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NAIVE MODEL OF ELECTROMAGNETIC STRUCTURE OF OCTET BARYONS

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1 INTRODUCTION

Experimentally we now know eight baryons $[p,n];[\Lambda];[\Sigma^+,\Sigma^0,\Sigma^-]$ and $[\Xi^0,\Xi^-]$ of the spin 1/2 which according to the SU(3) symmetry classification belong to the same octuplet. The electromagnetic (EM) structure of each of them is completely described by two scalar functions depending on the four-momentum transfer squared $t=-Q^2$. Usually they are chosen in the form of the Sachs electric $G_E(t)$ and magnetic $G_M(t)$ form factors [1] (FF's) which can be expressed through Dirac $F_1(t)$ and Pauli $F_2(t)$ FF's obtained [2] by the most general decomposition of the matrix element of a baryon EM current into a maximal number of linearly independent covariants constructed from momenta and spin parameters by means of the following relations

$$\begin{aligned} G_E(t) &= F_1(t)+\frac{t}{4m^2}F_2(t) \\ G_M(t) &= F_1(t)+F_2(t). \end{aligned} \tag{1}$$

Despite the fact that much work has been done since the discovery [3] of the EM structure of hadrons, the experimental situation about EM FF's of the octuplet of baryons is unsatisfactory up to now. There are good data on the proton in the space-like ($t<0$) region obtained from the process $e^-p\to e^-p$. In the time-like region just measurements with limited statistics and momentum range have been performed by $e^+e^-\to p\bar{p}$ and $\bar{p}p\to e^+e^-$ reactions. The neutron data exist only in the space--like region and they are essentially obtained from electron scattering on the deuterium by a model-dependent way.

Concerning other members of the baryon octet, the experimental situation is even worse. Only at one point corresponding to $t=5.693GeV^2$ the cross-section of the $\Lambda\bar{\Lambda}$ production in e^+e^- annihilation has been measured [4] and an upper limit on the cross-section of the $\Sigma^0\bar{\Sigma}^0$ production at the same energy was set at the same time. There is no experimental information on the EM structure of Ξ-hyperons up to now.

Inspired by a good experimental situation many more or less successful phenomenological models [5]–[12] have been devoted to the global description of the nucleon EM structure. However, missing are analogous attempts to predict the behaviour of EM FF's of other baryons of

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the same octet. There is only one global reproduction [13] of Λ-hyperon EM FF's in the framework of the simplified unitary and analytic VMD model and an another attempt [14] to predict the production cross-sections of baryon-antibaryon pairs in e^+e^- annihilation. The latter was achieved in the framework of the constrained free FF model in which, however, the asymptotic behaviour of FF's restricts strictly the number of vector mesons used in the model under consideration.

On the other hand, much progress has been achieved in understanding the static EM properties of the octet baryons, directly connected with a behaviour of EM FF's around $t = 0$. We have in mind mainly the use of various quark models [15),16], the EM current in the bound state approach to the Skyrme model [17] and the lattice QCD approach [18]. Nevertheless, these models are believed to be neither unique nor totally free of difficulties and objections. An evidence for the latter fact are values of the mean-square electric and magnetic radii of octet baryons calculated by the models under consideration which differ not only in magnitudes considerably but some of them even in sign.

To bring some more light to these problems, new efforts in this direction are desirable. Here we formulate a very simple model of the EM structure of octet baryons, in the framework of which reasonable values (more or less comparable with results of other models [15)–18]) of mean--square EM radii of octet baryons are predicted too. The model is constructed by parametrizing Dirac and Pauli EM FF's of octet baryons by the standard vector-meson-dominance (VMD) model [19] in a zero-width approximation where vector meson and baryon masses are fixed at the world averaged values. Restricting ourselves only to the ground state vector meson nonet and taking into account the Okubo-Zweig-Iizuka (OZI) rule [20)–22] strictly, the vector meson-nucleon coupling constants are completely determined just from a normalization of nucleon EM FF's. Then the vector meson-hyperon coupling constants are evaluated from the latter by the relations following from the SU(3) invariant Lagrangian for the vector-meson-baryon-antibaryon vertex. As a result, all parameters of the constructed model are determined and the values of mean-square EM radii of the complete octuplet of baryons can be predicted.

In the next section we construct a naive model of the EM structure of nucleons. Section 3. is devoted, first, to the evaluation of the vector meson-hyperon coupling constants from couplings to nucleons and then to a prediction of numerical values of mean-square EM radii of octuplet baryons. Conclusions and summary are given in section 4.

2 SIMPLE MODEL OF ELECTROMAGNETIC STRUCTURE OF NUCLEONS

To make this paper self-contained, first, we briefly outline the main features of the nucleon EM structure formalism. There is a decomposition of nucleon electric and magnetic FF's (1) into isoscalar and isovector parts of the Dirac and Pauli FF's as follows

$$
\begin{aligned}
G_E^p(t) &= [F_{1N}^s(t) + F_{1N}^v(t)] + \frac{t}{4m_p^2}[F_{2N}^s(t) + F_{2N}^v(t)] \\
G_M^p(t) &= [F_{1N}^s(t) + F_{1N}^v(t)] + [F_{2N}^s(t) + F_{2N}^v(t)] \\
G_E^n(t) &= [F_{1N}^s(t) - F_{1N}^v(t)] + \frac{t}{4m_n^2}[F_{2N}^s(t) - F_{2N}^v(t)] \\
G_M^n(t) &= [F_{1N}^s(t) - F_{1N}^v(t)] + [F_{2N}^s(t) - F_{2N}^v(t)].
\end{aligned}
\qquad (2)
$$

If we restrict ourselves only to the ground state vector meson nonet, then, according to the idea of the zero-width ($\Gamma_v = 0$) VMD model [19] each of $F_{1,2}^{s,v}$ in (2) is expressed in the form

$$
\begin{aligned}
F_{1N}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega NN}^{(1)}/f_\omega) \quad ; \quad F_{2N}^s(t) = \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega NN}^{(2)}/f_\omega) \\
F_{1N}^v(t) &= \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho NN}^{(1)}/f_\rho) \quad ; \quad F_{2N}^v(t) = \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho NN}^{(2)}/f_\rho)
\end{aligned}
\qquad (3)
$$

where in the isoscalar FF's we require the couplings of the ϕ-meson to nucleons to be zero, taking the OZI rule [20)–22] into account strictly.

According to a definition of $G_E^p(t)$; $G_M^p(t)$, $G_E^n(t)$, $G_M^n(t)$ FF's they are normalized as follows

$$G_E^p(0) = 1;\ G_M^p(0) = 1 + \mu_p;\ G_E^n(0) = 0;\ G_M^n(0) = \mu_n \qquad (4)$$

where μ_p, μ_n are the anomalous magnetic moments of the proton and neutron, respectively. Then from the relations (2) one gets the isoscalar and isovector FF normalization conditions

$$F_{1N}^s(0)=\frac{1}{2};\ F_{2N}^s(0)=\frac{1}{2}(\mu_p+\mu_n);F_{1N}^v(0)=\frac{1}{2};\ F_{2N}^v(0)=\frac{1}{2}(\mu_p-\mu_n) \tag{5}$$

which through the expressions (3) enable us to determine the ρ- and ω-meson-nucleon coupling constant ratios as follows

$$\begin{aligned}(f_{\omega NN}^{(1)}/f_\omega)=\frac{1}{2}; &\quad (f_{\omega NN}^{(2)}/f_\omega) = \frac{1}{2}(\mu_p+\mu_n);\\ (f_{\rho NN}^{(1)}/f_\rho)=\frac{1}{2}; &\quad (f_{\rho NN}^{(2)}/f_\rho) = \frac{1}{2}(\mu_p-\mu_n).\end{aligned} \tag{6}$$

The naive model of the EM structure of nucleons is then given by the relations (6),(3) and (2).

The electric and magnetic mean-square radius of any baryon may be extracted from the corresponding electric and magnetic FF's with the standard small t expansion of the Fourier transform of a charge or magnetic moment distribution by

$$< r_E^2 >= 6\frac{dG_E(t)}{dt}|_{t=0} \quad \text{and} \quad < r_M^2 >= 6\frac{dG_M(t)}{dt}|_{t=0} \tag{7}$$

respectively. Applying them to the nucleon EM FF's one gets the electric and magnetic mean-square radii of nucleons in the following form

$$\begin{aligned}< r_{Ep}^2 > &= 3\left[\frac{1}{m_\omega^2}+\frac{1}{m_\rho^2}+\frac{2\mu_p}{4m_p^2}\right]\\ < r_{Mp}^2 > &= 3\left[\frac{1+\mu_p+\mu_n}{m_\omega^2}+\frac{1+\mu_p-\mu_n}{m_\rho^2}\right]\\ < r_{En}^2 > &= 3\left[\frac{1}{m_\omega^2}-\frac{1}{m_\rho^2}+\frac{2\mu_n}{4m_n^2}\right]\\ < r_{Mn}^2 > &= 3\left[\frac{1+\mu_p+\mu_n}{m_\omega^2}-\frac{1+\mu_p-\mu_n}{m_\rho^2}\right].\end{aligned} \tag{8}$$

Now, taking all masses and values of the anomalous magnetic moments from the newest Review of Particle Properties [23] one gets numerically

$$\begin{aligned}< r_{Ep}^2 >&= 0.508 fm^2; &\quad < r_{Mp}^2 >&= 1.099 fm^2;\\ < r_{En}^2 >&= -0.133 fm^2; &\quad < r_{Mn}^2 >&= -0.763 fm^2.\end{aligned} \tag{9}$$

For a comparison we present also the experimental values [24] of the latter quantities

$$\begin{aligned}&< r_{Ep}^2 >_{exp}= 0.743\pm 0.083 fm^2;\ < r_{Mp}^2 >_{exp}= 1.986\pm 0.259 fm^2;\\ &< r_{En}^2 >_{exp}= -0.119\pm 0.002 fm^2;\ < r_{Mn}^2 >_{exp}= -1.458\pm 0.233 fm^2.\end{aligned} \tag{10}$$

As one can see from (9) and (10), the predicted values of the nucleon EM mean-square radii are in view of the simplicity of the used model in quite a good agreement (the magnetic mean-square radii less) with experiment. In view of the latter the use of the coupling constant ratios (6) for a prediction of the EM mean-square radii of other members of the octuplet baryons through the SU(3) symmetry seems to be authorized. However, this is a subject of the next section.

3 DESCRIPTION OF THE ELECTROMAGNETIC STRUCTURE OF HYPERONS

A decomposition of Λ-,Σ- and Ξ- hyperon electric and magnetic FF's (1) into isoscalar and isovector parts of the Dirac and Pauli FF's takes the following form

$$\begin{aligned}G_E^\Lambda(t) &= F_{1\Lambda}^s(t)+\frac{t}{4m_\Lambda^2}F_{2\Lambda}^s(t)\\ G_M^\Lambda(t) &= F_{1\Lambda}^s(t)+F_{2\Lambda}^s(t)\end{aligned} \tag{11}$$

$$\begin{aligned}G_E^{\Sigma^+}(t) &= [F_{1\Sigma}^s(t)+F_{1\Sigma}^v(t)]+\frac{t}{4m_{\Sigma^+}^2}[F_{2\Sigma}^s(t)+F_{2\Sigma}^v(t)]\\ G_M^{\Sigma^+}(t) &= [F_{1\Sigma}^s(t)+F_{1\Sigma}^v(t)]+[F_{2\Sigma}^s(t)+F_{2\Sigma}^v(t)]\\ G_E^{\Sigma^0}(t) &= F_{1\Sigma}^s(t)+\frac{t}{4m_{\Sigma^0}^2}F_{2\Sigma}^s(t)\\ G_M^{\Sigma^0}(t) &= F_{1\Sigma}^s(t)+F_{2\Sigma}^s(t)\\ G_E^{\Sigma^-}(t) &= [F_{1\Sigma}^s(t)-F_{1\Sigma}^v(t)]+\frac{t}{4m_{\Sigma^-}^2}[F_{2\Sigma}^s(t)-F_{2\Sigma}^v(t)]\\ G_M^{\Sigma^-}(t) &= [F_{1\Sigma}^s(t)-F_{1\Sigma}^v(t)]+[F_{2\Sigma}^s(t)-F_{2\Sigma}^v(t)]\end{aligned} \tag{12}$$

$$
\begin{aligned}
G_E^{\Xi^0}(t) &= [F_{1\Xi}^s(t) + F_{1\Xi}^v(t)] + \frac{t}{4m_{\Xi^0}^2}[F_{2\Xi}^s(t) + F_{2\Xi}^v(t)] \\
G_M^{\Xi^0}(t) &= [F_{1\Xi}^s(t) + F_{1\Xi}^v(t)] + [F_{2\Xi}^s(t) + F_{2\Xi}^v(t)] \qquad (13) \\
G_E^{\Xi^-}(t) &= [F_{1\Xi}^s(t) - F_{1\Xi}^v(t)] + \frac{t}{4m_{\Xi^-}^2}[F_{2\Xi}^s(t) - F_{2\Xi}^v(t)] \\
G_M^{\Xi^-}(t) &= [F_{1\Xi}^s(t) - F_{1\Xi}^v(t)] + [F_{2\Xi}^s(t) - F_{2\Xi}^v(t)]
\end{aligned}
$$

where

$$
\begin{aligned}
F_{1\Lambda}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Lambda\Lambda}^{(1)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Lambda\Lambda}^{(1)}/f_\phi) \\
F_{2\Lambda}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Lambda\Lambda}^{(2)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Lambda\Lambda}^{(2)}/f_\phi) \qquad (14)
\end{aligned}
$$

$$
\begin{aligned}
F_{1\Sigma}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Sigma\Sigma}^{(1)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Sigma\Sigma}^{(1)}/f_\phi) \\
F_{2\Sigma}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Sigma\Sigma}^{(2)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Sigma\Sigma}^{(2)}/f_\phi) \qquad (15) \\
F_{1\Sigma}^v(t) &= \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho\Sigma\Sigma}^{(1)}/f_\rho); \; F_{2\Sigma}^v(t) = \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho\Sigma\Sigma}^{(2)}/f_\rho)
\end{aligned}
$$

$$
\begin{aligned}
F_{1\Xi}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Xi\Xi}^{(1)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Xi\Xi}^{(1)}/f_\phi) \\
F_{2\Xi}^s(t) &= \frac{m_\omega^2}{m_\omega^2 - t}(f_{\omega\Xi\Xi}^{(2)}/f_\omega) + \frac{m_\phi^2}{m_\phi^2 - t}(f_{\phi\Xi\Xi}^{(2)}/f_\phi) \qquad (16) \\
F_{1\Xi}^v(t) &= \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho\Xi\Xi}^{(1)}/f_\rho); \; F_{2\Xi}^v(t) = \frac{m_\rho^2}{m_\rho^2 - t}(f_{\rho\Xi\Xi}^{(2)}/f_\rho).
\end{aligned}
$$

Now, if all masses are fixed at the world averaged values [23], then only unknown parameters of the model are coupling constant ratios appearing in relations (14)-(16). They will be estimated from the vector meson-nucleon coupling constants given by (6) by utilizing the SU(3) symmetry.

Really, from the SU(3) invariant Lagrangian for the vector meson-baryon-antibaryon vertex

$$
\begin{aligned}
L_{VB\bar{B}} &= \frac{i}{\sqrt{2}} f^F [\bar{B}_\beta^\alpha \gamma_\mu B_\gamma^\beta - \bar{B}_\gamma^\beta \gamma_\mu B_\beta^\alpha](V_\mu)_\alpha^\gamma + \\
&+ \frac{i}{\sqrt{2}} f^D [\bar{B}_\gamma^\beta \gamma_\mu B_\beta^\alpha + \bar{B}_\beta^\alpha \gamma_\mu B_\gamma^\beta](V_\mu)_\alpha^\gamma + \\
&+ \frac{i}{\sqrt{2}} f^S \bar{B}_\beta^\alpha \gamma_\mu B_\alpha^\beta \omega_\mu^0 \qquad (17)
\end{aligned}
$$

with a consideration of the ω - ϕ mixing

$$
\begin{aligned}
\phi^0 &= \phi_8 \cos\vartheta - \omega_1 \sin\vartheta \\
\omega^0 &= \phi_8 \sin\vartheta + \omega_1 \cos\vartheta \qquad (18)
\end{aligned}
$$

where $B, \bar{B}$ and V are [25] baryon, antibaryon and vector meson octuplet matrices, ω_μ^0 is the omega-meson singlet, f^F, f^D and f^S are the corresponding SU(3) coupling constants and ϑ is the mixing angle, one can obtain the following expressions for coupling constants of ρ-, ω-, ϕ-mesons to octet baryons

$$
\begin{aligned}
f_{\rho NN}^{(1,2)} &= \frac{1}{2}(f_{1,2}^D + f_{1,2}^F) \\
f_{\omega NN}^{(1,2)} &= \frac{1}{\sqrt{2}} \cos\vartheta \cdot f_{1,2}^S - \frac{1}{2\sqrt{3}} \sin\vartheta \cdot (3f_{1,2}^F - f_{1,2}^D) \qquad (19) \\
f_{\phi NN}^{(1,2)} &= \frac{1}{\sqrt{2}} \sin\vartheta \cdot f_{1,2}^S + \frac{1}{2\sqrt{3}} \cos\vartheta \cdot (3f_{1,2}^F - f_{1,2}^D)
\end{aligned}
$$

$$
\begin{aligned}
f_{\omega\Lambda\Lambda}^{(1,2)} &= \frac{1}{\sqrt{2}} \cos\vartheta \cdot f_{1,2}^S + \frac{1}{\sqrt{3}} \sin\vartheta \cdot f_{1,2}^D \\
f_{\phi\Lambda\Lambda}^{(1,2)} &= \frac{1}{\sqrt{2}} \sin\vartheta \cdot f_{1,2}^S - \frac{1}{\sqrt{3}} \cos\vartheta \cdot f_{1,2}^D \qquad (20)
\end{aligned}
$$

$$
\begin{aligned}
f_{\rho\Sigma\Sigma}^{(1,2)} &= -f_{1,2}^F \\
f_{\omega\Sigma\Sigma}^{(1,2)} &= \frac{1}{\sqrt{2}} \cos\vartheta \cdot f_{1,2}^S - \frac{1}{\sqrt{3}} \sin\vartheta \cdot f_{1,2}^D \qquad (21) \\
f_{\phi\Sigma\Sigma}^{(1,2)} &= \frac{1}{\sqrt{2}} \sin\vartheta \cdot f_{1,2}^S + \frac{1}{\sqrt{3}} \cos\vartheta \cdot f_{1,2}^D
\end{aligned}
$$

$$f^{(1,2)}_{\rho\Xi\Xi} = \frac{1}{2}(f^D_{1,2} - f^F_{1,2})$$
$$f^{(1,2)}_{\omega\Xi\Xi} = \frac{1}{\sqrt{2}}\cos\vartheta \cdot f^S_{1,2} + \frac{1}{2\sqrt{3}}\sin\vartheta \cdot (3f^F_{1,2} + f^D_{1,2}) \quad (22)$$
$$f^{(1,2)}_{\phi\Xi\Xi} = \frac{1}{\sqrt{2}}\sin\vartheta \cdot f^S_{1,2} - \frac{1}{2\sqrt{3}}\cos\vartheta \cdot (3f^F_{1,2} + f^D_{1,2}).$$

The mixing angle $\vartheta = 39.83°$ is determined by the Gell-Mann-Okubo quadratic mass formula

$$m^2_\phi \cos^2\vartheta + m^2_\omega \sin^2\vartheta = \frac{4m^2_{K^*} - m^2_\rho}{3}. \quad (23)$$

The universal vector meson coupling constants

$$f_\rho = 4.9905 \pm 0.1089; \; f_\omega = 17.0550 \pm 0.2990; \; f_\phi = 12.8832 \pm 0.0003 \quad (24)$$

are calculated [26] by utilization of the newest experimental results [23] on the corresponding lepton widths.

Then from (24) and (6) the following values of the vector meson-nucleon coupling constants are obtained

$$f^{(1)}_{\omega NN} = 8.5275, \quad f^{(2)}_{\omega NN} = -1.0250,$$
$$f^{(1)}_{\rho NN} = 2.4953, \quad f^{(2)}_{\rho NN} = 9.2471, \quad (25)$$

which through a solution of the equations (19) (considering strictly the OZI rule [20) −22)] i.e. $f^{(1)}_{\phi NN} = f^{(2)}_{\phi NN} = 0$) the values

$$f^S_1 = 9.2614, \quad f^S_2 = -1.1132,$$
$$f^F_1 = -3.4825, \quad f^F_2 = 5.1921, \quad (26)$$
$$f^D_1 = 8.4730, \quad f^D_2 = 13.3021,$$

of the SU(3) coupling constant produce.

As a result, by means of the relations (20),(21) and (22), together with (24), the following ratios of the vector meson-hyperon coupling constants are obtained

$$(f^{(1)}_{\omega\Lambda\Lambda}/f_\omega) = 0.4786, \quad (f^{(2)}_{\omega\Lambda\Lambda}/f_\omega) = 0.2530,$$
$$(f^{(1)}_{\phi\Lambda\Lambda}/f_\phi) = 0.0340, \quad (f^{(2)}_{\phi\Lambda\Lambda}/f_\phi) = -0.4969, \quad (27)$$

$$(f^{(1)}_{\rho\Sigma\Sigma}/f_\rho) = 0.6978, \quad (f^{(2)}_{\rho\Sigma\Sigma}/f_\rho) = -1.0404,$$
$$(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega) = 0.1112, \quad (f^{(2)}_{\omega\Sigma\Sigma}/f_\omega) = -0.3239, \quad (28)$$
$$(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi) = 0.6172, \quad (f^{(2)}_{\phi\Sigma\Sigma}/f_\phi) = 0.4187,$$

$$(f^{(1)}_{\rho\Xi\Xi}/f_\rho) = 1.1978, \quad (f^{(2)}_{\rho\Xi\Xi}/f_\rho) = 0.8125,$$
$$(f^{(1)}_{\omega\Xi\Xi}/f_\omega) = 0.2735, \quad (f^{(2)}_{\omega\Xi\Xi}/f_\omega) = 0.2776, \quad (29)$$
$$(f^{(1)}_{\phi\Xi\Xi}/f_\phi) = 0.3596, \quad (f^{(2)}_{\phi\Xi\Xi}/f_\phi) = -0.5361.$$

Our model of the EM FF's of hyperons is then given by the relations (11)-(16) and (27)-(29).

The corresponding electric and magnetic mean-square radii have the following forms

$$<r^2_{E\Lambda}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Lambda\Lambda}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Lambda\Lambda}/f_\phi)+\frac{1}{4m^2_\Lambda}[(f^{(2)}_{\omega\Lambda\Lambda}/f_\omega)+(f^{(2)}_{\phi\Lambda\Lambda}/f_\phi)]\right\}$$

$$<r^2_{M\Lambda}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Lambda\Lambda}/f_\omega)+(f^{(2)}_{\omega\Lambda\Lambda}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Lambda\Lambda}/f_\phi)+(f^{(2)}_{\phi\Lambda\Lambda}/f_\phi)]\right\} \quad (30)$$

$$<r^2_{E\Sigma^+}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)+\frac{1}{m^2_\rho}(f^{(1)}_{\rho\Sigma\Sigma}/f_\rho)+\right.$$
$$\left.+\ \frac{1}{4m^2_{\Sigma^+}}[(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)+(f^{(2)}_{\rho\Sigma\Sigma}/f_\rho)]\right\}$$

$$<r^2_{M\Sigma^+}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)]+\right.$$
$$\left.+\ \frac{1}{m^2_\rho}[(f^{(1)}_{\rho\Sigma\Sigma}/f_\rho)+(f^{(2)}_{\rho\Sigma\Sigma}/f_\rho)]\right\}$$

$$<r^2_{E\Sigma^0}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)+\frac{1}{4m^2_{\Sigma^0}}[(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)]\right\}$$

$$<r^2_{M\Sigma^0}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)]\right\} \quad (31)$$

$$<r^2_{E\Sigma^-}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)-\frac{1}{m^2_\rho}(f^{(1)}_{\rho\Sigma\Sigma}/f_\rho)+\right.$$
$$\left.+\ \frac{1}{4m^2_{\Sigma^-}}[(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)-(f^{(2)}_{\rho\Sigma\Sigma}/f_\rho)]\right\}$$

$$<r^2_{M\Sigma^-}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Sigma\Sigma}/f_\omega)+(f^{(2)}_{\omega\Sigma\Sigma}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Sigma\Sigma}/f_\phi)+(f^{(2)}_{\phi\Sigma\Sigma}/f_\phi)]-\right.$$
$$\left.-\ \frac{1}{m^2_\rho}[(f^{(1)}_{\rho\Sigma\Sigma}/f_\rho)+(f^{(2)}_{\rho\Sigma\Sigma}/f_\rho)]\right\}$$

$$<r^2_{E\Xi^0}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Xi\Xi}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Xi\Xi}/f_\phi)+\frac{1}{m^2_\rho}(f^{(1)}_{\rho\Xi\Xi}/f_\rho)+\right.$$
$$\left.+\ \frac{1}{4m^2_{\Xi^0}}[(f^{(2)}_{\omega\Xi\Xi}/f_\omega)+(f^{(2)}_{\phi\Xi\Xi}/f_\phi)+(f^{(2)}_{\rho\Xi\Xi}/f_\rho)]\right\}$$

$$<r^2_{M\Xi^0}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Xi\Xi}/f_\omega)+(f^{(2)}_{\omega\Xi\Xi}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Xi\Xi}/f_\phi)+(f^{(2)}_{\phi\Xi\Xi}/f_\phi)]+\right.$$
$$\left.+\ \frac{1}{m^2_\rho}[(f^{(1)}_{\rho\Xi\Xi}/f_\rho)+(f^{(2)}_{\rho\Xi\Xi}/f_\rho)]\right\} \quad (32)$$

$$<r^2_{E\Xi^-}> = 6\left\{\frac{1}{m^2_\omega}(f^{(1)}_{\omega\Xi\Xi}/f_\omega)+\frac{1}{m^2_\phi}(f^{(1)}_{\phi\Xi\Xi}/f_\phi)-\frac{1}{m^2_\rho}(f^{(1)}_{\rho\Xi\Xi}/f_\rho)+\right.$$
$$\left.+\ \frac{1}{4m^2_{\Xi^-}}[(f^{(2)}_{\omega\Xi\Xi}/f_\omega)+(f^{(2)}_{\phi\Xi\Xi}/f_\phi)-(f^{(2)}_{\rho\Xi\Xi}/f_\rho)]\right\}$$

$$<r^2_{M\Xi^-}> = 6\left\{\frac{1}{m^2_\omega}[(f^{(1)}_{\omega\Xi\Xi}/f_\omega)+(f^{(2)}_{\omega\Xi\Xi}/f_\omega)]+\frac{1}{m^2_\phi}[(f^{(1)}_{\phi\Xi\Xi}/f_\phi)+(f^{(2)}_{\phi\Xi\Xi}/f_\phi)]-\right.$$
$$\left.-\ \frac{1}{m^2_\rho}[(f^{(1)}_{\rho\Xi\Xi}/f_\rho)+(f^{(2)}_{\rho\Xi\Xi}/f_\rho)]\right\}$$

and substituing (27)-(29) into them, the electric and magnetic mean--square radii of octet baryons are numerically evaluated as presented in Table 1. and Table 2., where also a comparison with results obtained in the framework of the lattice QCD [18] and the quark [15),16] and Skyrme [17] models is carried out.

In the case of the electric mean-square radii a perfect agreement in the sign and more or less also in magnitude with other predictions is realized. However, in the magnetic mean-square radii some discrepancy is noticed.

The latter may be naturally explained by a naiveté of the used model i.e. by a confinement only to the ρ-, ω- and ϕ- mesons in the VMD parametrization of the baryon EM FF's, leading already in the case of the nucleons to the stronger disagreement of the magnetic mean-square radii with experiment than of the electric ones. Really, by including two families of excited states [23] of ρ- and ω- mesons into the VMD parametrization of the nucleon EM FF's and determining the corresponding ratios

Table 1. The electric mean-square radii of octet baryons predicted by our naive model and their comparison with predictions following from the lattice QCD and the quark (QM) and Skyrme (SM) models.

BARYONS	$< r_E^2 >$ $[fm^2]$					
	Latt. QCD [18]	QM [15]	QM [16]	SM [17]	Our results	Exp.
p	0.426	0.870	0.664	0.775	0.508	0.743
n	< 0	0	0	-0.308	-0.133	-0.119
Λ	> 0	0.120	0.091	0.107	0.179	—
Σ^+	0.532	0.990	0.753	0.964	0.418	—
Σ^0	> 0	0.120	0.091	0.107	0.185	—
Σ^-	-0.332	-0.750	-0.570	-0.751	-0.049	—
Ξ^0	> 0	0.240	0.190	0.221	0.678	—
Ξ^-	-0.262	-0.630	-0.475	-0.261	-0.325	—

Table 2. The magnetic mean-square radii of octet baryons predicted by our naive model and their comparison with predictions following from the lattice QCD and the Skyrme (SM) model.

BARYONS	$< r_M^2 >$ $[fm^2]$			
	Latt. QCD [18]	SM [17]	Our results	Exp.
p	0.832	1.241	1.099	1.986
n	-0.451	-0.842	-0.763	-1.458
Λ	-0.076	-0.116	0.175	—
Σ^+	0.778	1.401	0.016	—
Σ^0	0.187	0.305	0.152	—
Σ^-	-0.416	-0.790	0.287	—
Ξ^0	-0.237	-0.605	0.967	—
Ξ^-	-0.069	0.162	-0.625	—

of the vector meson-nucleon coupling constants (besides the use of the normalizations) in an optimal fit of existing nucleon FF experimental data, perfect values of the nucleon EM mean-square radii are obtained. However, the absence of the second excited state of the $\phi(1020)$- meson and the leptonic width even for $\phi(1680)$ [23] as well prevent to extend that scheme to other members of the baryon octet.

Anyway, in view of the simplicity of our model and a generally accepted cca 30% standard accuracy of the used SU(3) symmetry the obtained results are quite plausible.

4 CONCLUSIONS AND SUMMARY

We have constructed a very simple model of the EM structure of the octet baryons used to predict numerical values of the EM mean-square radii of all members of the baryon octuplet without utilization of any experimental point on the baryon EM FF's.

The idea consists in the following. The Dirac and Pauli EM FF's of the octet baryons are parametrized by using the standard VMD model in a zero width approximation, where we have confined ourselves only to the ground state vector meson nonet. In this case isoscalar parts of the Dirac and Pauli FF's contain the $\omega(783)$ and $\phi(1020)$ contributions; and isovector parts, only the $\rho(770)$ contribution. If all masses are fixed at the world averaged values, the only unknown parameters of the model are vector meson-baryon coupling constants.

In the nucleon case, taking into account the OZI rule strictly, the coupling constants of the ϕ- meson to nucleons are zero and then the coupling constants of the ω- and ρ- meson to nucleons are completely determined by a normalization of nucleon EM FF's. The vector meson-hyperon coupling constants are obtained from the latter by using the SU(3) relations. Owing to the simplicity of the used model, the obtained results for EM mean-square radii are encouraging.

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