$g_{K\Lambda N}$ and $g_{K\Sigma N}$ coupling constants in light cone QCD sum rules

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The strong coupling constants $g_{K\Lambda N}$ and $g_{K\Sigma N}$ for the structure $\sigma_{\mu\nu}\gamma_5$ are calculated within light-cone QCD sum rules. A comparison of our results on these couplings with predictions from traditional QCD sum rules is presented.

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I. INTRODUCTION

In understanding the dynamics of kaon nucleon scattering or photokaon production in the nucleon, it is important to know the hadronic coupling constants involving the kaons. Among them, $g_{K\Lambda N}$ and $g_{K\Sigma N}$ are the most relevant coupling constants. Phenomenological models for the determination of these constants from kaon-nucleon scattering and from the kaon photoproduction involve many unknown parameters (see, for example, [1] and references therein). Therefore any prediction about these constants is strongly model dependent and suffers from large uncertainties. For this reason a quantitative calculation of the g_{KYN} ($Y=\Lambda$ or Σ) coupling constants with a tractable and reliable theoretical approach is needed.

It is widely accepted that QCD is the underlying theory of strong interactions. In the typical hadronic scale the strong coupling constant $\alpha_s(\mu=m_{\rm had})$ becomes large and QCD is nonperturbative. For this reason the calculation of g_{KYN} is related to the nonperturbative sector of QCD, and some kind of nonperturbative approach is needed for the determination of the above-mentioned coupling constants. Among various nonperturbative methods, QCD sum rules [2] are a powerful one. This method is based on the short distance operator product expansion (OPE) of the vacuum-vacuum correlation function in terms of condensates. For processes involving the light mesons π, K, or ρ, there is an alternative method to the traditional QCD sum rules, namely, light-cone QCD sum rules [3]. In this approach the expansion of the vacuum-meson correlator is performed near the light cone in terms of the meson wave functions. The meson wave functions are defined by the matrix elements of nonlocal composite operators sandwiched between the meson and vacuum states and classified by their twists, rather than dimensions of the operators, as is the case in the traditional sum rules (more about application of light-cone QCD sum rules can be found in [5–12] and references therein).

In this work we employ light-cone QCD sum rules method to extract the coupling constants g_{KYN}. These coupling constants were investigated in the framework of the traditional QCD sum rules method in [1,13] for the structure $\not{q}\gamma_5$ and for the structure $\sigma_{\mu\nu}\gamma_5$ in [14]. The discrepancy between the results of these works makes it necessary to perform independent calculations in determining the coupling constants g_{KYN}. In the present article we restrict ourselves to consideration of the structure $\sigma_{\mu\nu}\gamma_5$ whose choice is dictated by the following reason. In [15,16] it was pointed out that there is a coupling scheme dependence for the structures $\gamma_5, \not{q}\gamma_5$ (i.e., the dependence on the pseudoscalar or pseudovector forms of the effective interaction Lagrangian of the pion with hadrons in the phenomenological part have been used), while the structure $\sigma_{\mu\nu}\gamma_5$ is shown to be independent of any coupling schemes.

In order to calculate the coupling constants g_{KYN}, we start with the following two-point function:

$$\Pi(p,p_1,q)=\int d^4x\, e^{ipx}\langle 0|T\,\eta_Y(x)\,\overline{\eta}_N(0)|K(q)\rangle, \qquad (1)$$

where p and η_Y are the four-momentum of the hyperon and its interpolating current, respectively, η_N is the nucleon interpolating current, and q is the four-momentum of K meson. The interpolating currents for Λ, Σ, and N are [17,18]

$$\eta_\Lambda=\sqrt{\frac{2}{3}}\,\epsilon_{abc}[(u_a^TC\gamma_\mu s_b)\gamma_5\gamma^\mu d_c-(d_a^TC\gamma_\mu s_b)\gamma_5\gamma^\mu u_c],$$

$$\eta_{\Sigma^0}=\sqrt{2}\,\epsilon_{abc}[(u_a^TC\gamma_\mu s_b)\gamma_5\gamma^\mu d_c+(d_a^TC\gamma_\mu s_b)\gamma_5\gamma^\mu u_c],$$

$$\eta_N=\epsilon_{abc}(u_a^TC\gamma_\mu u_b)\gamma_5\gamma^\mu d_c, \qquad (2)$$

where s, u, and d are strange, up, and down quark fields, respectively, C is the charge conjugation operator, and a, b, and c are the color indices.

As has already been mentioned, it was pointed out in [14,15] that a better determination of $g_{\pi NN}$ can be done by the structure $\sigma_{\mu\nu}\gamma_5$, since this structure is independent of the effective models employed in the phenomenological part. This fact motivates us to calculate g_{NYK} in this structure.

Using the Lorentz, parity, and charge conjugation invariance, $T(p,p_1,q)$ can be represented in the following general form:

$$\begin{aligned}T(p,p_1,q)&=T_1(p^2,p_1^2,q^2)\gamma_5+T_2(p^2,p_1^2,q^2)\not{q}\gamma_5\\&+T_3(p^2,p_1^2,q^2)\not{P}\gamma_5\\&+T_4(p^2,p_1^2,q^2)\sigma_{\mu\nu}\gamma_5p^\mu q^\nu,\end{aligned} \qquad (3)$$

where $q=p-p_1$ and $P=(p+p_1)/2$.

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On the phenomenological part, these different Dirac structures are obtained by saturating correlator (1) of the Y state:

$$T=\langle 0|\eta_Y|Y(p)\rangle\langle Y(p)|\overline{\eta}_N|K(q)\rangle. \tag{4}$$

The matrix elements in Eq. (4) are defined in the following way:

$$\langle 0|\eta_Y|Y(p)\rangle=\lambda_Y u(p),$$

$$\langle Y(p)|\overline{\eta}_N|K(q)\rangle=\lambda_N g_{KYN}\overline{u}(p)\gamma_5\frac{1}{\not{p}_1-m_N}. \tag{5}$$

Substituting Eq. (5) into Eq. (4), we get

$$T=\frac{g_{KYN}\lambda_Y\lambda_N}{(p^2-m_Y^2)(p_1^2-m_N^2)}(\not{p}+m_Y)\gamma_5(\not{p}_1+m_N)$$
$$+\text{higher resonances},$$

which can be written as

$$T=\frac{g_{KYN}\lambda_Y\lambda_N}{(p^2-m_Y^2)(p_1^2-m_N^2)}\Bigg[(m_Y m_N-pp_1)\gamma_5+\frac{m_Y+m_N}{2}\not{q}\gamma_5$$
$$-\frac{m_Y-m_N}{2}\not{P}\gamma_5-i\sigma_{\alpha\beta}p_\alpha q_\beta\gamma_5\Bigg]. \tag{6}$$

Choosing the structure $\sigma_{\alpha\beta}\gamma_5$ as the physical part, we have

$$T^{\text{phys}}=-i\frac{g_{KYN}\lambda_Y\lambda_N}{(p^2-m_Y^2)(p_1^2-m_N^2)}p_\alpha q_\beta. \tag{7}$$

Let us now turn our attention to the theoretical part of the correlator (1). From Eq. (1) we immediately get

$$T=\alpha\int dx\, e^{ipx}\{-4\gamma_5\gamma_\mu i\mathcal{S}\gamma_\nu\gamma_5\langle 0|\overline{u}(0)\gamma_\nu\mathcal{C}\, i\mathcal{S}^T\mathcal{C}^{-1}\gamma_\mu s(x)|K(q)\rangle\mp\gamma_5\gamma_\mu i\mathcal{S}\gamma_\nu\gamma_5\gamma_\mu i\mathcal{S}\gamma_\nu\gamma_5\langle 0|\overline{u}(0)\gamma_5 s(x)|K(q)\rangle$$
$$\mp\gamma_5\gamma_\mu i\mathcal{S}\gamma_\nu\gamma_5\gamma_\rho\gamma_\mu i\mathcal{S}\gamma_\nu\gamma_5\langle 0|\overline{u}(0)\gamma_\rho\gamma_5 s(x)|K(q)\rangle\}, \tag{8}$$

where the upper (lower) sign corresponds to the Λ (Σ) case and $\alpha=\sqrt{2/3}(\sqrt{2})$ for Λ (Σ). In Eq. (8), $\mathcal{S}$ is the full light quark propagator containing both perturbative and nonperturbative contributions,

$$i\mathcal{S}=i\frac{\not{x}}{2\pi^2x^4}-\left(\frac{\langle\overline{q}q\rangle}{12}+\frac{x^2m_0^2}{192}\langle\overline{q}q\rangle\right)-i\frac{g_s}{16\pi^2}\int_0^1 du\left\{\frac{\not{x}}{x^2}\sigma_{\alpha\beta}G^{\alpha\beta}(ux)-4i\frac{x_\alpha}{x^2}G^{\alpha\beta}\gamma_\beta\right\}+\cdots. \tag{9}$$

It follows from Eq. (8) that, in order to calculate the correlator function in QCD, the matrix elements of the nonlocal operators between the vacuum and kaon states are needed. These matrix elements are defined in terms of kaon wave functions, and up to twist 4 these wave functions can be written as [6,7]

$$\langle 0|\overline{u}(0)\gamma_\mu\gamma_5 s(x)|K(q)\rangle=if_\pi q_\mu\int_0^1 du\, e^{-iuqx}[\varphi_K(u)+x^2g_1(u)]+f_\pi\left(x_\mu-\frac{x^2q_\mu}{qx}\right)\int_0^1 du\, e^{-iuqx}g_2(u),$$

$$\langle 0|\overline{u}(0)i\gamma_5 s(x)|K(q)\rangle=f_K\mu_K\int_0^1 du\, e^{-iuqx}\varphi_p(u),$$

$$\langle 0|\overline{u}(0)\sigma_{\alpha\beta}\gamma_5 s(x)|K(q)\rangle=(q_\alpha x_\beta-q_\beta x_\alpha)\frac{if_K\mu_K}{6}\int_0^1 du\, e^{-iuqx}\varphi_\sigma(u),$$

$$\langle 0|\overline{u}(0)\gamma_\mu\gamma_5 G_{\alpha\beta}(ux)s(x)|K(q)\rangle=\left[q_\beta\left(g_{\alpha\mu}-\frac{x_\alpha q_\mu}{qx}\right)-q_\alpha\left(g_{\beta\mu}-\frac{x_\beta q_\mu}{qx}\right)\right]\int\mathcal{D}\alpha_i\varphi_\perp(\alpha_i)e^{-iqx(\alpha_1+u\alpha_3)}$$
$$+\frac{q_\mu}{qx}(q_\alpha x_\beta-q_\beta x_\alpha)\int\mathcal{D}\alpha_i\varphi_\parallel(\alpha_i)e^{-iqx(\alpha_1+u\alpha_3)},$$

$$\langle 0|\overline{u}(0)\gamma_\mu ig\widetilde{G}_{\alpha\beta}(ux)s(x)|K(q)\rangle=\left[q_\beta\left(g_{\alpha\mu}-\frac{x_\alpha q_\mu}{qx}\right)-q_\alpha\left(g_{\beta\mu}-\frac{x_\beta q_\mu}{qx}\right)\right]\int\mathcal{D}\alpha_i\widetilde{\varphi}_\perp(\alpha_i)e^{-iqx(\alpha_1+u\alpha_3)}$$
$$+\frac{q_\mu}{qx}(q_\alpha x_\beta-q_\beta x_\alpha)\int\mathcal{D}\alpha_i\widetilde{\varphi}_\parallel(\alpha_i)e^{-iqx(\alpha_1+u\alpha_3)}, \tag{10}$$

where

$$\mu_K=\frac{m_K^2}{m_u+m_s}, \quad \int \mathcal{D}\alpha_i \equiv \int d\alpha_1 d\alpha_2 \alpha_3 \delta(1-\alpha_1-\alpha_2-\alpha_3).$$

Because of the choice of the gauge $x^\mu A_\mu(x)=0$, the path-ordered gauge factor $\mathcal{P}\exp i[g_s\int du\, x^\mu A_\mu(ux)]$ has been omitted. The wave function $\varphi_K(u)$ is the leading twist $\tau=2$, $g_1(u)$, $\varphi_\perp$, $\varphi_\parallel$, $\tilde{\varphi}_\perp$, and $\tilde{\varphi}_\parallel$, are twist $\tau=4$, and $\varphi_p(u)$ and $\varphi_\sigma(u)$ are the twist $\tau=3$ wave functions. Using Eqs. (8), (9), and (10), for the structure $\sigma_{\alpha\beta}\gamma_5$ we get

$$\begin{aligned} T^{\text{theor}} = i\alpha \int dx\, e^{ipx}\Bigg\{ & -4\frac{f_K}{2\pi^2x^4}\left(\frac{\langle\bar{q}q\rangle}{12}+\frac{x^2m_0^2}{192}\langle\bar{q}q\rangle\right)2q_\beta x_\alpha \int du\, e^{-iuqx}\{\varphi_K(u)+x^2[g_1(u)+G_2(u)]\} - 4\frac{2f_K}{16\pi^2x^2}\left(\frac{\langle\bar{q}q\rangle}{12}\right.\\ & \left.+\frac{x^2m_0^2}{192}\langle\bar{q}q\rangle\right)2q_\beta x_\alpha \int du \int \mathcal{D}\alpha_i e^{-iqx(\alpha_1+u\alpha_3)}[\varphi_\parallel(1-2u)-\tilde{\varphi}_\parallel] \mp \left[-\frac{4}{\pi^2x^4}\left(\frac{\langle\bar{q}q\rangle}{12}+\frac{x^2m_0^2}{192}\langle\bar{q}q\rangle\right)x_\alpha\right]\\ & \times\left[-q_\beta\int du\, e^{-iuqx}\{\varphi_K(u)+x^2[g_1(u)+G_2(u)]\}\right]\Bigg\}, \end{aligned} \tag{11}$$

where

$$G_2(u)=-\int_0^u g_2(v)dv.$$

In deriving this equation we omit terms which are equal to zero after integration over x. After Fourier transformation for the theoretical part of the correlator function, we get

$$\begin{aligned} T^{\text{theor}} = -i\alpha f_K p_\alpha q_\beta\Bigg\{ & 4\int du\,\varphi_K(u)\left[\frac{\langle\bar{q}q\rangle}{12}\left(\frac{2}{(p-qu)^2}+\frac{1}{2}\frac{m_0^2}{(p-qu)^4}\right)\right]+\frac{8}{3}\langle\bar{q}q\rangle\int du\left[(g_1(u)+G_2(u)]\frac{1}{(p-qu)^4}\right.\\ & -\frac{2}{3}\langle\bar{q}q\rangle\int du\int \mathcal{D}\alpha_i[\varphi_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)(1-2u)-\tilde{\varphi}_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)]\pm 4\left[\frac{\langle\bar{q}q\rangle}{12}\int du\,\varphi_K(u)\left(\frac{2}{(p-qu)^2}\right.\right.\\ & \left.\left.+\frac{1}{2}\frac{m_0^2}{(p-qu)^4}\right)\right]\pm\frac{8}{3}\langle\bar{q}q\rangle\int du\left[(g_1(u)+G_2(u)]\frac{1}{(p-qu)^4}\right\}. \end{aligned} \tag{12}$$

According to the general strategy of QCD sum rules, the quantitative prediction for g_{KYN} can be obtained by matching the representations of a correlator (1) in terms of hadronic [Eq. (7)] and quark-gluon degrees of freedom [Eq. (12)]. Equating Eqs. (7) and (12), and performing a double Borel transformation for the variables p^2 and p_1^2 in order to suppress higher state and continuum contributions, we finally get the following sum rules for $g_{K\Lambda N}$ and $g_{K\Sigma N}$ coupling constants:

$$\begin{aligned} g_{K\Lambda N}\lambda_\Lambda\lambda_N = f_K M^2 e^{(m_N^2+m_\Lambda^2)/2M^2}\sqrt{\frac{2}{3}}\langle\bar{q}q\rangle\Bigg\{ & \frac{4}{3}\varphi_K(u_0)f_0(s_0/M^2)+\frac{1}{3M^2}\varphi_K(u_0)m_0^2+\frac{16}{3M^2}[g_1(u_0)+G_2(u_0)]\\ & +\frac{2}{3M^2}\int_0^{u_0}d\alpha_1\int_{u_0-\alpha_1}^{1-\alpha_1}\frac{d\alpha_3}{\alpha_3}\left[\left(1-2\frac{u_0-\alpha_1}{\alpha_3}\right)\varphi_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)-\tilde{\varphi}_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)\right]\Bigg\}, \end{aligned} \tag{13}$$

$$g_{K\Sigma N}\lambda_\Sigma\lambda_N = f_K e^{(m_N^2+m_\Sigma^2)/2M^2}\sqrt{2}\,\frac{2}{3}\langle\bar{q}q\rangle\int_0^{u_0}d\alpha_1\int_{0-\alpha_1}^{1-\alpha_1}\frac{d\alpha_3}{\alpha_3}\left[\left(1-2\frac{u_0-\alpha_1}{\alpha_3}\right)\varphi_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)-\tilde{\varphi}_\parallel(\alpha_1,1-\alpha_1-\alpha_3,\alpha_3)\right], \tag{14}$$

where the function

$$f_n(s_0/M^2)=1-e^{-s_0/M^2}\sum_{k=0}^{n}\frac{(s_0/M^2)^k}{k!}$$

is the factor used to subtract the continuum, which is modeled by the dispersion integral in the region $s_1,\ s_2 \geqslant s_0,\ s_0$ being the continuum threshold [of course, the continuum threshold for Eq. (13) is different than that for Eq. (14)],

$$u_0=\frac{M_2^2}{M_1^2+M_2^2}, \quad M^2=\frac{M_1^2M_2^2}{M_1^2+M_2^2},$$

and M_1^2 and M_2^2 are the Borel parameters. Since the masses of N, Λ, and Σ are very close to each other, we can choose

M_1^2 and M_2^2 to be equal to each other, i.e., $M_1^2 = M_2^2 = 2M^2$, from which it follows that $u_0 = 1/2$.

From Eqs. (13) and (14) we see that the coupling constants $g_{K\Lambda N}$ and $g_{K\Sigma N}$ are determined by the quark condensate and wave functions (for the structure $\sigma_{\alpha\beta}\gamma_5$). We can deduce from these expressions that the coupling constant $g_{K\Lambda N}$ is determined mainly by the lowest twist ($\tau=2$) wave function $\varphi_K(u)$ and that the $g_{K\Sigma N}$ is determined by the twist ($\tau=4$) wave function; hence, we expect that $g_{K\Lambda N} > g_{K\Sigma N}$. Indeed, our numerical calculations confirm this expectation, as is presented in the next section.

II. NUMERICAL ANALYSIS

The principal nonperturbative inputs in the sum rules (13) and (14) are the kaon wave functions on the light cone. In [3] a theoretical framework has been developed to study these functions. In particular, it has been shown that the wave functions can be expanded in terms of the matrix elements of conformal operators which in a leading logarithmic approximation do not mix under renormalization. For details, we refer the reader to the original literature [4,7]. In our numerical analysis we use the set of wave functions proposed in [7]. The explicit expressions of the wave functions and the values of the various parameters are

$$\varphi_K(u,\mu) = 6u\bar{u}[1 + a_1(\mu) C_1^{3/2}(2u-1) + a_2(\mu) \times C_2^{3/2}(2u-1)],$$

$$g_1(u,\mu) = \frac{5}{2}\delta^2(\mu)\bar{u}^2 u^2 + \frac{1}{2}\varepsilon(\mu)\delta^2(\mu)\Big[u\bar{u}(2+13u\bar{u}) + 10u^3 \ln u\left(2 - 3u + \frac{6}{5}u^2\right) + 10\bar{u}^3 \ln \bar{u}\left(2 - 3\bar{u} + \frac{6}{5}\bar{u}^2\right)\Big],$$

$$G_2(u,\mu) = \frac{5}{3}\delta^2(\mu)\bar{u}^2 u^2,$$

$$\varphi_\parallel(\alpha_i) = 120\delta^2(\mu)\varepsilon(\mu)(\alpha_1 - \alpha_2)\alpha_1\alpha_2\alpha_3,$$

$$\tilde{\varphi}_\parallel = -120\delta^2(\mu)\alpha_1\alpha_2\alpha_3\left[\frac{1}{3} + \varepsilon(\mu)(1-3\alpha_3)\right], \quad (15)$$

where the $C_1^{3/2}$ and $C_2^{3/2}$ are the Gegenbauer polynomials defined as

$$C_1^{3/2}(2u-1) = 3(2u-1),$$

$$C_2^{3/2}(2u-1) = \frac{3}{2}[5(2u-1)^2 - 1], \quad (16)$$

and $a_1(\mu = 1\text{ GeV}) = 0.17$ and $a_2(\mu = 1\text{ GeV}) = 0.2$ (see for example, [4] and the second reference in [7]). The parameter $\delta(\mu)^2$ was estimated from QCD sum rules to have the value $\delta^2(\mu) = 0.2\text{ GeV}^2$ [19], and $\varepsilon(\mu = 1\text{ GeV}) = 0.5$ [7]. Furthermore, we take $f_K = 0.156\text{ GeV}$, $\mu_K(\mu = 1\text{ GeV}) = 1\text{ GeV}$, $m_0^2 = 0.8\text{ GeV}^2$, $\langle \bar{q}q\rangle|_{\mu=1\text{ GeV}} = -(0.243\text{ GeV})^3$, $s_0^\Lambda = (m_\Lambda + 0.5)^2\text{ GeV}^2$, and $s_0^\Sigma = (m_\Sigma + 0.5)^2\text{ GeV}^2$. Also remember that all further calculations are performed at $u = u_0 = 1/2$.

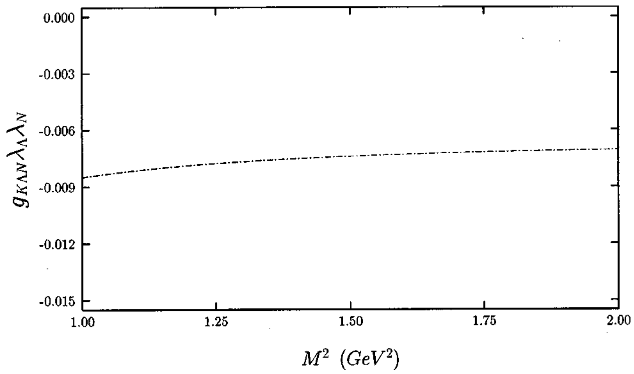

FIG. 1. The dependence of $g_{K\Lambda N}\lambda_\Lambda\lambda_N$ on the Borel parameter M^2.

Having fixed the input parameter, one must find the range of values of M^2 for which the sum rules (13) and (14) are reliable. The lowest possible value of M^2 is determined by the requirement that the terms proportional to the highest inverse power of the Borel parameters stay reasonably small. The upper bound of M^2 is determined by demanding that the continuum contribution be not too large. The interval of M^2 which satisfies both conditions is $1\text{ GeV}^2 < M^2 < 2\text{ GeV}^2$. The dependence of Eqs. (13) and (14) on M^2 is depicted in Figs. 1 and 2. From these figures one can directly predict

$$g_{K\Lambda N}\lambda_\Lambda\lambda_N = -0.008 \pm 0.001, \quad (17)$$

$$g_{K\Sigma N}\lambda_\Sigma\lambda_N = -0.0006 \pm 0.0001. \quad (18)$$

In determining the values of the strong coupling constants $g_{K\Lambda N}$ and $g_{K\Sigma N}$, we need the residues of hadronic currents, i.e., λ_N, λ_Λ, and λ_Σ, whose values are obtained from the corresponding mass sum rules for the nucleon and Λ and Σ hyperons [17,18] as follows:

$$|\lambda_N|^2 e^{-m_N^2/M^2} 32\pi^4 = M^6 f_2(s_0^N/M^2) + \frac{4}{3}a^2, \quad (19)$$

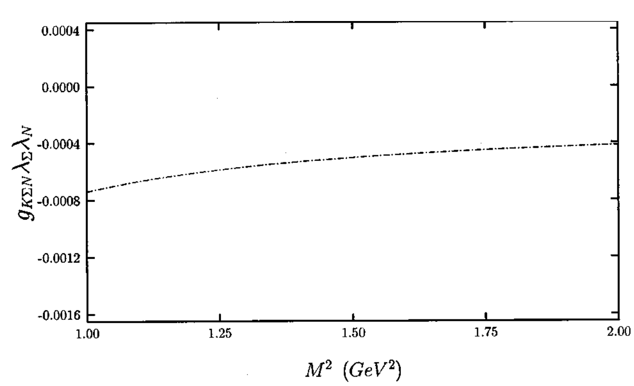

FIG. 2. The same as in Fig. 1, but for $g_{K\Sigma N}\lambda_\Sigma\lambda_N$.

$$|\lambda_\Lambda|^2 e^{-m_\Lambda^2/M^2} 32\pi^4 = M^6 f_2(s_0^\Lambda/M^2) + \frac{2}{3} a m_s \times (1-3\gamma) M^2 f_0(s_0^\Lambda/M^2) + b M^2 f_0 \times (s_0^\Lambda/M^2) + \frac{4}{9} a^2 (3+4\gamma), \tag{20}$$

$$|\lambda_\Sigma|^2 e^{-m_\Sigma^2/M^2} 32\pi^4 = M^6 f_2(s_0^\Sigma/M^2) - 2 a m_s \times (1+\gamma) M^2 f_0(s_0^\Sigma/M^2) + b M^2 f_0 \times (s_0^\Sigma/M^2) + \frac{4}{3} a^2, \tag{21}$$

where

$$a = -2\pi^2 \langle \bar{q} q \rangle,$$

$$b = \frac{\alpha_s \langle G^2 \rangle}{\pi} \simeq 0.12\,\mathrm{GeV}^4,$$

$$\gamma = \frac{\langle \bar{q} q \rangle}{\langle \bar{s} s \rangle} - 1 = -0.2,$$

and the functions $f_2(x)$ and $f_0(x)$ describe subtraction of the continuum contributions, whose explicit forms are presented just after Eq. (14). Dividing both sides of Eq. (17), $\lambda_\Lambda \lambda_N$, and Eq. (18) by $\lambda_\Sigma \lambda_N$, whose numerical values are obtained from Eqs. (19), (20), and (21), respectively, for $g_{K\Lambda N}$ and $g_{K\Sigma N}$ coupling constants we get

$$|g_{K\Lambda N}| = 10 \pm 2,$$

$$|g_{K\Sigma N}| = 0.75 \pm 0.15. \tag{22}$$

Let us compare our predictions of $g_{K\Lambda N}$ and $g_{K\Sigma N}$ coupling constants with that of traditional three-point QCD sum rules results for the structure $\sigma_{\mu\nu}\gamma_5 p_\mu q_\nu$ [14]. The results for these quantities in framework of the traditional three-point QCD sum rules method are

$$|g_{K\Lambda N}| = 2.37 \pm 0.09,$$

$$|g_{K\Sigma N}| = 0.025 \pm 0.015. \tag{23}$$

When Eqs. (23) and (24) are compared, it is observed that the light-cone predictions on $g_{K\Lambda N}$ and $g_{K\Sigma N}$ are approximately 4 and 30 times larger, respectively, compared to that of the traditional three-point QCD sum rules results.

Here we would like to remind the reader that these coupling constants are investigated in the framework of the traditional QCD sum rules, by considering a two-point correlator sandwiched between the vacuum and kaon states for the structure $\not{q}\gamma_5$ in [21], and the results obtained are

$$|g_{K\Lambda N}| = 10 \pm 6,$$

$$|g_{K\Sigma N}| = 3.6 \pm 2.0. \tag{24}$$

When these results are compared with those given in Eq. (21), we see that the predictions of both sum rules concerning the coupling constant $g_{K\Lambda N}$ are quite close, while the coupling constant $g_{K\Sigma N}$ in our case is 5 times smaller compared to the one given in [20] for the central values.

As an additional remark, it should be noted that the values of the coupling constants $g_{K\Lambda N}$ and $g_{K\Sigma N}$ obtained in this work differ from that of the exact SU(3) prediction. Using de Swart's convention [21], SU(3) symmetry predicts

$$g_{K\Lambda N} = -\frac{1}{\sqrt{3}}(3 - 2\alpha_{\mathcal{D}}) g_{\pi NN}, \tag{25}$$

$$g_{K\Sigma N} = (2\alpha_{\mathcal{D}} - 1) g_{\Pi NN}. \tag{26}$$

Taking $\alpha_{\mathcal{D}} = 0.64$ [22] from Eqs. (25) and (26), we have

$$\left| \frac{g_{K\Lambda N}}{g_{K\Sigma N}} \right| \simeq 3.55, \tag{27}$$

while our result for this ratio is $|g_{K\Lambda N}/g_{K\Sigma N}| \simeq 12$.

Such a large difference among the predictions of the light-cone and traditional sum rules and SU(3) symmetry for the ratio of the couplings $g_{K\Lambda N}/g_{K\Sigma N}$ [see Eqs. (22), (23), and (27)] may indicate that the Ioffe currents are not optimal for the determination of the above-mentioned coupling constants. So it may be useful to use other representations [23] for the nucleon currents for the determination of the coupling constants of the kaon with baryons which we plan to discuss in the future elsewhere.

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