformations.
U&A models of baryon EM structure

\[ V(t) = i \frac{\sqrt{(\frac{t_{1s} - t_s}{t^s_0})^{1/2} + (\frac{t-t_s}{t^s_0})^{1/2}}} \sqrt{(\frac{t_{1s} - t_s}{t^s_0})^{1/2} + (\frac{t-t_s}{t^s_0})^{1/2} - \sqrt{(\frac{t_{1s} - t_s}{t^s_0})^{1/2} - (\frac{t-t_s}{t^s_0})^{1/2}}} \]  

(28)

and similarly for \( W(t), U(t), \) and \( X(t) \), which map the corresponding four-sheeted Riemann surfaces always into one \( V-, W-, U-, X- \) plane.

Then for every iso-scalar and iso-vector baryon Dirac and Pauli FF one obtains just one analytic and smooth function in the domain from \(-\infty\) to \(+\infty\) in the forms
U&A models of baryon EM structure

\[
F_{1s}^B[V(t)] = \left( \frac{1 - V^2}{1 - V_0^2} \right)^4 \left\{ F_{1s}^B[V(0)]H_{\omega''}(V)H_{\phi''}(V) + \right. \\
+ \left[ H_{\phi''}(V)H_{\omega'}(V) \frac{(C_{\phi''}^{1s} - C_{\phi'}^{1s})}{(C_{\phi''}^{1s} - C_{\omega'}^{1s})} + H_{\omega''}(V)H_{\phi'}(V) \frac{(C_{\omega''}^{1s} - C_{\phi'}^{1s})}{(C_{\phi''}^{1s} - C_{\omega''}^{1s})} - H_{\omega''}(V)H_{\phi''}(V) \right] \left( f_{1s}^{(1) BB}/f_{\omega'} \right) + \\
+ \left[ H_{\phi''}(V)H_{\phi'}(V) \frac{(C_{\phi''}^{1s} - C_{\phi'}^{1s})}{(C_{\phi''}^{1s} - C_{\phi''}^{1s})} + H_{\omega''}(V)H_{\omega'}(V) \frac{(C_{\omega''}^{1s} - C_{\phi'}^{1s})}{(C_{\phi''}^{1s} - C_{\omega''}^{1s})} - H_{\omega''}(V)H_{\phi''}(V) \right] \left( f_{1s}^{(1) \phi}/f_{\phi'} \right) + \\
+ \left[ H_{\phi''}(V)L_{\omega}(V) \frac{(C_{\phi''}^{1s} - C_{\omega}^{1s})}{(C_{\phi''}^{1s} - C_{\omega''}^{1s})} + H_{\omega''}(V)L_{\omega}(V) \frac{(C_{\omega''}^{1s} - C_{\omega}^{1s})}{(C_{\omega''}^{1s} - C_{\omega''}^{1s})} - H_{\omega''}(V)H_{\phi''}(V) \right] \left( f_{1s}^{(1) \omega}/f_{\omega} \right) + \\
+ \left[ H_{\phi''}(V)L_{\phi}(V) \frac{(C_{\phi''}^{1s} - C_{\phi}^{1s})}{(C_{\phi''}^{1s} - C_{\phi''}^{1s})} + H_{\omega''}(V)L_{\phi}(V) \frac{(C_{\omega''}^{1s} - C_{\phi}^{1s})}{(C_{\phi''}^{1s} - C_{\omega''}^{1s})} - H_{\omega''}(V)H_{\phi''}(V) \right] \left( f_{1s}^{(1) \phi}/f_{\phi} \right) \right\} \\
to be dependent on 5 free physically interpretable parameters

\[
(f_{1s}^{(1) \omega}/f_{\omega}), (f_{1s}^{(1) \phi}/f_{\phi}), (f_{1s}^{(1) \omega}/f_{\omega}), (f_{1s}^{(1) \phi}/f_{\phi}), t_{m}^{1s},
\]

(30)
\[ F_{1\nu}^B[W(t)] = \left( \frac{1 - W^2}{1 - W^2_N} \right)^4 \left\{ F_{1\nu}^B[W(0)]L_\rho(W)L_{\rho'}(W) + \right. \\
+ \left[ L_{\rho'}(W)L_{\rho''}(W) \left( \frac{C_{a_{1\nu}}^{\rho'} - C_{a_{1\nu}}^{\rho''}}{C_{a_{1\nu}}^{\rho'} - C_{a_{1\nu}}^{\rho''}} + L_\rho(W)L_{\rho''}(W) \left( \frac{C_{a_{1\nu}}^{\rho} - C_{a_{1\nu}}^{\rho''}}{C_{a_{1\nu}}^{\rho} - C_{a_{1\nu}}^{\rho''}} \right) - \right. \\
\left. \left. \left. - L_\rho(W)L_{\rho'}(W) \right\} \left( f_\rho^{(1)} \rho_{BB} / f_\rho \right) \right\} \]

to be dependent on 2 free physically interpretable parameters

\[ (f_\rho^{(1)} \rho_{BB} / f_\rho), t_{\nu}^{1\nu}, \]
$F_{2s}^B[U(t)] = \left( \frac{1 - U^2}{1 - U^2_N} \right)^6 \left\{ F_{2s}^B[U(0)]H_{\omega''}(U)H_{\phi''}(U)H_{\omega'}(U) + 
+ \left[ H_{\phi''}(U)H_{\omega'}(U)H_{\phi'}(U) \frac{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\omega'}^2 - C_{\phi'}^2)}{(C_{\phi''}^2 - C_{\omega'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + H_{\omega''}(U)H_{\omega'}(U)H_{\phi'}(U) \frac{(C_{\omega''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)}{(C_{\omega''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + 
+ H_{\omega''}(U)H_{\phi''}(U)H_{\phi'}(U) \frac{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\omega'}^2 - C_{\phi'}^2)}{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} \right] \left( f_{\phi''BB}^2 / f_{\phi'}^2 \right) + 
+ \left[ H_{\phi''}(U)H_{\omega'}(U)L_{\omega}(U) \frac{(C_{\phi''}^2 - C_{\omega}^2)(C_{\phi'}^2 - C_{\omega}^2)}{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + H_{\omega''}(U)H_{\omega'}(U)L_{\omega}(U) \frac{(C_{\omega''}^2 - C_{\omega}^2)(C_{\phi'}^2 - C_{\omega}^2)}{(C_{\omega''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + 
+ H_{\omega''}(U)H_{\phi''}(U)L_{\omega}(U) \frac{(C_{\phi''}^2 - C_{\omega}^2)(C_{\phi'}^2 - C_{\omega}^2)}{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} \right] \left( f_{\omega BB}^2 / f_{\omega} \right) + 
+ \left[ H_{\phi''}(U)H_{\omega'}(U)L_{\phi}(U) \frac{(C_{\phi''}^2 - C_{\phi}^2)(C_{\phi'}^2 - C_{\phi}^2)}{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + H_{\omega''}(U)H_{\omega'}(U)L_{\phi}(U) \frac{(C_{\omega''}^2 - C_{\phi}^2)(C_{\phi'}^2 - C_{\phi}^2)}{(C_{\omega''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} + 
+ H_{\omega''}(U)H_{\phi''}(U)L_{\phi}(U) \frac{(C_{\phi''}^2 - C_{\phi}^2)(C_{\phi'}^2 - C_{\phi}^2)}{(C_{\phi''}^2 - C_{\phi'}^2)(C_{\phi'}^2 - C_{\phi'}^2)} \right] \left( f_{\phi BB}^2 / f_{\phi} \right) \right\}$
to be dependent on 4 free physically interpretable parameters

\[(f_{\phi/BB}^{(2)}/f_{\phi'})\), (f_{\omega/BB}^{(2)}/f_{\omega}), (f_{\phi/BB}^{(2)}/f_{\phi}), t_{in}^{2s},\]  (34)

\[F_{2\nu}[X(t)] = \left(\frac{1 - X^2}{1 - X_N^2}\right)^6 \left\{ F_{2\nu}[X(0)]L_{\rho}(U)L_{\rho'}(U)H_{\rho''}(U) \right\} \]  (35)

to be dependent on 1 free physically interpretable parameter
\[t_{in}^{2\nu},\]
\textbf{U&A models of baryon EM structure}

where

\[ L_r(V) = \frac{(V_N - V_r)(V_N - V_r^*)(V_N - 1/V_r)(V_N - 1/V_r^*)}{(V - V_r)(V - V_r^*)(V - 1/V_r)(V - 1/V_r^*)}, \quad r = \omega, \phi \]

\[ C_{r1s} = \frac{(V_N - V_r)(V_N - V_r^*)(V_N - 1/V_r)(V_N - 1/V_r^*)}{-(V_r - 1/V_r)(V_r - 1/V_r^*)}, \quad r = \omega, \phi \]

\[ H_l(V) = \frac{(V_N - V_l)(V_N - V_l^*)(V_N + V_l)(V_N + V_l^*)}{(V - V_l)(V - V_l^*)(V + V_l)(V + V_l^*)}, \quad l = \omega''', \phi''', \omega', \phi' \]

\[ C_{l1s} = \frac{(V_N - V_l)(V_N - V_l^*)(V_N + V_l)(V_N + V_l^*)}{-(V_l - 1/V_l)(V_l - 1/V_l^*)} \]

\[ L_k(W) = \frac{(W_N - W_k)(W_N - W_k^*)(W_N - 1/W_k)(W_N - 1/W_k^*)}{(W - W_k)(W - W_k^*)(W - 1/W_k)(W - 1/W_k^*)}, \quad k = \rho''', \rho', \rho \]

\[ C_{k1v} = \frac{(W_N - W_k)(W_N - W_k^*)(W_N - 1/W_k)(W_N - 1/W_k^*)}{-(W_k - 1/W_k)(W_k - 1/W_k^*)}, \quad k = \rho''', \rho', \rho \]
UNITARY AND ANALYTIC MODELS OF OCTET BARYON EM STRUCURE

NUMERICAL VALUES OF COUPLING CONSTANT RATIO VALUES IN BARYON EM STRUCTURE MODELS

CONCLUSIONS

U&A models of baryon EM structure

\[ L_r(U) = \frac{(U_N - U_r)(U_N - U_r^*)(U_N - 1/U_r)(U_N - 1/U_r^*)}{(U - U_r)(U - U_r^*)(U - 1/U_r)(U - 1/U_r^*)} , \]
\[ C_r^{2s} = \frac{(U_N - U_r)(U_N - U_r^*)(U_N - 1/U_r)(U_N - 1/U_r^*)}{-(U_r - 1/U_r)(U_r - 1/U_r^*)} , r = \omega, \phi \]
\[ H_l(U) = \frac{(U_N - U_l)(U_N - U_l^*)(U_N + U_l)(U_N + U_l^*)}{(U - U_l)(U - U_l^*)(U - 1/U_l)(U - 1/U_l^*)} , \]
\[ C_l^{2s} = \frac{(U_N - U_l)(U_N - U_l^*)(U_N + U_l)(U_N + U_l^*)}{-(U_l - 1/U_l)(U_l - 1/U_l^*)} , l = \omega'', \phi'', \omega', \phi' \]
\[ L_k(X) = \frac{(X_N - X_k)(X_N - X_k^*)(X_N - 1/X_k)(X_N - 1/X_k^*)}{(X - X_k)(X - X_k^*)(X - 1/X_k)(X - 1/X_k^*)} , \]
\[ C_k^{2\nu} = \frac{(X_N - X_k)(X_N - X_k^*)(X_N - 1/X_k)(X_N - 1/X_k^*)}{-(X_k - 1/X_k)(X_k - 1/X_k^*)} , k = \rho', \rho \]
So, if we know **numerical values of free parameters** in $F_{1s}^B[V(t)], F_{1v}^B[W(t)], F_{2s}^B[U(t)], F_{2v}^B[X(t)]$, **one can predict behaviors** of electric $G_E^B(t)$ and magnetic $G_M^B(t)$ FFs of any baryon from the $1/2^+$ octet.
The simplest way of a determination of the coupling constant ratios is in the **nucleon case**, as there is around **530 reliable experimental points on the nucleon EM FFs** - dominant for protons and less experimental information exists on the neutron - in the spacelike and timelike region.

It is sufficient to **adjust** $F_{1s}^B[V(t)]$, $F_{1v}^B[W(t)]$, $F_{2s}^B[U(t)]$, $F_{2v}^B[X(t)]$ by **normalizations** corresponding to nucleons and the **by a comparison of obtained expressions for** $G_E^P(t)$, $G_M^P(t)$, $G_E^n(t)$, $G_E^n(t)$ **with existing experimental data** the following values of coupling constant ratios are found.
Numerical values of coupling constant ratios

for nucleons (p and n):

\[
\begin{align*}
\frac{f^{(1)}_{\rho NN}}{f_{\rho}} &= (0.3747 \pm 0.0022) \\
\frac{f^{(1)}_{\omega NN}}{f_{\omega}} &= (1.5717 \pm 0.0022) \\
\frac{f^{(1)}_{\phi NN}}{f_{\phi}} &= (-1.1247 \pm 0.0011) \\
\frac{f^{(1)}_{\omega' NN}}{f_{\omega'}} &= (0.0418 \pm 0.0065) \\
\frac{f^{(1)}_{\phi' NN}}{f_{\phi'}} &= (0.1879 \pm 0.0010) \\
\frac{f^{(2)}_{\omega NN}}{f_{\omega}} &= (-0.2096 \pm 0.0067) \\
\frac{f^{(2)}_{\phi NN}}{f_{\phi}} &= (0.2657 \pm 0.0067) \\
\frac{f^{(2)}_{\phi' NN}}{f_{\phi'}} &= (0.1781 \pm 0.0029)
\end{align*}
\]
There are no data on EM FFs of $1/2^+$ octet hyperons $\Lambda, \Sigma^+, \Sigma^0, \Sigma^-, \Xi^0, \Xi^-$, only some total cross section points of $e^+e^-$-annihilation into hyperon-antihyperon exist and one can not repeat a similar to nucleons procedure in determination of the unknown coupling constant ratios in the Unitary&Analytic hyperon EM structure model. Despite of this fact, we have found a method for numerical determination of unknown free hyperon coupling constant ratios in Unitary&Analytic hyperon EM structure models utilizing the known nucleon coupling constant ratios (43) and the SU(3) invariant Lagrangians of vector-meson interaction with octet baryons

$$L_{VBB} = \frac{i}{\sqrt{2}} f^F [\bar{B}_\alpha^\beta \gamma_\mu B^\alpha_{\gamma\mu} - \bar{B}_\gamma^\beta \gamma_\mu B_\alpha^\gamma_{\mu\beta}](V_\mu)^\gamma_\alpha + \frac{i}{\sqrt{2}} f^D [\bar{B}_\gamma^\beta \gamma_\mu B_\alpha^\gamma_{\mu\beta} + \bar{B}_\alpha^\beta \gamma_\mu B^\alpha_{\gamma\mu}](V_\mu)^\gamma_\alpha +$$

$$+ \frac{i}{\sqrt{2}} f^S \bar{B}_\beta^\alpha \gamma_\mu B_\alpha^\beta \omega_{\mu}^0$$

(44)
Numerical values of coupling constant ratios

where baryons are represented here by the **octet matrices**

\[
B = \begin{pmatrix}
\frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda^0}{\sqrt{6}} & \Sigma^+ & p \\
\Sigma^- & -\frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda^0}{\sqrt{6}} & n \\
\Xi^- & \Xi^0 & -\frac{2\Lambda^0}{\sqrt{6}} \\
\end{pmatrix}, \quad (45)
\]

\[
\bar{B} = \begin{pmatrix}
\frac{\bar{\Sigma}^0}{\sqrt{2}} + \frac{\bar{\Lambda}^0}{\sqrt{6}} & \bar{\Sigma}^- & \bar{\Xi}^- \\
\bar{\Sigma}^+ & -\frac{\bar{\Sigma}^0}{\sqrt{2}} + \frac{\bar{\Lambda}^0}{\sqrt{6}} & \bar{\Xi}^0 \\
\bar{p} & \bar{n} & -\frac{2\bar{\Lambda}^0}{\sqrt{6}} \\
\end{pmatrix}, \quad (46)
\]
Numerical values of coupling constant ratios

and the $1^{-}$ vector-meson nonet is classified into an octet matrix and a singlet like

$$
\nu = \begin{pmatrix}
\omega_8/\sqrt{6} + \rho^0/\sqrt{2} & \rho^+ & K^{*+} \\
\rho^- & \omega_0/\sqrt{6} - \rho^0/\sqrt{2} & K^*0 \\
K^{*-} & \overline{K}^*0 & -2\omega_8/\sqrt{6}
\end{pmatrix}, \omega_0. \quad (47)
$$

Decomposing the Lagrangian (44) into a sum of products of single matrix elements one can derive relations between $f_{VBB}$ and the coupling constants $f^F, f^D, f^S$ of SU(3) invariant Lagrangian. However, the $\omega_8, \omega_0$ in Lagrangian do not represent experimentally observed particles and therefore one has to use the so-called $\omega - \phi$ mixing form through the real $\omega(782)$ and $\phi(1020)$ vector-mesons. There are generally 8 different mixing forms,

Numerical values of coupling constant ratios

but only four of them

1. \( \omega_0 = \omega \cos \theta + \phi \sin \theta \)
   \( \omega_8 = \omega \sin \theta - \phi \cos \theta \)

4. \( \omega_0 = -\omega \cos \theta - \phi \sin \theta \)
   \( \omega_8 = -\omega \sin \theta + \phi \cos \theta \)

5. \( \omega_0 = \omega \cos \theta - \phi \sin \theta \)
   \( \omega_8 = \omega \sin \theta + \phi \cos \theta \)

8. \( \omega_0 = -\omega \cos \theta + \phi \sin \theta \)
   \( \omega_8 = -\omega \sin \theta - \phi \cos \theta \).

are physically acceptable.

Then the relations between \( f_{VBB} \) and the coupling constants \( f^F, f^D, f^S \) of SU(3) invariant Lagrangian take the forms
Numerical values of coupling constant ratios

for nucleons

1. \( f_{\rho NN} = \frac{1}{2} (f_F + f_D) \)

\( f_{\omega NN} = \frac{1}{\sqrt{2}} f_S \cos \theta + \frac{1}{2\sqrt{3}} (3f_F - f_D) \sin \theta \)

\( f_{\phi NN} = \frac{1}{\sqrt{2}} f_S \sin \theta - \frac{1}{2\sqrt{3}} (3f_F - f_D) \cos \theta \)

4. \( f_{\rho NN} = \frac{1}{2} (f_F + f_D) \)

\( f_{\omega NN} = -\frac{1}{\sqrt{2}} f_S \cos \theta - \frac{1}{2\sqrt{3}} (3f_F - f_D) \sin \theta \)

\( f_{\phi NN} = -\frac{1}{\sqrt{2}} f_S \sin \theta + \frac{1}{2\sqrt{3}} (3f_F - f_D) \cos \theta \)

5. \( f_{\rho NN} = \frac{1}{2} (f_F + f_D) \)

\( f_{\omega NN} = \frac{1}{\sqrt{2}} f_S \cos \theta + \frac{1}{2\sqrt{3}} (3f_F - f_D) \sin \theta \)

\( f_{\phi NN} = -\frac{1}{\sqrt{2}} f_S \sin \theta + \frac{1}{2\sqrt{3}} (3f_F - f_D) \cos \theta \)
Numerical values of coupling constant ratios

8. \[ f_{\rho NN} = +\frac{1}{2}(f^F + f^D) \]

\[ f_{\omega NN} = -\frac{1}{\sqrt{2}} f^S \cos \theta - \frac{1}{2\sqrt{3}} (3f^F - f^D) \sin \theta \]

\[ f_{\phi NN} = +\frac{1}{\sqrt{2}} f^S \sin \theta - \frac{1}{2\sqrt{3}} (3f^F - f^D) \cos \theta. \]

and similarly for hyperons.

So, if one knows numerical values of SU(3) \( f^F, f^D, f^S \) coupling constants, then one can evaluated coupling constants for all \( 1/2^+ \) octet baryons.

Further we demonstrate, how one can find these \( f^F, f^D, f^S \) coupling constants by utilizing previous relations for nucleons, together with numerical values of \( f_{VNN}/f_V \) in (43).
The reversed relations to the previous one are

1. \[ f^F = \frac{\sqrt{3}}{2} (f_{\omega NN} \sin \theta - f_{\phi NN} \cos \theta) + \frac{1}{2} f_{\rho NN} \]

2. \[ f^D = -\frac{\sqrt{3}}{2} (f_{\omega NN} \sin \theta - f_{\phi NN} \cos \theta) + \frac{3}{2} f_{\rho NN} \]

3. \[ f^S = \sqrt{2} (f_{\omega NN} \cos \theta + f_{\phi NN} \sin \theta) \]

4. \[ f^F = \frac{\sqrt{3}}{2} (-f_{\omega NN} \sin \theta + f_{\phi NN} \cos \theta) + \frac{1}{2} f_{\rho NN} \]

5. \[ f^D = -\frac{\sqrt{3}}{2} (-f_{\omega NN} \sin \theta + f_{\phi NN} \cos \theta) + \frac{3}{2} f_{\rho NN} \]

6. \[ f^S = \sqrt{2} (-f_{\omega NN} \cos \theta - f_{\phi NN} \sin \theta) \]
Numerical values of coupling constant ratios

8. \[ f^F = \frac{\sqrt{3}}{2} (-f_{\omega NN} \sin \theta - f_{\phi NN} \cos \theta) + \frac{1}{2} f_{\rho NN} \]

\[ f^D = -\frac{\sqrt{3}}{2} (-f_{\omega NN} \sin \theta - f_{\phi NN} \cos \theta) + \frac{3}{2} f_{\rho NN} \]

\[ f^S = \sqrt{2} (-f_{\omega NN} \cos \theta + f_{\phi NN} \sin \theta) \]

However, before the numerical values of \( f_{VNN}^{(i)}, i = 1, 2 \) are determined from the nucleon coupling constant ratios (43) by means of the values of the universal vector-meson coupling constants \( f_V \) to be extracted from lepton widths \( \Gamma(V \rightarrow e^+ e^-) \) of the vector-mesons under consideration.

But, the latter can provide only the absolute values of the corresponding \( f_V \), as this is contained in the expression for lepton width \( \Gamma(V \rightarrow e^+ e^-) \) quadratically.
Numerical values of coupling constant ratios

Signs of $f_V$

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1. \[ \frac{1}{f_\rho} : \frac{1}{f_\omega} : \frac{1}{f_\phi} = -\sqrt{3} : -\sin \theta : +\cos \theta \]

4. \[ \frac{1}{f_\rho} : \frac{1}{f_\omega} : \frac{1}{f_\phi} = -\sqrt{3} : +\sin \theta : -\cos \theta \]

5. \[ \frac{1}{f_\rho} : \frac{1}{f_\omega} : \frac{1}{f_\phi} = -\sqrt{3} : -\sin \theta : -\cos \theta \]

(51)

8. \[ \frac{1}{f_\rho} : \frac{1}{f_\omega} : \frac{1}{f_\phi} = -\sqrt{3} : +\sin \theta : +\cos \theta \]
Numerical values of coupling constant ratios are strongly dependent on physically acceptable $\omega - \phi$ mixing forms (48) and if we apply $f_\rho = |4.956|$, $f_\omega = |17.058|$, $f_\phi = |13.542|$ with signs given in (51) in coupling constant ratios found in a fitting procedure one gets

1. $f_{(1)}^{(1)}_{\rho NN} = -1.8570$; $f_{(1)}^{(1)}_{\omega NN} = -26.8101$; $f_{(1)}^{(1)}_{\phi NN} = -15.2307$
2. $f_{(1)}^{(1)}_{\rho NN} = -1.8570$; $f_{(1)}^{(1)}_{\omega NN} = +26.8101$; $f_{(1)}^{(1)}_{\phi NN} = +15.2307$
3. $f_{(1)}^{(1)}_{\rho NN} = -1.8570$; $f_{(1)}^{(1)}_{\omega NN} = -26.8101$; $f_{(1)}^{(1)}_{\phi NN} = +15.2307$
4. $f_{(1)}^{(1)}_{\rho NN} = -1.8570$; $f_{(1)}^{(1)}_{\omega NN} = +26.8101$; $f_{(1)}^{(1)}_{\phi NN} = -15.2307$

Substituting them into relation for $f^F$, $f^D$, $f^S$ together with $\theta = 38.35^0$, calculated by Gell-Mann-Okubo quadratic mass formula, one finds

$$f_1^F = -4.9916; \quad f_1^D = +1.2776; \quad f_1^S = -43.0979;$$

independent on the used $\omega - \phi$ mixing form.
Numerical values of coupling constant ratios

Similarly are found also
\[ f_2^F = -7.6976; \quad f_2^D = -21.0036; \quad f_2^S = +7.1225; \quad (54) \]

and
\[ f_1^{F'} = -5.1607; \quad f_1^{D'} = -16.4400; \quad f_1^{S'} = -9.3767; \quad (55) \]

\[ f_2^{F'} = +29.9610; \quad f_2^{D'} = +5.7612; \quad f_2^{S'} = +20.0463; \quad (56) \]
Numerical values of coupling constant ratios

If they are substituted into the relations for $f_{VYY}^{(i)}$ and $f_{V'YY}^{(i)}$, with $i = 1, 2$ and $Y = \Lambda, \Sigma, \Xi$, respectively, to be derived from the vector-meson-baryon interaction Lagrangian as a functions of these SU(3) coupling constants, and these are divided respectively by $f_\rho = |4.9582|$, $f_\omega = |17.0620|$, $f_\phi = |13.4428|$ and $f_\rho' = |13.6491|$, $f_\omega' = |47.6022|$, $f_\phi' = |33.6598|$ with signs to be dependent on the four different $\omega - \phi$-mixing forms, one gets unknown coupling constants ratios of vector-meson with hyperons in the hyperon Unitary&Analytic EM structure models as follows:
Numerical values of coupling constant ratios

for $\Lambda$-hyperon

\[
\begin{align*}
(f^{(1)}_{\omega\Lambda\Lambda} / f_{\omega}) &= +1.4389 \\
(f^{(1)}_{\phi\Lambda\Lambda} / f_{\phi}) &= -1.3359 \\
(f^{(1)}_{\omega'\Lambda\Lambda} / f_{\omega'}) &= -0.2253 \\
(f^{(1)}_{\phi'\Lambda\Lambda} / f_{\phi'}) &= -0.3104 \\
(f^{(2)}_{\omega\Lambda\Lambda} / f_{\omega}) &= -0.8554 \\
(f^{(2)}_{\phi\Lambda\Lambda} / f_{\phi}) &= -0.7623 \\
(f^{(2)}_{\phi'\Lambda\Lambda} / f_{\phi'}) &= +0.4437
\end{align*}
\]

(57)
Numerical values of coupling constant ratios

for $\Sigma$-hyperons

\[
\begin{align*}
(f_{\rho\Sigma\Sigma}^{(1)}/f_\rho) &= +1.0072 \\
(f_{\omega\Sigma\Sigma}^{(1)}/f_\omega) &= +1.3742 \\
(f_{\phi\Sigma\Sigma}^{(1)}/f_\phi) &= -1.4391 \\
(f_{\omega'\Sigma\Sigma}^{(1)}/f_{\omega'}) &= +0.2327 \\
(f_{\phi'\Sigma\Sigma}^{(1)}/f_{\phi'}) &= -0.1004 \\
(f_{\omega\Sigma\Sigma}^{(2)}/f_\omega) &= +0.2096 \\
(f_{\phi\Sigma\Sigma}^{(2)}/f_\phi) &= +0.9331 \\
(f_{\phi'\Sigma\Sigma}^{(2)}/f_{\phi'}) &= +0.3701
\end{align*}
\]
Numerical values of coupling constant ratios

for $\Xi$-hyperons

\[
\begin{align*}
(f^{(1)}_{\rho\Xi\Xi}/f_\rho) &= -0.6325 \\
(f^{(1)}_{\omega\Xi\Xi}/f_\omega) &= +1.2571 \\
(f^{(1)}_{\phi\Xi\Xi}/f_\phi) &= -1.6254 \\
(f^{(1)}_{\omega'\Xi\Xi}/f_{\omega'}) &= +0.1412 \\
(f^{(1)}_{\phi'\Xi\Xi}/f_{\phi'}) &= -0.2718 \\
(f^{(2)}_{\omega\Xi\Xi}/f_\omega) &= -0.6941 \\
(f^{(2)}_{\phi\Xi\Xi}/f_\phi) &= -0.5064 \\
(f^{(2)}_{\phi'\Xi\Xi}/f_{\phi'}) &= +0.6536
\end{align*}
\]
Conclusions

The Λ, Σ, Ξ hyperons EM structure - as generalization of the nucleon U&A EM structure model. Based on the fact - analytic properties of the hyperon EM FFs, up to the position of effective inelastic thresholds, equal with analytic properties of the nucleon EM FFs. Models depend on some coupling constant ratios \((f_{VBB}/f_V)\) as free parameters, they have been found from known nucleon coupling constant ratios and SU(3) invariant Lagrangians of vector-meson-baryon interaction. In their specification a principal role played the \(\omega - \phi\) mixing forms with universal vector-meson coupling constants \(f_V\). All coupling constant ratios as free parameters of the Λ, Σ, Ξ EM structure models have been evaluated numerically.
Thank you for your attention.