Static properties of octet baryons in a field-theoretic quark model

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We consider here static properties, such as the magnetic moments, g_A/g_V, and charge radii of baryons in a field-theoretic quark model, where translationally invariant SU(6) baryon states are described by constituent quark field operators and harmonic oscillator wave functions. The constituent quark field operators of hadrons at rest, with a particular ansatz, satisfy the Dirac-type algebra and are also Lorentz boosted in a definite manner to describe the baryons in motion. Such a description of hadrons was quite successful in explaining varieties of hadronic phenomena and presently we also observe a reasonable agreement with experiments, wherever available. We may note that the present investigation does not contain any free parameters as they are prefixed by the experimental data as well as from the earlier applications of the model.

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I. INTRODUCTION

The study of the static properties of baryons, such as the magnetic moments, g_A/g_V, and the charge radii, are of much interest in investigating the structure of baryons. But these, being the low energy phenomena, cannot be studied from first principle applications of quantum chromodynamics (QCD) [1], despite its being the correct theory for hadrons. For this one resorts to phenomenological models for hadrons based on quantum field theory. Thus we investigate here the static properties of octet baryons based on a field-theoretic quark model which was earlier applied to estimate the static properties such as the charge radius of the proton, g_A/g_V for the nucleons, and the magnetic moments of p, n, and Λ [2,3]. However, in the present investigation we extend it to estimate the same for the other octet baryons and Ω^-. In the present field-theoretic quark model the baryons in their rest frames are assumed to consist of constituent quarks occupying fixed energy levels [2]. The constituent quarks are described by the four component quark field operators which, with some ansatz, satisfy the free Dirac-type algebra. Further the SU(6) symmetric baryon states are constructed in terms of these constituent quark field operators and harmonic oscillator wave functions to describe baryons at rest; e.g., for a proton one can write such a state as

$$|p_{1/2}(\mathbf{0})\rangle=\frac{\epsilon_{ijk}}{3\sqrt{2}}\int d\mathbf{k}_1 d\mathbf{k}_2 d\mathbf{k}_3 \delta(\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3)\tilde{u}_p(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3) \times[u_{I1/2}^{i\dagger}(\mathbf{k}_1)u_{I1/2}^{j\dagger}(\mathbf{k}_2)d_{I-1/2}^{k\dagger}(\mathbf{k}_3)-u_{I1/2}^{i\dagger}(\mathbf{k}_1)u_{I-1/2}^{j\dagger}(\mathbf{k}_2)d_{I1/2}^{k\dagger}(\mathbf{k}_3)]|\text{vac}\rangle , \tag{1.1}$$

with the normalized harmonic oscillator wave function taken as

$$\tilde{u}_p(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)=\left[\frac{3R_p^4}{\pi^2}\right]^{3/4}\exp\left[-R_p^2\sum_{i<j}(\mathbf{k}_i-\mathbf{k}_j)^2/6\right] , \tag{1.2}$$

where R_p is the harmonic oscillator radius for the proton. In the present model, one can also obtain the SU(6) states for other baryons with quark field operators of appropriate flavors as reported in the Appendix. Also, in the present model the constituent quark field operators describing hadrons at rest are Lorentz boosted in a particular manner [3] to describe the hadrons in motion, and thus the SU(6) states for all octet baryons can be constructed analogous to Eq. (1.1) and those in the Appendix.

The present field-theoretic quark model has been earlier applied to a variety of hadronic phenomena, such as coherent [2–4] and incoherent [5] phenomena with a reasonable amount of success. Recently, the model has also successfully been applied to explain the strong CP-violation problem in the context of the electric dipole moment of the neutron [6], the weak mixing problem in the context of K_L-K_S and B_d^0-$\bar{B}_d^0$ mixing [7], the leptonic decay of vector mesons [8], and the weak leptonic decay of pseudoscalar mesons [9]. Keeping the above successes in mind we extend its application to estimate the magnetic moments, g_A/g_V, and charge radii of octet baryons and Ω^-, where the experimental signals, wherever available, are quite clean to compare with.

The present article is organized as follows. In Sec II, we describe the calculations of magnetic moments, g_A/g_V, as well as the charge radii of octet baryons and Ω^-. In Sec. III, we estimate the results and make a comparative analysis of these with the experiment as well as other theoretical estimations.

II. STATIC PROPERTIES OF BARYONS

We consider here the magnetic moments, g_A/g_V, and charge radii of octet baryons and, for this, we deduce their respective expressions both in nonrelativistic as well as relativistic frames.

A. Magnetic moments of baryons

We first consider the nonrelativistic expressions for magnetic moments of octet baryons. To do so one usually considers the electromagnetic interaction in quark space, with $A^0=0$, as

$$H_I(x)=-\sum_Q e_Q Q^\dagger(x)(\boldsymbol{\alpha}\cdot\mathbf{A})Q(x) . \tag{2.1}$$

$Q(x)$ is the constituent quark field operator of the model [2] which when substituted in (2.1) yields

$$H_I^{\mathrm{em}}(x)=\sum_{Q,\alpha} e_Q g_Q Q_I^{\alpha\dagger}(x)[f_Q\boldsymbol{\sigma}\cdot(\nabla\times\mathbf{A})]Q_I^\alpha(x) . \tag{2.2}$$

The effective Hamiltonian in (2.2), when sandwiched between the static baryon states $|B_{1/2}(\mathbf{0})\rangle$, yields an expression for the magnetic moment of the baryon in the nonrelativistic model as

$$\mu_B=(2\pi)^3\langle B_{1/2}(\mathbf{0})|\sum_{Q,\alpha} e_Q g_Q Q_I^{\alpha\dagger}(\mathbf{0})\times(f_Q\sigma_3)Q_I^\alpha(\mathbf{0})|B_{1/2}(\mathbf{0})\rangle , \tag{2.3}$$

where α is the color index and the factor $(2\pi)^3$ in Eq. (2.3) arises due to translational invariance. Also Eq. (2.3) when written in momentum space becomes.

$$\mu_B=\langle B_{1/2}(\mathbf{0})|\sum_{Q,\alpha} e_Q g_Q \int d\mathbf{k}\,d\mathbf{k}' Q_I^{\alpha\dagger}(\mathbf{k}')(f_Q(\mathbf{k})\sigma_3)\times Q_I^\alpha(\mathbf{k})|B_{1/2}(\mathbf{0})\rangle . \tag{2.4}$$

Next, using explicit SU(6) states for the baryons as reported in the Appendix and the two component quark field operators of the model [2], one can obtain the expressions for the magnetic moments of individual baryons. However, such an estimation was made in Ref. [2] for the proton, neutron, and Λ, and so we obtain them for the other baryons as

$$\mu_{\Sigma^+}=\tfrac{1}{3}\left[\frac{8g_u}{3}\left[1-\frac{g_u^2}{2R_{\Sigma^+}^2}\right]+\frac{g_s}{3}\left[1-\frac{g_s^2}{2R_{\Sigma^+}^2}\right]\right] , \tag{2.5a}$$

$$\mu_{\Sigma^-}=-\tfrac{1}{3}\left[\frac{4g_d}{3}\left[1-\frac{g_d^2}{2R_{\Sigma^-}^2}\right]-\frac{g_s}{3}\left[1-\frac{g_s^2}{2R_{\Sigma^-}^2}\right]\right] , \tag{2.5b}$$

$$\mu_{\Sigma^0}=\tfrac{1}{2}[\mu_{\Sigma^+}+\mu_{\Sigma^-}] , \tag{2.5c}$$

$$\mu_{\Xi^0}=-\tfrac{1}{3}\left[\frac{2g_u}{3}\left[1-\frac{g_u^2}{2R_{\Xi^0}^2}\right]+\frac{4g_s}{3}\left[1-\frac{g_s^2}{2R_{\Xi^0}^2}\right]\right] , \tag{2.5d}$$

$$\mu_{\Xi^-}\leftrightarrow\mu_{\Sigma^-}\quad(\text{with } d\leftrightarrow s) , \tag{2.5e}$$

$$\mu_{\Sigma^0\Lambda}=\left[\frac{1}{\sqrt{3}}\right]\left[\frac{2g_u}{3}\left[1-\frac{g_u^2}{(R_\Sigma^2+R_\Lambda^2)}\right]+\frac{g_d}{3}\left[1-\frac{g_d^2}{(R_\Sigma^2+R_\Lambda^2)}\right]\right] . \tag{2.5f}$$

In the present model, we also deduce the expression for the magnetic moment for the Ω^- baryon as

$$\mu_{\Omega^-}=-\left[g_S\left[1-\frac{g_s^2}{2R_{\Omega^-}^2}\right]\right] . \tag{2.5g}$$

Ordinarily, one calculates the magnetic moments of the baryons in a relativistic quark model where the electromagnetic current is sandwiched between the moving baryon states. One identifies the magnetic moment of the baryon in the Breit frame as [3]

$$\frac{i}{(2\pi)^3}u_{I1/2}^\dagger[\boldsymbol{\sigma}\times(-2\mathbf{p})]^i u_{I1/2}\mu_B=\langle B_{1/2}(-\mathbf{p})|J^i(0)|B_{1/2}(\mathbf{p})\rangle . \tag{2.6}$$

To estimate μ_B from (2.6) one has to use states for baryons in motion as obtained through their states at rest, as mentioned in the earlier section. Thus, we obtain the relativistic expressions for the magnetic moments of octet baryons as

$$\mu_{\Sigma^+}=\frac{1}{3}\left[\frac{8}{3}\left\{\frac{1}{2m_{\Sigma^+}}\left[1-\frac{4g_u^2}{3R_{\Sigma^+}^2}\right]+g_u(\lambda_2+\lambda_3)\right\}+\frac{1}{3}\left\{\frac{1}{2m_{\Sigma^+}}\left[1-\frac{4g_s^2}{3R_{\Sigma^+}^2}\right]+g_s(\lambda_1+\lambda_2)\right\}\right] , \tag{2.7a}$$

$$\mu_{\Sigma^-}=-\frac{1}{3}\left[\frac{4}{3}\left\{\frac{1}{2m_{\Sigma^-}}\left[1-\frac{4g_d^2}{3R_{\Sigma^-}^2}\right]+g_d(\lambda_2+\lambda_3)\right\}-\frac{1}{3}\left\{\frac{1}{2m_{\Sigma^-}}\left[1-\frac{4g_s^2}{3R_{\Sigma^-}^2}\right]+g_s(\lambda_1+\lambda_2)\right\}\right] , \tag{2.7b}$$

$$\mu_{\Sigma^0}=\tfrac{1}{2}[\mu_{\Sigma^+}+\mu_{\Sigma^-}] , \tag{2.7c}$$

$$\mu_{\Xi^0}=-\frac{1}{3}\left[\frac{2}{3}\left\{\frac{1}{2m_{\Xi^0}}\left[1-\frac{4g_u^2}{3R_{\Xi^0}^2}\right]+g_u(\lambda_2+\lambda_3)\right\}+\frac{4}{3}\left\{\frac{1}{2m_{\Xi^0}}\left[1-\frac{4g_s^2}{3R_{\Xi^0}^2}\right]+g_s(\lambda_1+\lambda_2)\right\}\right], \tag{2.7d}$$

$$\mu_{\Xi^-}=\frac{1}{3}\left[\frac{1}{3}\left\{\frac{1}{2m_{\Xi^-}}\left[1-\frac{4g_d^2}{3R_{\Xi^-}^2}\right]+g_d(\lambda_2+\lambda_3)\right\}-\frac{4}{3}\left\{\frac{1}{2m_{\Xi^-}}\left[1-\frac{4g_s^2}{3R_{\Xi^-}^2}\right]+g_s(\lambda_1+\lambda_2)\right\}\right], \tag{2.7e}$$

$$\mu_{\Sigma^0\Lambda}=\frac{1}{\sqrt{3}}\left[\frac{1}{2m_{\Sigma^0}^{1/2}m_\Lambda^{1/2}}\left[1-\frac{8g_u^2}{3(R_{\Sigma^0}^2+R_\Lambda^2)}\right]+\frac{2}{3}g_u(\lambda_2+\lambda_3)+\frac{1}{3}g_d(\lambda_1+\lambda_2)\right]. \tag{2.7f}$$

In the present relativistic framework, we also deduce the expression for the magnetic moment for the Ω^- baryon as

$$\mu_{\Omega^-}=-\left[\frac{1}{2m_{\Omega^-}}\left[1-\frac{4g_s^2}{3R_{\Omega^-}^2}\right]+g_S(\lambda_2+\lambda_3)\right], \tag{2.7g}$$

where the λ_i's used in the above equations, with $i=1,2,3$, are the energy fractions of the hadron carried by the quark and they are positive with their sum being 1, i.e., $\lambda_1+\lambda_2+\lambda_3=1$ [2,3].

B. g_A/g_V of octet baryons

We next consider, in the present field-theoretic quark model, to obtain the expressions for g_A/g_V for the decay processes involving I-spin and V-spin currents. However, this calculation will not need any Lorentz boosting of hadrons and so here we do a nonrelativistic estimation of g_A/g_V. This was in fact done in Ref. [2] for the particular process $n\to p+e^-+\bar{\nu}_e$ whereas we consider here a baryon in general B decaying into another baryon B' along with an electron and an antineutrino, i.e., $B\to B'+e^-+\bar{\nu}_e$. In such processes one of the quarks of B, say of flavor q_1, transforms into one of the quarks of B', say of flavor q_2. Thus, the same process can also be imagined to be occurring in quark space as $q_1\to q_2+e^-+\bar{\nu}_e$ and hence the corresponding current involved with the process can be written as $\bar{q}_2(0)\gamma\gamma_5 q_1(0)$, which in fact when sandwiched between the static baryon states yields

$$(g_A/g_V)_{B\to B'}=(2\pi)^3\langle B'_{1/2}(\mathbf{0})|\bar{q}_2(0)\gamma\gamma_5 q_1(0)|B_{1/2}(\mathbf{0})\rangle\ , \tag{2.8}$$

which, also when written in the momentum space, becomes

$$(g_A/g_V)_{B\to B'}=\langle B'_{1/2}(\mathbf{0})|\int d\mathbf{k}\,d\mathbf{k}'\bar{q}_2(\mathbf{k}')\gamma\gamma_5 q_1(\mathbf{k})|B_{1/2}(\mathbf{0})\rangle\ . \tag{2.9}$$

The right-hand side of (2.9), when evaluated by taking different baryon states explicitly, yields a general formula for g_A/g_V as

$$(g_A/g_V)=C_{BB'}\left[\frac{4R_B^2R_{B'}^2}{R_B^2+R_{B'}^2}\right]^{3/2}\left\{1-\frac{(g_{q_1}+g_{q_2})^2}{R_B^2+R_{B'}^2}+\frac{4g_{q_1}g_{q_2}}{3(R_B^2+R_{B'}^2)}\right\}, \tag{2.10}$$

where $C_{BB'}$ is a baryon transition-dependent factor which in fact arises due to the corresponding normalization and number of possible contractions encountered in the respective processes. We in fact quote them separately during our discussions while making a comparison of our estimations with the experiments as well as other investigations in the next section.

C. Charge radii of octet baryons

In this subsection we deduce the expressions for charge radii of baryons in the present field-theoretic quark model. To do so we define the electric form factor in the Breit frame as [3]

$$G_E^B(t)=(2\pi)^3(p^0/m)\langle B_{1/2}(-\mathbf{p})|J_{\text{em}}^0(0)|B_{1/2}(\mathbf{p})\rangle\ , \tag{2.11}$$

where the momentum transfer variable $t=-(\mathbf{p}'-\mathbf{p})^2=-4\mathbf{p}^2$. The charge density operator in terms of quark field operators ψ_Q is written as [3]

$$J_{\text{em}}^0(0)=\sum_Q e_Q\bar{\psi}_Q(0)\gamma^0\psi_Q(0)\ , \tag{2.12}$$

where e_Q is the charge of quark of flavor Q and in momentum space becomes

$$J^0_{\rm em}(0)=(2\pi)^{-3}\left[\frac{p^0}{m}\right]\sum_{Q,\alpha} e_Q\int d\mathbf{k}\,d\mathbf{k}' Q^{\dagger\alpha}_{Ir}[L(-p)k']u_r^\dagger(\mathbf{k}')u_s(\mathbf{k})Q^\alpha_{Is}[L(p)k]\ , \tag{2.13}$$

with $Q_{Ir}[L(p)k]$ as the Lorentz transformed quark field operators and $u_r(\mathbf{k})$ as the spinors of this model [3]. Equation (2.13), when substituted in (2.11), yields the expression for the electric form factor of the baryon B as

$$G_E^B(t)=\left[\frac{p^0}{m}\right]^2\langle B_{1/2}(-\mathbf{p})|\sum_Q e_Q\int d\mathbf{k}\,d\mathbf{k} Q^{\dagger\alpha}_{Ir}[L(-p)k']u_r^\dagger(\mathbf{k}')u_s(\mathbf{k})Q^\alpha_{Is}[L(p)k]|B_{1/2}(\mathbf{p})\rangle\ . \tag{2.14}$$

Thus, using the explicit baryon states and equal time algebra, the electric form factor of a baryon as described above can be written in general form, with i,j,k cyclic indices, as

$$G_E^B(\tau)=\sum_{i=1}^3 e_{Q_i}\left[1+\frac{g^2_{Q_i}}{2}(\lambda_j+\lambda_k)^2\right]\exp\left[-\frac{R_B^2}{8}\{3(\lambda_j+\lambda_k)^2+(\lambda_j-\lambda_k)^2\}\tau\right]\ , \tag{2.15}$$

where $\tau=t/[1-t/(4m^2)]=-(m/p^0)^2 4\mathbf{p}^2$ and Q_i's are the constituent quarks. We may note here that such an estimation was made, in particular, for the proton only in Ref. [3] whereas in the present investigation we have obtained it for any baryon, in general.

Thus in a conventional manner using (2.15) we obtain a general expression for the charge radius of a baryon, with cyclic indices i,j,k, as

$$\langle r^2_{\rm ch}\rangle^{1/2}=\left[6\sum_{i=1}^3 e_{Q_i}\left\{\frac{R_B^2}{8}[3(\lambda_j+\lambda_k)^2+(\lambda_j-\lambda_k)^2]+\frac{g^2_{Q_i}}{2}(\lambda_j+\lambda_k)^2\right\}\right]^{1/2}\ . \tag{2.16}$$

Thus, using the expressions for the magnetic moments, g_A/g_V, and charge radius as described in (2.5) and (2.7), (2.10) and (2.16), respectively, we estimate them for different baryons and discuss them in the following section.

III. RESULTS AND DISCUSSION

Using the expressions for the magnetic moments, g_A/g_v, and charge radius as described in Sec. II we estimate them here. To do so, our calculations primarily depend on the parameters such as the quark masses, the harmonic oscillator radius, and the baryon masses. The baryon masses we take as their experimentally measured values [10], whereas for the quark masses we take for u, d, and s quarks as

$$m_u=0.308\ \text{GeV},\quad m_d=0.295\ \text{GeV},\quad m_s=0.485\ \text{GeV}\ . \tag{3.1}$$

In the present model, the quark masses are used to evaluate the g_Q's by the relation $g_Q=1/(2m_Q)$ which is in fact used directly to estimate the static properties [2,3]. For the harmonic oscillator radius we take all the octet baryons to be the same:

$$R_B^2=14.5\ \text{GeV}^{-2}\ . \tag{3.2}$$

With these parameters we make both nonrelativistic and relativistic estimations of magnetic moments of all the octet baryons using expressions (2.5) and (2.7), respectively, and have reported them in Table I where we also compare them with experiment [10] and find reasonable

TABLE I. Estimated magnetic moments (in nm) of octet baryons and Ω^- in the present model compared with the experiment and other theoretical estimations.

μ_B	Present investigation Nonrel.	Present investigation Rel.	Ref. [11] (nm)	Ref. [12] (nm)	Ref. [13] (nm)	Experiment [10] (nm)
μ_p	2.788	2.794	2.79	2.607	2.89	2.792
μ_n	−1.8945	−1.8942	−1.91	−1.71	−1.91	−1.913
μ_Λ	−0.623	−0.612	−0.613	−0.616	−0.66	−0.613±0.004
μ_{Σ^+}	2.67	2.68	2.31	2.494	2.24	2.42±0.05
μ_{Σ^-}	−1.069	−1.088	−0.93	−0.953	−0.79	−1.16±0.025
μ_{Σ^0}	0.8	0.79		0.771		0.61±0.04
μ_{Ξ^0}	−1.447	−1.45	−1.2	−1.376	−1.20	−1.25±0.014
μ_{Ξ^-}	−0.511	−0.487	−0.47	−0.559	−0.52	−0.65±0.0025
$\lvert\mu_{\Sigma^0\Lambda}\rvert$	1.62	1.6	1.40	1.482	1.61	1.61±0.08
μ_{Ω^-}	−1.86	−1.80	−1.3			−1.94±0.22

TABLE II. Estimated baryon transition factors $C_{BB'}$ and the g_A/g_V in the present model compared with the experiment and other estimations.

Decay process	$C_{BB'}$	"Present investigation (g_A/g_V)"	Ref. [12]	Ref. [14]	Experiment [10]
$n \to p + e^- + \bar{\nu}_e$	$\frac{5}{3}$	1.244	1.02	1.157	1.2573±0.0028
$\Lambda \to p + e^- + \bar{\nu}_e$	-1	-0.83	-0.702	-0.865	-0.718 ± 0.015
$\Sigma^- \to n + e^- + \bar{\nu}_e$	$\frac{1}{3}$	0.278	0.234	0.234	0.34±0.017
$\Xi^- \to \Lambda + e^- + \bar{\nu}_e$	$-\frac{1}{3}$	-0.278	-0.153	-0.3	-0.25 ± 0.05
$\Xi^- \to \Sigma^0 + e^- + \bar{\nu}_e$	$-\frac{5}{3}$	-1.39	-1.1624		-1.287 ± 0.158
$\Xi^0 \to \Sigma^+ + e^- + \bar{\nu}_e$	$\frac{5}{3}$	1.39	1.1624		

agreement. We may note here that though the magnetic moments of the proton, neutron, and Λ were estimated earlier [2,3], for the sake of completeness and comparison we have reported them in Table I. Further, we observe that the relativistic corrections over the nonrelativistic ones are found to be very small, as expected. Here we also compare them with other theoretical attempts. In a recent analysis by Das and Misra [11], with the idea of different effective quark masses for different sets of baryons, the magnetic moments were estimated and we observe that our estimations are close to theirs though we have a fixed set of parameters for all the octet baryons. In another analysis [12] in an independent quark potential model approach the magnetic moments of octet baryons have been calculated and we find these are not much different from ours. Also, in an additive quark model [13] the magnetic moments of octet baryons have been estimated and when we compare our results with theirs we find they are not very much different from ours. In addition to the octet baryons, we have also estimated the magnetic moment of the decouplet Ω^- baryon as a pure strange baryon and here also we observe a close agreement with the most recent experimental data [10].

Next with the same set of parameters as taken above we also estimate g_A/g_V for baryon decays using expression (2.10) and the appropriate multiplicative factors $C_{BB'}$ as reported in Table II. Here also we compare them with experiment [10], wherever available, and observe a reasonable agreement. In the independent quark model approach [12], g_A/g_V for baryon decay processes have been calculated and when we compare our estimations with theirs we find that theirs are not very much different from ours except for the process $n \to p + e^- + \bar{\nu}_e$ where we observe a better agreement with the experiment [10] than theirs. Also in a most recent analysis in color dielectric model (CDM) [14], g_A/g_V for different processes have been estimated and we observe that their estimations are close to ours. In fact, we have compared the estimations of Refs. [12] and [14] with ours in Table II. Further, we also observe that our estimations of g_A/g_V for the process $\Xi^- \to \Sigma^0 + e^- + \bar{\nu}_e$ are within the limits of most recent measurements [10]. Thus for the overall agreement of our estimations of g_A/g_V, the result we have quoted for the $\Xi^0 \to \Sigma^+ + e^- + \bar{\nu}_e$ process may be treated as a prediction of the present field-theoretic quark model, which in fact may be measured in future experiments.

We also estimate the charge radii of all the octet baryons in the field-theoretic quark model again with the same set of parameters as in the earlier two estimations. However, the experimental results here are very limited by the fact that except for the proton and neutron others so far have not been measured. However, there are other theoretical estimations [15–17] for the charge radii of baryons and we have compared ours with them and the experiments [18,19] in Table III. For the neutron we observe a nonzero charge radius which in fact is due to the SU(2)-breaking effect. However, in the SU(2) symmetry

TABLE III. The root mean square charge radii (in fm) of the baryons in the present estimation compared with the estimations in (MIT) bag model, Skyrme model, cloudy bag model, color dielectric model, and the experiment.

Baryon	Present estimation	MIT [15]	CDM [16]	Skyrme [17]	CBM [17]	Experiment
p	0.827	0.73	0.835	0.88	0.84	0.82±0.02 [18]
n	-0.12	0.0	0.0	-0.55	-0.35	-0.34 [19]
Λ	0.346	0.16	0.343	0.33	0.08	
Σ^0	0.346	0.16	0.343	0.33	0.14	
Σ^+	0.985	0.75	1.16	0.98	0.75	
Σ^-	-0.849	-0.71	-1.05	-0.87	-0.76	
Ξ^0	0.495	0.23	0.47	0.47	0.15	
Ξ^-	-0.826	-0.69	-0.98	-0.51	-0.72	
Ω^-	-0.791	-0.67	-0.91	-0.38	-0.75	

limit it exactly vanishes in the present model, like in other isospin symmetric quark models [15,16].

In all these estimations of the static properties of baryons we observe that the harmonic oscillator wave functions taken for the baryons has made the calculations more simple and analytically tractable. Here one does not have the complication of numerical calculations as do other models [14–17]. Thus, the present field-theoretic quark model for hadrons gives a reasonable explanation for the static properties of the octet baryons and Ω^- in a simplified and tractable manner.

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APPENDIX

The SU(6) symmetric states of octet baryons in nonrelativistic frame are written as

$$|n_{1/2}(\mathbf{0})\rangle=\frac{\epsilon_{ijk}}{3\sqrt{2}}\int\delta(\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3)\tilde{u}_n(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)d\mathbf{k}_1d\mathbf{k}_2d\mathbf{k}_3 \times[u^{i\dagger}_{I1/2}(\mathbf{k}_1)d^{j\dagger}_{I1/2}(\mathbf{k}_2)d^{k\dagger}_{I-1/2}(\mathbf{k}_3)-u^{i\dagger}_{I-1/2}(\mathbf{k}_1)d^{j\dagger}_{I1/2}(\mathbf{k}_2)d^{k\dagger}_{I1/2}(\mathbf{k}_3)]|\mathrm{vac}\rangle\ , \tag{A1}$$

$$|\Lambda_{1/2}(\mathbf{0})\rangle\frac{\epsilon_{ijk}}{2\sqrt{3}}\int\delta(\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3)\tilde{u}_\Lambda(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)d\mathbf{k}_1d\mathbf{k}_2d\mathbf{k}_3 \times[u^{i\dagger}_{I-1/2}(\mathbf{k}_1)d^{j\dagger}_{I1/2}(\mathbf{k}_2)s^{k\dagger}_{I1/2}(\mathbf{k}_3)-u^{i\dagger}_{I1/2}(\mathbf{k}_1)d^{j\dagger}_{I-1/2}(\mathbf{k}_2)s^{k\dagger}_{I1/2}(\mathbf{k}_3)]|\mathrm{vac}\rangle\ , \tag{A2}$$

$$|\Sigma^0_{1/2}(\mathbf{0})\rangle=\frac{\epsilon_{ijk}}{6}\int\delta(\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3)\tilde{u}_\Sigma(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)d\mathbf{k}_1d\mathbf{k}_2d\mathbf{k}_3[2u^{i\dagger}_{I1/2}(\mathbf{k}_1)d^{j\dagger}_{I1/2}(\mathbf{k}_2)s^{k\dagger}_{I-1/2}(\mathbf{k}_3)-u^{i\dagger}_{I1/2}(\mathbf{k}_1)d^{j\dagger}_{I-1/2}(\mathbf{k}_2)s^{k\dagger}_{I1/2}(\mathbf{k}_3) -u^{i\dagger}_{I-1/2}(\mathbf{k}_1)d^{j\dagger}_{I1/2}(\mathbf{k}_2)s^{k\dagger}_{I1/2}(\mathbf{k}_3)]|\mathrm{vac}\rangle\ , \tag{A3}$$

$$|\Sigma^+_{1/2}(\mathbf{0})\rangle\leftrightarrow|p_{1/2}(\mathbf{0})\rangle \quad \text{with } (s\leftrightarrow d)\ , \tag{A4}$$

$$|\Sigma^-_{1/2}(\mathbf{0})\rangle\leftrightarrow|\Sigma^+_{1/2}(\mathbf{0})\rangle \quad \text{with } (d\leftrightarrow u)\ , \tag{A5}$$

$$|\Xi^0_{1/2}(\mathbf{0})\rangle\leftrightarrow|n_{1/2}(\mathbf{0})\rangle \quad \text{with } (s\leftrightarrow d)\ , \tag{A6}$$

$$|\Xi^-_{1/2}(\mathbf{0})\rangle\leftrightarrow|\Sigma^-_{1/2}(\mathbf{0})\rangle \quad \text{with } (s\leftrightarrow d)\ , \tag{A7}$$

$$|\Omega^-_{3/2}(\mathbf{0})\rangle=\frac{\epsilon_{ijk}}{6}\int\delta(\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3)\tilde{u}_\Omega(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)d\mathbf{k}_1d\mathbf{k}_2d\mathbf{k}_3[s^{i\dagger}_{I1/2}(\mathbf{k}_1)s^{j\dagger}_{I1/2}(\mathbf{k}_2)s^{k\dagger}_{I1/2}(\mathbf{k}_3)]|\mathrm{vac}\rangle\ . \tag{A8}$$

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