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Strange magnetic moments of octet baryons under $SU(3)$ breaking

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Abstract: Magnetic moments of octet baryons are parameterized to all orders of the flavor $SU(3)$ breaking with the irreducible tensor technique in order to extract the contribution of each flavor quark to the magnetic moments of the octet baryons. The not-yet measured magnetic moment of Σ^0 is predicted to be 0.649 $\mu_{\rm N}$. Our parameterized forms for the magnetic moments are explicitly flavor-dependent, and hence each flavor component of the magnetic moments can be evaluated directly via the flavor projection operator. It is found that the strange magnetic moment of the nucleon is suppressed due to the small isoscalar anomalous magnetic moment of the nucleon. In particular, the strange magnetic form factor of the nucleon turns out to be positive, $G_{\rm N}^{(\rm s)}(0)=0.428\ \mu_{\rm N}$, which is consistent with recent data.

Key words: octet baryons, strange magnetic moment, $SU(3)$ symmetry breaking

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1 Introduction

The strange quark content of the nucleon magnetic moment is important for investigating the internal structure of the nucleon. Recently, the SAMPLE Collaboration measured the neutral weak form factors at low momentum transfer to yield the proton magnetic form factor $G_{\rm M}^{\rm s}(Q^2=0.1\ {\rm GeV}^2)=+0.37\pm0.20\pm0.26\pm0.07\ \mu_{\rm N}$ [1], and the HAPPEX Collaboration reported $G_{\rm M}^{\rm s}(Q^2=0.1\ {\rm GeV}^2)=+0.18\pm0.27\ \mu_{\rm N}$ [2]. A global fit of all the measurements gives $G_{\rm M}^{\rm s}(Q^2=0.1\ {\rm GeV}^2)=+0.12\pm0.55\pm0.07\ \mu_{\rm N}$ [3]. Many attempts have been made to determine the strange magnetic moment of the nucleon by taking different theoretical approaches, however the results vary widely from negative [4–16] to positive [17–21] values. It is suggested in recent work [22] that the sign of the strange moment in the proton reflects the hidden strange quark components which preferentially forms a colored quark cluster rather than the conventional kaon and hyperon configuration. Therefore more precise experiments can be a crucial check for these theoretical models.

Our present work is in line with the recent one [23] in the group theoretical approach, where the constraints imposed by the $SU(3)$ symmetry breaking pattern and the mixing of the representations in the magnetic moment operators other than the baryon wave functions are examined and consequently the strange magnetic moment of the proton is extracted by estimating the breaking parameters with the help of the constituent quark model. In contrast to Ref. [23], we employ the irreducible tensor technique to parameterize the baryon octet magnetic moments to all orders of the flavor $SU(3)$ breaking. The parameterized forms for the magnetic moments are explicitly flavor-dependent, and hence the each flavor component of the magnetic moments can be evaluated directly via the flavor projection operator.

2 Octet-octet baryon field bilinears

The baryon octet is generated in the $SU(3)$ symmetry by irreducible tensor B^i_j, which may be expressed in 3×3 matrix form:

$$B=\begin{pmatrix} \dfrac{\Sigma^0}{\sqrt{2}}+\dfrac{\Lambda}{\sqrt{6}} & \Sigma^+ & p \\ \Sigma^- & -\dfrac{\Sigma^0}{\sqrt{2}}+\dfrac{\Lambda}{\sqrt{6}} & n \\ \Xi^- & \Xi^0 & -\sqrt{\dfrac{2}{3}}\Lambda \end{pmatrix}, \quad (1)$$

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satisfying the normalization condition

$$(B^i_l, B^j_m) = \delta^{ij}\delta_{lm} - \frac{1}{3}\delta^i_l\delta^j_m. \tag{2}$$

The direct product of the baryon octet and its Hermite conjugate can be decomposed into a direct sum of all possible irreducible representations:

$$\bar{8}\otimes 8 = 27\oplus 10\oplus \bar{10}\oplus 8\oplus 8\oplus 1. \tag{3}$$

Explicit expression of the decomposition (3), which we refer to for careful treatment [24, 25], is given by

$$\begin{aligned}\bar{B}^i_l B^j_m =& \frac{1}{2}T^{ij}_{lm} + \frac{1}{2\sqrt{3}}(\varepsilon_{lmk}T^{kij} + \varepsilon^{ijk}\widetilde{T}_{klm}) \\ &+\sqrt{\frac{3}{10}}\left[\delta^i_m T^j_l + \delta^j_l T^i_m - \frac{2}{3}(\delta^i_l T^j_m + \delta^j_m T^i_l)\right] \\ &+\frac{1}{\sqrt{6}}(\delta^i_m \widetilde{T}^j_l - \delta^j_l \widetilde{T}^i_m) \\ &+\frac{1}{2\sqrt{2}}\left(\delta^i_m\delta^j_l - \frac{1}{3}\delta^i_l\delta^j_m\right)T,\end{aligned} \tag{4}$$

where the sum

$$T = \frac{1}{2\sqrt{2}}\bar{B}^i_j B^j_i, \tag{5}$$

is clearly a singlet. The mixed tensor

$$T^i_j = \sqrt{\frac{3}{10}}\left(\bar{B}^k_j B^i_k + \bar{B}^i_k B^k_j - \frac{4\sqrt{2}}{3}\delta^i_j T\right), \tag{6}$$

is traceless and therefore gives an octet. Likewise,

$$\widetilde{T}^i_j = \frac{1}{\sqrt{6}}(\bar{B}^k_j B^i_k - \bar{B}^i_k B^k_j), \tag{7}$$

represents another octet. The symmetric tensor

$$T^{ijk} = \frac{1}{2\sqrt{3}}(\varepsilon^{ilm}\bar{B}^j_l B^k_m + \varepsilon^{klm}\bar{B}^i_l B^j_m + \varepsilon^{jlm}\bar{B}^k_l B^i_m), \tag{8}$$

stands for the decuplet. Similarly, the symmetric tensor

$$\widetilde{T}_{ijk} = \frac{1}{2\sqrt{3}}(\varepsilon_{ilm}\bar{B}^l_j B^m_k + \varepsilon_{klm}\bar{B}^l_i B^m_j + \varepsilon_{jlm}\bar{B}^l_k B^m_i), \tag{9}$$

describes the antidecuplet. The mixed tensor

$$\begin{aligned}T^{ij}_{lm} =& \frac{1}{2}(\bar{B}^i_l B^j_m + \bar{B}^i_m B^j_l + \bar{B}^j_l B^i_m + \bar{B}^j_m B^i_l) \\ &-\frac{1}{\sqrt{30}}(\delta^i_l T^j_m + \delta^i_m T^j_l + \delta^j_l T^i_m + \delta^j_m T^i_l) \\ &-\frac{1}{3\sqrt{2}}(\delta^i_l\delta^j_m + \delta^i_m\delta^j_l)T,\end{aligned} \tag{10}$$

constructs the 27-plet.

The above irreducible tensors have the exact isospin (T), the third component of an isospin (T_3), and hypercharge (Y), except for the irreducible tensors with $T_3=0$ and $Y=0$ in the octet and 27-plet, which are mixed tensors. Let us denote the tensor $T^{(\mu)}_{TT_3Y}$ with (T, T_3, Y) in the irreducible representation μ, then these mixed tensors can be eventually decomposed into the irreducibles with $T_3=0$, $Y=0$ as [26]

$$\begin{aligned}T^1_1 &= -\frac{1}{\sqrt{2}}T^{(8)}_{1,0,0} + \frac{1}{\sqrt{6}}T^{(8)}_{0,0,0}, \\ T^2_2 &= \frac{1}{\sqrt{2}}T^{(8)}_{1,0,0} + \frac{1}{\sqrt{6}}T^{(8)}_{0,0,0}, \\ T^3_3 &= -\sqrt{\frac{2}{3}}T^{(8)}_{0,0,0};\end{aligned} \tag{11}$$

and

$$\begin{aligned}T^{11}_{11} &= \sqrt{\frac{2}{3}}T^{(27)}_{2,0,0} + \sqrt{\frac{2}{5}}T^{(27)}_{1,0,0} + \sqrt{\frac{2}{15}}T^{(27)}_{0,0,0}, \\ T^{12}_{12} &= -\sqrt{\frac{2}{3}}T^{(27)}_{2,0,0} + \frac{1}{\sqrt{30}}T^{(27)}_{0,0,0}, \\ T^{22}_{22} &= \sqrt{\frac{2}{3}}T^{(27)}_{2,0,0} - \sqrt{\frac{2}{5}}T^{(27)}_{1,0,0} + \sqrt{\frac{2}{15}}T^{(27)}_{0,0,0}, \\ T^{13}_{13} &= -\sqrt{\frac{2}{5}}T^{(27)}_{1,0,0} - \sqrt{\frac{3}{10}}T^{(27)}_{0,0,0}, \\ T^{23}_{23} &= \sqrt{\frac{2}{5}}T^{(27)}_{1,0,0} - \sqrt{\frac{3}{10}}T^{(27)}_{0,0,0}, \\ T^{33}_{33} &= \sqrt{\frac{6}{5}}T^{(27)}_{0,0,0},\end{aligned} \tag{12}$$

where the traceless condition and the results of inner products are involved in determining the parameters with the conventional sign choice [27]. The direct decomposition (4) indicates that these operators, associated with some physical quantities such as magnetic moment, have nonzero elements among the spin-1/2 baryon multiplets.

3 Magnetic moments of octet baryons

The baryon matrix elements of magnetic moments can be parameterized by constructing a $SU(3)$ singlet. In the tensor notation, it is achieved by fully contracting the upper and lower indices of the three tensors representing two baryon multiplets and the magnetic moment operator. In what follows we perform a separate treatment of the isoscalar and isovector parts of the magnetic moment operator.

Only the singlet, octet and 27-plet are physically allowed in the isoscalar channel. The magnetic moment operators, which preserve the isospin and hypercharge conversations, have the parameterized form

$$\begin{aligned}\mu_{\mathrm{B}}^{\mathrm{IS}} = {} & a_1\mathrm{Tr}(\bar{B}B)+\frac{1}{2}a_{8_1}\mathrm{Tr}(\bar{B}[Y,B]) \\ & +\frac{1}{2}a_{8_2}\mathrm{Tr}(\bar{B}\{Y,B\})+a_{27}\left[\frac{3}{2}\mathrm{Tr}(\bar{B}\{Y,\{Y,B\}\})\right. \\ & +\frac{1}{2}\mathrm{Tr}(\bar{B}[Y,[Y,B]])+\frac{2}{5}\mathrm{Tr}(\bar{B}\{Y,B\}) \\ & \left.-\frac{5}{6}\mathrm{Tr}(\bar{B}B)\right]. \end{aligned} \quad (13)$$

This leads to the following magnetic moment formula in the scalar sector:

$$\begin{aligned}\mu_{\mathrm{N}}^{\mathrm{IS}} &= a_1+\frac{1}{2}a_{8_1}-\frac{1}{6}a_{8_2}-\frac{3}{10}a_{27}, \\ \mu_{\Xi}^{\mathrm{IS}} &= a_1-\frac{1}{2}a_{8_1}-\frac{1}{6}a_{8_2}-\frac{3}{10}a_{27}, \\ \mu_{\Sigma}^{\mathrm{IS}} &= a_1+\frac{1}{3}a_{8_2}+\frac{1}{10}a_{27}, \\ \mu_{\Lambda}^{\mathrm{IS}} &= a_1-\frac{1}{3}a_{8_2}+\frac{9}{10}a_{27}. \end{aligned} \quad (14)$$

Here the I-spin symmetry of the isomultiplets is preserved as expected.

Similarly, in the isovector sector, the magnetic operator, which preserves only the conservations of the third component of isospin T_3 and hypercharge Y, is the sum of the octet, decuplet, and anticuplet and 27-plet operators with $T=1$, $T_3=0$ and $Y=0$,

$$\begin{aligned}\mu_{\mathrm{B}}^{\mathrm{IV}} = {} & b_{8_1}\mathrm{Tr}(\bar{B}[T_3,B])+b_{8_2}\mathrm{Tr}(\bar{B}\{T_3,B\}) \\ & +b_{10}\left[\mathrm{Tr}(\bar{B}[T_3,\{Y,B\}])-\mathrm{Tr}(\bar{B}\{T_3,[Y,B]\})\right] \\ & +b_{27}\left[\mathrm{Tr}(\bar{B}\{T_3,\{Y,B\}\})\right. \\ & \left.-\frac{1}{15}\mathrm{Tr}(\bar{B}\{T_3,B\})\right], \end{aligned} \quad (15)$$

where the hermitian nature of the decuplet and the antidecuplet has been taken into account. In Eq. (15), the 27-plet operator with $T=2$ cannot be induced under isospin symmetry, and so it is expected to be a higher-order correction and has been safely neglected. Thus the isovector magnetic moments of the octet baryons are as follows:

$$\begin{aligned}\mu_{\mathrm{p}^+}^{\mathrm{IV}} &= \frac{1}{2}b_{8_1}+\frac{1}{2}\left(b_{8_2}-\frac{2}{5}b_{27}\right)-\frac{2}{3}b_{10}, \\ \mu_{\mathrm{n}}^{\mathrm{IV}} &= -\frac{1}{2}b_{8_1}-\frac{1}{2}\left(b_{8_2}-\frac{2}{5}b_{27}\right)+\frac{2}{3}b_{10}, \\ \mu_{\Xi^0}^{\mathrm{IV}} &= \frac{1}{2}b_{8_1}-\frac{1}{2}\left(b_{8_2}-\frac{2}{5}b_{27}\right)-\frac{2}{3}b_{10}, \\ \mu_{\Xi^-}^{\mathrm{IV}} &= -\frac{1}{2}b_{8_1}+\frac{1}{2}\left(b_{8_2}-\frac{2}{5}b_{27}\right)+\frac{2}{3}b_{10}, \\ \mu_{\Sigma^+}^{\mathrm{IV}} &= b_{8_1}+\frac{2}{3}b_{10}, \\ \mu_{\Sigma^-}^{\mathrm{IV}} &= -b_{8_1}-\frac{2}{3}b_{10}, \\ \mu_{\Sigma^0\Lambda}^{\mathrm{IV}} &= \frac{1}{\sqrt{3}}\left(b_{8_2}+\frac{3}{5}b_{27}\right), \end{aligned} \quad (16)$$

and in the vector sector the magnetic momentums of Σ^0 and Λ vanish.

In Eqs. (14) and (16), the eight parameters are involved as reduced matrix elements of magnetic moment operators for the singlet, symmetric octet, antisymmetric octet, decuplet, antidecuplet and 27-plet. The reduced matrix elements for the singlet, decuplet, antidecuplet and 27-plet contribute only to the anomalous moments since the electromagnetic current has no component of these representations [23]. These parameters have been fitted to eight available magnetic moments of the octet baryons and their values are displayed in Table 1. The total magnetic moments reproduced by the fit are summarized in Table 2 with the isoscalar and isovector moments given separately. The numerical results predict the not-yet measured magnetic moment of Σ^0 with great accuracy, $\mu_{\Sigma^0}=0.649\ \mu_{\mathrm{N}}$. It is indicated that the contributions from the singlet, decuplet and 27-plet representations are small in comparison with the overall magnitudes of the magnetic moments. Under the $SU(3)$ breaking, the ratios $b_{8_1}/a_{8_1}=1.35948$ and $b_{8_2}/a_{8_2}=1.46939$, differ from 1 implied by the $SU(3)$ symmetry.

Table 1. The fitted parameters (in units of μ_{N}).

isoscalar		isovector	
a_1	0.03914	b_{8_1}	1.89043
a_{8_1}	1.39026	b_{8_2}	2.70700
a_{8_2}	1.84226	b_{10}	−0.12215
a_{27}	−0.04228	b_{27}	0.13601

Table 2. Magnetic moments and their flavor decomposition, together with the strange form factors of the octet baryons (in units of μ_{N}). The input data are labeled with stars.

	$\mu_{\mathrm{B}}^{\mathrm{Exp}}$	$\mu_{\mathrm{B}}^{\mathrm{Fit}}$	$\mu_{\mathrm{B}}^{\mathrm{IS}}$	$\mu_{\mathrm{B}}^{\mathrm{IV}}$	$\mu_{\mathrm{B}}^{(\mathrm{u})}$	$\mu_{\mathrm{B}}^{(\mathrm{d})}$	$\mu_{\mathrm{B}}^{(\mathrm{s})}$	$G_{\mathrm{M}}^{\mathrm{s}}$
p	2.79285*	2.79285	0.43990	2.35295	2.91085	0.02479	−0.14279	0.42838
n	−1.91304*	−1.91304	0.43990	−2.35295	0.04789	−1.79504	−0.14279	0.42838
Σ^+	2.458*	2.458	0.64900	1.809	2.84262	−0.40941	0.02479	−0.07437
Σ^0	—	0.649	0.64900	0	2.61091	−1.08220	0.02479	−0.07437
Σ^-	−1.160*	−1.16	0.64900	−1.809	0.57020	−1.75499	0.02579	−0.07437
Ξ^0	−1.250*	−1.25	−0.95035	−0.29965	0.02479	−0.20516	−1.06963	3.20888
Ξ^-	−0.6507*	−0.6507	−0.95035	0.29965	0.39414	0.02479	−1.06963	3.20888
Λ	−0.613*	−0.613	−0.613	0	0.58533	−0.34421	−0.85412	2.56237
$\Sigma^0\to\Lambda$	1.61*	1.61	0	1.61	0.97088	0.63912	0	0

4 Strange moments of the baryon octet

The flavor components of the magnetic moments can be evaluated with the help of the flavor-project operators,

$$P_{\mathrm{u}}=\frac{1}{3}+T_3+\frac{Y}{2},$$
$$P_{\mathrm{d}}=\frac{1}{3}-T_3+\frac{Y}{2}, \tag{17}$$
$$P_{\mathrm{s}}=\frac{1}{3}-Y.$$

The same programme has been used to obtain the q-flavor magnetic moments in chiral models with the $SU(3)$ group structure [17]. It is found that the strange magnetic moments of the octet baryons only come from the isoscalar sector, and the I-spin symmetry is conserved in those isomultiplets which have the same strangeness in the s-flavor channel, namely

$$\mu_{\mathrm{B}}^{(\mathrm{s})}=\mu_{\mathrm{B}}^{\mathrm{IS(s)}},\quad \mu_{\mathrm{B}}^{(\mathrm{s})}=\mu_{\bar{\mathrm{B}}}^{(\mathrm{s})} \tag{18}$$

with $\bar{\mathrm{B}}$ being the isospin conjugate baryon in the isomultiplets of the baryon. The strange magnetic moments of the isomultiplets can be expressed in terms of the group theoretical parameters as

$$\begin{aligned}\mu_{\mathrm{N}}^{(\mathrm{s})}&=\frac{1}{3}a_1+\frac{2}{3}a_{8_1}-\frac{2}{3}a_{8_2}+\frac{11}{90}a_{27},\\ \mu_{\Xi}^{(\mathrm{s})}&=\frac{1}{3}a_1-\frac{2}{3}a_{8_1}-\frac{2}{3}a_{8_2}+\frac{11}{90}a_{27},\\ \mu_{\Sigma}^{(\mathrm{s})}&=\frac{1}{3}a_1-\frac{5}{18}a_{27},\\ \mu_{\Lambda}^{(\mathrm{s})}&=\frac{1}{3}a_1-\frac{8}{9}a_{8_2}+\frac{103}{90}a_{27},\end{aligned} \tag{19}$$

and the s-flavor component vanishes for the transition moment between Σ^0 and Λ.

For u- and d-flavor channels we also find that all the baryon octet magnetic moments fulfill the model independent relations:

$$\mu_{\mathrm{B}}^{\mathrm{IS(u)}}=\mu_{\bar{\mathrm{B}}}^{\mathrm{IS(d)}},\quad \mu_{\mathrm{B}}^{\mathrm{IV(u)}}=-\mu_{\bar{\mathrm{B}}}^{\mathrm{IV(d)}}. \tag{20}$$

Therefore we only give the explicit form of the baryon magnetic moments in the u-flavor channel:

$$\begin{aligned}\mu_{\mathrm{p}}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1+\frac{1}{3}a_{8_1}+\frac{1}{3}a_{8_2}-\frac{13}{90}a_{27},\\ \mu_{\mathrm{n}}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1-\frac{5}{18}a_{27},\\ \mu_{\Xi^0}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1-\frac{5}{18}a_{27},\\ \mu_{\Xi^-}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1-\frac{1}{3}a_{8_1}+\frac{1}{3}a_{8_2}-\frac{13}{90}a_{27},\\ \mu_{\Sigma^+}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1+\frac{1}{3}a_{8_1}+\frac{1}{3}a_{8_2}+\frac{17}{90}a_{27},\\ \mu_{\Sigma^0}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1+\frac{1}{3}a_{8_2}+\frac{17}{90}a_{27},\\ \mu_{\Sigma^-}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1-\frac{1}{3}a_{8_1}+\frac{1}{3}a_{8_2}+\frac{17}{90}a_{27},\\ \mu_{\Lambda}^{\mathrm{IS(u)}}&=\frac{1}{3}a_1+\frac{1}{9}a_{8_2}-\frac{11}{90}a_{27},\\ \mu_{\Sigma\Lambda}^{\mathrm{IS(u)}}&=\frac{1}{3\sqrt{3}}a_{8_2}+\frac{7}{15\sqrt{3}}a_{27},\end{aligned} \tag{21}$$

for isoscalar and

$$\begin{aligned}\mu_{\mathrm{p}}^{\mathrm{IV(u)}}&=\frac{1}{2}b_{8_1}+\frac{1}{2}b_{8_2}-\frac{2}{3}b_{10}-\frac{1}{5}b_{27},\\ \mu_{\mathrm{n}}^{\mathrm{IV(u)}}&=\mu_{\Xi^0}^{(u)}=\mu_{\Xi^-}^{(d)}=0,\\ \mu_{\Xi^-}^{\mathrm{IV(u)}}&=-\frac{1}{2}b_{8_1}+\frac{1}{2}b_{8_2}+\frac{2}{3}b_{10}-\frac{1}{5}b_{27},\\ \mu_{\Sigma^+}^{\mathrm{IV(u)}}&=\frac{1}{2}b_{8_1}+\frac{1}{2}b_{8_2}+\frac{2}{3}b_{10}+\frac{3}{10}b_{27},\end{aligned}$$

$$\mu_{\Sigma^0}^{\mathrm{IV(u)}} = \frac{1}{2}b_{8_2} + \frac{3}{10}b_{27},$$
$$\mu_{\Sigma^-}^{\mathrm{IV(u)}} = -\frac{1}{2}b_{8_1} + \frac{1}{2}b_{8_2} - \frac{1}{3}b_{10} + \frac{3}{10}b_{27},$$
$$\mu_{\Lambda}^{\mathrm{IV(u)}} = \frac{1}{6}b_{8_2} + \frac{1}{10}b_{27},$$
$$\mu_{\Sigma\Lambda}^{\mathrm{IV(u)}} = \frac{1}{2\sqrt{3}}b_{8_2} + \frac{\sqrt{3}}{10}b_{27}, \quad (22)$$

for isovector channels.

The results for flavor magnetic moments are given in Table 2. The electromagnetic form factors of the octet baryons with an internal structure are defined by the matrix elements of the electromagnetic current between the initial and final baryon states. Using the s-flavor charge operator in the electromagnetic currents, in the limit of zero momentum transfer, one can obtain the strange form factors of the baryon octet

$$G_{\mathrm{E}}^{(\mathrm{s})}(0) = S, \quad G_{\mathrm{M}}^{(\mathrm{s})}(0) = -3\mu_{\mathrm{B}}^{(\mathrm{s})} \quad (23)$$

in terms of the strange quantum number of the baryon $S = 1 - Y$ and the strange components of the baryon octet magnetic moments $\mu_{\mathrm{B}}^{(\mathrm{s})}$. The results of the strange form factors are presented in Table 2.

5 Conclusion

The irreducible tensor technique is adopted to parameterize the magnetic moments of the octet baryons to all orders of the $SU(3)$ breaking in the group theoretical approach. The not-yet measured magnetic moment of Σ^0 is predicted to be 0.649 μ_{N}. The parameterized forms for the magnetic moments are explicitly flavor-dependent, and hence the each flavor component of the magnetic moments can be evaluated directly via the flavor projection operator. We sequentially evaluate the flavor components of the magnetic moments of the octet baryons, which satisfy the new relations given by (18) and (20). It is found that the nucleon strange magnetic moment is suppressed due to the small isoscalar anomalous magnetic moment of the nucleon. In particular, the strange magnetic form factor of the nucleon is predicted to be positive, $G_{\mathrm{N}}^{(\mathrm{s})}(0) = 0.428\ \mu_{\mathrm{N}}$. It is compatible with the experimental data [1, 2], and is larger than that given in Ref. [23] and slightly smaller than that from the chiral models with the $SU(3)$ group structure [17].

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