ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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НОВОСИБИРСК

Wave Functions of Octet Baryons

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ABSTRACT

The properties of the leading twist wave functions of baryons entering the nucleon octet are investigated using the QCD sum rules. The properties of SU(3)-symmetry breaking effects in baryon wave functions are elucidated. The model wave functions are proposed which fulfil the sum rules requirement.

The asymptotic behaviour of various baryon form-factors (which can be measured in $e^+e^- \to \bar{B}B$) is found out.

1. INTRODUCTION

In the SU(3)-symmetry limit the wave functions of octet baryons have the form shown in Table 1. Here $\varphi_N(x)$ is the dimensionless leading twist nucleon wave function normalized by $\int_0^1 d_3x\, \varphi_N(x) = 1$, $f_N \simeq 0.5 \cdot 10^{-2}$ GeV^2 is the constant which determines the value of the nucleon wave function at the origin. (All needed definitions and conventions used in this paper can be taken from the previous paper [1]).

The properties of the nucleon wave function $\varphi_N(x)$ have been investigated in detail in [1] (see also [2, 3]). It is a goal of this paper to consider the properties of SU(3)-symmetry breaking effects in the baryon wave functions. The properties of SU(3)-symmetry breaking in the meson wave functions have been investigated in [4] (see also the review [5]).

We use below the same method for obtaining sum rules as for the nucleon. Therefore, we use here heavily the formulae and results from our previous paper [1]. For the same reason we give mainly the results, not going into much details.

2. Σ-HYPERON

The Σ-hyperon leading twist wave function is determined by the matrix element of the three-local operator:

$$\langle 0 |\, \varepsilon^{ijk} u^i_\alpha(z_1)\, u^j_\beta(z_2)\, s^k_\gamma(z_3)\, | \Sigma(p) \rangle = \frac{1}{4} f_\Sigma \{ (\hat{p} C)_{\alpha\beta} (\gamma_5 \Sigma)_\gamma V_\Sigma(z_i p) +$$

$$+(\hat{p}\gamma_5 C)_{\alpha\beta}\,\Sigma_\gamma\, A_\Sigma(z_i p)\} - \frac{1}{4} f_\Sigma^T\,(\sigma_{\mu\nu}\, p_\nu C)_{\alpha\beta}\,(\gamma_\mu\gamma_5\Sigma)_\gamma\, T_\Sigma(z_i p)\,; \qquad (1)$$

$$V_\Sigma(x_1, x_2, x_3) = V_\Sigma(x_2, x_1, x_3)\,; \quad T_\Sigma(x_1, x_2, x_3) = T_\Sigma(x_2, x_1, x_3)\,,$$

$$A_\Sigma(x_1, x_2, x_3) = -A_\Sigma(x_2, x_1, x_3)\,, \quad \int_0^1 d_3x\, V_\Sigma(x) = \int_0^1 d_3x\, T_\Sigma(x) = 1\,. \qquad (2)$$

With the SU(3)-symmetry breaking taken into account $T_\Sigma(x)$ can not be expressed through $V_\Sigma(x)$ and $A_\Sigma(x)$. The formulae (1) and (2) are equivalent to the following form of the Σ-state:

$$|\Sigma^\uparrow\rangle = \int_0^1 \frac{d_3x}{4\sqrt{6}}\,\{ f_\Sigma(V_\Sigma(x) - A_\Sigma(x))\,|u^\uparrow(x_1)\,u^\downarrow(x_2)\,s^\uparrow(x_3)\rangle -$$

$$- f_\Sigma^T\, T_\Sigma(x)\,|u^\uparrow(x_1)\,u^\uparrow(x_2)\,s^\downarrow(x_3)\rangle\}\,. \qquad (3)$$

To find the moments of $\varphi_\Sigma(x) = V_\Sigma(x) - A_\Sigma(x)$ and the constant f_Σ we use the correlators obtained from [1] (formula (9)) by the replacement $d\to s$:

$$I_\Sigma^{(n)}(q, z) = i\int dx\, e^{iqx}\,\langle 0|\,T\{J_\tau^{(n)}(x)\,\bar{J}_{\tau'}^{(1)}(0)\}\,|0\rangle\,\hat{z}_{\tau'\tau} = (zq)^{n+4}\, I_\Sigma^{(n)}(q^2)\,; \qquad (4)$$

$$J_\tau^{(n)}(x) = \varepsilon^{ijk}\,[D^{n_1}u(x)]^i\, C\hat{z}\,\{[D^{n_2}u(x)]^j\,[D^{n_3}\gamma_5 s(x)]_\tau^k -$$

$$-[D^{n_2}\gamma_5 u(x)]^j\,[D^{n_3}s(x)]_\tau^k\}\,, \qquad (5)$$

$$J_{\tau'}^{(1)}(0) = \varepsilon^{ijk}\,[Du(0)]^i\, C\hat{z}\,\{u^j(0)\,(\gamma_5 s(0))_{\tau'}^k - s^j(0)\,(\gamma_5 u(0))_{\tau'}^k\}\,.$$

The spectral density is taken in the standard form:

$$\frac{1}{\pi}\,\mathrm{Im}\, I_\Sigma^{(n)}(s) = 4 r_\Sigma^{(n)}\,\delta(s - M_\Sigma^2) + \binom{\text{next}}{\text{reson.}} + \frac{\gamma_1^{(n)}}{480\pi^4}\, s\,\theta(s - s_n)\,,$$

$$r_\Sigma^{(n)} = |f_\Sigma|^2\left\{\frac{1}{2}\,\varphi_\Sigma^{(100)} + \frac{f_\Sigma^T}{f_\Sigma}\, T_\Sigma^{(100)}\right\}\varphi_\Sigma^{(n)}\,, \qquad (6)$$

$$\varphi_\Sigma^{(n)} = \int_0^1 d_3x\, x_1^{n_1} x_2^{n_2} x_3^{n_3}\,(V_\Sigma(x) - A_\Sigma(x))\,.$$

The sum rules then have the form:

$$4 r_\Sigma^{(n)}\,\exp\left\{-\frac{M_\Sigma^2}{M^2}\right\} + \binom{\text{next}}{\text{reson.}} = \frac{\gamma_1^{(n)}}{480\pi^4}\, M^4\{1 - (1+H)\,e^{-H}\} -$$

$$-\frac{\gamma_2^{(n)} m_s^2 M^2}{480\pi^4}\,(1 - e^{-H}) + \frac{\gamma_3^{(n)}}{48\pi^2}\,\langle\frac{\alpha_s}{\pi}\,G^2\rangle + \frac{4}{81\pi}\,\frac{\gamma_4^{(n)}}{M^2}\,\langle\sqrt{\alpha_s}\,\bar{u}u\rangle^2 +$$

$$+\frac{\gamma_5^{(n)}}{48\pi^2}\, m_s\langle\bar{s}s\rangle - \frac{\gamma_6^{(n)} m_s}{72\pi^2 M^2}\,\langle\bar{s}ig\sigma_{\mu\nu}G_{\mu\nu}^a\frac{\lambda^a}{2}s\rangle, \quad \sigma_{\mu\nu} = \frac{1}{2}\,[\gamma_\mu, \gamma_\nu]\,. \qquad (7)$$

In (7): the term $\sim\gamma_1^{(n)}$ is due to Fig. 1 diagram with massless quarks; the term $\sim\gamma_2^{(n)}$ is a correction to this diagram due to the s-quark mass; the term $\sim\gamma_3^{(n)}$ is due to Fig. 2 diagrams; the term $\sim\gamma_5^{(n)}$ is due to Fig. 3 diagrams; the term $\sim\gamma_4^{(n)}$ is due to Fig. 4 and

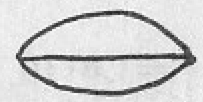

Fig. 1.

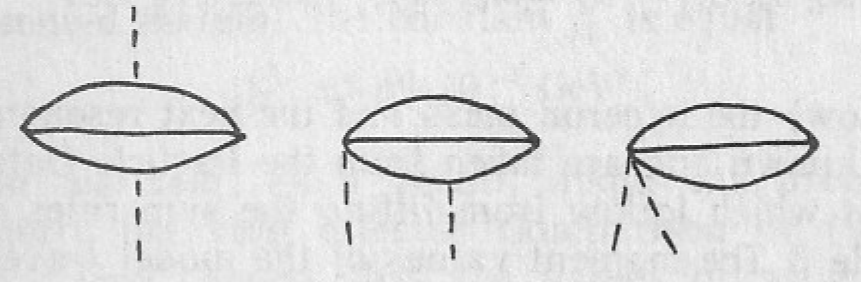

Fig. 2.

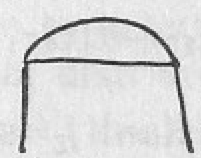

Fig. 3.

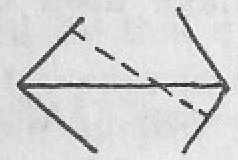

Fig. 4.

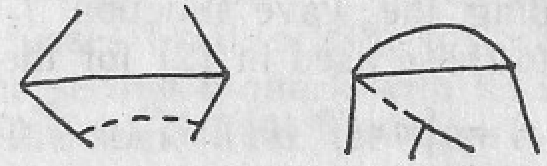

Fig. 5.

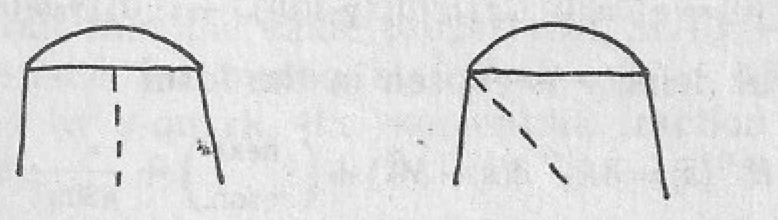

Fig. 6.

Fig. 5 diagrams (these diagrams give both $\langle\bar{u}u\rangle$ and $\langle\bar{s}s\rangle$ condensates, and to simplify the formulae we have written the summary contribution using $\langle \bar{s}s \rangle \simeq 0.8 \langle \bar{u}u \rangle$, see [5]); the term $\sim \gamma_6^{(n)}$ is due to Fig. 6 diagrams.

The coefficients $\gamma_i^{(n)}$ are given in Table 2a. When fitting the sum rules we used the standard values of condensates (see, for instance, [5]):

$$\langle \frac{\alpha_s}{\pi} G^2 \rangle = 1.2 \cdot 10^{-2}\ \text{GeV}^4, \quad \langle \bar{u}u \rangle \simeq -(0.25\ \text{GeV})^3,$$

$$\langle \bar{s}s \rangle \simeq 0.8 \langle \bar{u}u \rangle, \quad \langle \sqrt{\alpha_s}\, \bar{u}u \rangle^2 = 1.8 \cdot 10^{-4}\ \text{GeV}^6, \quad m_s \simeq 150\ \text{MeV},$$

$$\langle \bar{s} ig\, \sigma_{\mu\nu} G^a_{\mu\nu} \frac{\lambda^a}{2} s \rangle = m_0^2 \langle \bar{s}s \rangle, \quad m_0^2 \simeq 0.75\ \text{GeV}^2.$$

Here (and below) the hyperon mass and the next resonance mass are considered as known and are taken from the Particle Data Tables.

The results which follow from fitting the sum rules (7) are presented in Table 3 The moment values of the model wave function

$$\varphi_\Sigma(x, \mu \simeq 1\ \text{GeV}) = \varphi_{as}(x) [0.36x_1^2 + 0.24x_2^2 + 0.14x_3^2 - 0.54x_1x_2 - $$
$$- 0.16x_3(x_1 + x_2) + 0.05(x_1 - x_2)] \cdot 42. \qquad (8)$$

are also given therein. The constant f_Σ is equal:

$$|f_\Sigma| \simeq 0.51 \cdot 10^{-2}\ \text{GeV}^2. \qquad (9)$$

For finding the wave function $T_\Sigma(x)$ we have used correlators analogous to those used in [2] for the nucleon:

$$K^{(n)}(q, z) = i \int dx\, e^{iqx} \langle 0 | T\{ T_\tau^{(n)}(x)\, J_{\tau'}^{(0)}(0)\} | 0 \rangle \hat{z}_{\tau'\tau} = (zq)^{n+3} K^{(n)}(q^2),$$

$$T_\tau^{(n)}(x) = \varepsilon^{ijk} [D^{n_1} u(x)]^i C \sigma_{\mu\nu} z_\nu [D^{n_2} u(x)]^j [D^{n_3} \gamma_\mu \gamma_5 s(x)]^k_\tau, \qquad (10)$$

$$J_{\tau'}^{(0)}(0) = \varepsilon^{ijk} u^i(0)\, C\hat{z} \{ u^j(0) (\gamma_5 s(0))^k_{\tau'} - s^j(0) (\gamma_5 u(0))^k_{\tau'} \}.$$

The spectral density is chosen in the form

$$\frac{1}{\pi}\, \text{Im}\, K^{(n)}(s) = 8 R_\Sigma^{(n)}\, \delta(s - M_\Sigma^2) + \binom{\text{next}}{\text{reson.}} + \frac{\varkappa_1^{(n)}}{480\pi^4}\, s\, \theta(s - s_n),$$

$$R_\Sigma^{(n)} = |f_\Sigma^T|^2 \left\{ 1 + \frac{1}{2} \frac{f_\Sigma}{f_\Sigma^T} \right\} T_\Sigma^{(n)}. \qquad (11)$$

The corresponding sum rules have the form

$$8 R_\Sigma^{(n)} \exp\left\{ -\frac{M_\Sigma^2}{M^2} \right\} + \binom{\text{next}}{\text{reson.}} = \frac{\varkappa_1^{(n)}}{480\pi^4} M^4 \{ 1 - (1 + H) e^{-H} \} -$$

$$- \frac{\varkappa_2^{(n)}}{480\pi^4} m_s^2 M^2 (1 - e^{-H}) + \frac{\varkappa_3^{(n)}}{48\pi^2} \langle \frac{\alpha_s}{\pi} G^2 \rangle + \frac{4}{81\pi} \frac{\varkappa_4^{(n)}}{M^2} \langle \sqrt{\alpha_s}\, \bar{u}u \rangle^2 +$$

$$+ \frac{\varkappa_5^{(n)}}{48\pi^2} m_s \langle \bar{s}s \rangle - \frac{\varkappa_6^{(n)} m_s}{72\pi^2 M^2} \langle \bar{s} ig\, \sigma_{\mu\nu} G^a_{\mu\nu} \frac{\lambda^a}{2} s \rangle. \qquad (12)$$

The coefficients $\varkappa_i^{(n)}$ are given in Table 2b. The results for the moment values are presented in Table 3. The moment values of the model wave function

$$T_\Sigma(x) = \varphi_{as}(x)\, 42 [0.32(x_1^2 + x_2^2) + 0.16x_3^2 - 0.47x_1x_2 - 0.24x_3(x_1 + x_2)]. \qquad (13)$$

are also presented therein. The constant f_Σ^T is equal

$$|f_\Sigma^T| \simeq 0.49 \cdot 10^{-2}\ \text{GeV}^2. \qquad (14)$$

What can we said, as a result, about the properties of the SU(3)-symmetry breaking effects? Comparison of (9), (14) with $|f_N| \simeq 0.5 \cdot 10^{-2}$ GeV^2 shows that the values of wave functions at the origin remain approximately equal ($f_N = f_\Sigma = f_\Sigma^T$ in exact SU(3)-limit). The role of the symmetry breaking is much more significant in the quark momenta distributions.

For the wave function $\varphi = (V - A)$, for instance, the comparison of first moments values ($n_1 + n_2 + n_3 = 1$) in Table 3 here and in Table 5 in [1] shows the following. When the d-quark of the proton is replaced by the s-quark of the Σ^+-hyperon, the momentum fraction carried by this quark increases from $\simeq 23\%$ to $\simeq 30\%$. Moreover, this increase is due to the second u-quark with its spin antiparallel to the baryon spin. At the same time, the first u-quark with its spin parallel to the baryon spin carries $\simeq (55-58)\%$ in both the proton and Σ^+-states.

Let us point out that the same property of SU(3) — breaking effects is characteristic for meson states also [4]: when u (or d) quark is replaced by s-quark, the momentum fraction it carries increases.

3. Ξ-HYPERON

The leading twist wave functions of the Ξ-hyperon are determined by the matrix element

$$\langle 0 | \varepsilon^{ijk} s^i_\alpha(z_1)\, s^j_\beta(z_2)\, d^k_\gamma(z_3) | \Xi^-(p) \rangle = \frac{1}{4} f_\Xi \{ (\hat{p}C)_{\alpha\beta} (\gamma_5 \Xi)_\gamma V_\Xi(z_i p) +$$

$$+(\hat{p}\gamma_5 C)_{\alpha\beta}\,\Xi_\gamma\,A_\Xi(z_i p)\} - \frac{1}{4} f_\Xi^T\, T_\Xi(z_i p)\,(\sigma_{\mu\nu}p_\nu C)_{\alpha\beta}\,(\gamma_\mu\gamma_5\Xi)_\gamma\,,$$

$$V_\Xi(x_1,x_2,x_3) = V_\Xi(x_2,x_1,x_3), \qquad T_\Xi(x_1,x_2,x_3) = T_\Xi(x_2,x_1,x_3),$$

$$A_\Xi(x_1,x_2,x_3) = -A_\Xi(x_2,x_1,x_3), \qquad \int_0^1 d_3x\, V_\Xi(x) = \int_0^1 d_3x\, T_\Xi(x) = 1\,. \tag{15}$$

The equivalent definition has (at $p_z\to\infty$) the form

$$|\Xi^\uparrow\rangle = \int_0^1 \frac{d_3x}{4\sqrt{6}} \{ f_\Xi(V_\Xi(x) - A_\Xi(x))\ |s^\uparrow(x_1)\, s^\downarrow(x_2)\, d^\uparrow(x_3)\rangle -$$

$$- f_\Xi^T\, T_\Xi(x)\, |s^\uparrow(x_1)\, s^\uparrow(x_2)\, d^\downarrow(x_3)\rangle\}\,. \tag{16}$$

(the SU(3)-symmetry limit see in Table 1).

We have studied the following correlators:

$$I_\Xi^{(n)}(q,z) = i\int dx\, e^{iqx}\langle 0|T\{J_\tau^{(n)}(x)\,\bar{J}_{\tau'}^{(1)}(0)\}\ |0\rangle \hat{z}_{\tau'\tau} = (zq)^{n+4} I_\Xi^{(n)}(q^2)\,,$$

$$J_\tau^{(n)}(x) = \varepsilon^{ijk}[D^{n_1}s(x)]^i\, C\hat{z}\{[D^{n_2}s(x)]^j\,[D^{n_3}\gamma_5 d(x)]_\tau^k - [D^{n_2}\gamma_5 s(x)]^j\,[D^{n_3}d(x)]_\tau^k\}\,,$$

$$J_{\tau'}^{(1)}(0) = \varepsilon^{ijk}[Ds(0)]^i\, C\hat{z}\{s^j(0)\,(\gamma_5 d(0))_{\tau'}^k - d^j(0)\,(\gamma_5 s(0))_{\tau'}^k\}\,. \tag{17}$$

The spectral density was chosen in the form (6) with the replacement $\Sigma\to\Xi$. The sum rules have the form (7) with the replacement: $r_\Sigma^{(n)}\to r_\Xi^{(n)}$, $M_\Sigma^2\to M_\Xi^2$, $\gamma_i^{(n)}\to\delta_i^{(n)}$ and the coefficients $\delta_i^{(n)}$ are given in Table 4a. The results are presented in Table 5. The moment values of the model wave function $\varphi_\Xi(x) = V_\Xi(x) - A_\Xi(x)$

$$\varphi_\Xi(x) = \varphi_{as}(x)\, 42\,[0.38x_1^2 + 0.20x_2^2 + 0.16x_3^2 - 0.26x_1x_2 -$$

$$-0.30x_3(x_1+x_2) + 0.02(x_1-x_2)]\,,$$

$$|f_\Xi| \simeq 0.53\cdot 10^{-2}\ \mathrm{GeV}^2\,. \tag{18}$$

are also given therein.

The correlators which were used for finding $T_\Xi(x)$ are obtained from (10) by the replacement: $u\to s$, $s\to d$. The corresponding sum rules have the form (12) with the replacement $\varkappa_i^{(n)}\to\rho_i^{(n)}$, and the coefficients $\rho_i^{(n)}$ are given in Table 4b. The results are presented in Table 5. The moment values of the model wave functions

$$T_\Xi(x) = \varphi_{as}(x)\, 42\,[0.28(x_1^2+x_2^2) + 0.18x_3^2 - 0.16x_1x_2 - 0.35x_3(x_1+x_2)]\,. \tag{19}$$

are also given therein. The constant f_Ξ^T is equal

$$|f_\Xi^T| \simeq 0.54\cdot 10^{-2}\ \mathrm{GeV}^2\,. \tag{20}$$

The comparison of the proton and Ξ^--hyperon wave functions $\varphi_N(x)$ and $\varphi_\Xi(x)$ (see Table 5 here and Table 5 in [1]) shows that when proton's u-quarks are replaced by Ξ^--hyperon's s-quarks, the momentum fraction carried by the first quark remains approximately the same ($\simeq 58\%$) while the second and third quarks exchanged their momentum fractions:

$$\langle x_2\rangle_p \simeq \langle x_3\rangle_\Xi \simeq 0.19\,; \qquad \langle x_3\rangle_p \simeq \langle x_2\rangle_\Xi \simeq 0.23\,.$$

4. Λ-HYPERON

The leading twist wave functions of the Λ-hyperon are determined by the matrix element:

$$\langle 0|\varepsilon^{ijk} u_\alpha^i(z_1)\, d_\beta^j(z_2)\, s_\gamma^k(z_3)\,|\Lambda(p)\rangle = \frac{1}{4} f_\Lambda\{(\hat{p}C)_{\alpha\beta}(\gamma_5\Lambda)_\gamma\, V_\Lambda(z_i p) +$$

$$+(\hat{p}\gamma_5 C)_{\alpha\beta}\,\Lambda_\gamma\, A_\Lambda(z_i p)\} - \frac{1}{4} f_\Lambda^T(\sigma_{\mu\nu}p_\nu C)_{\alpha\beta}(\gamma_\mu\gamma_5\Lambda)_\gamma\, T_\Lambda(z_i p)\,,$$

$$V_\Lambda(x_1,x_2,x_3) = -V_\Lambda(x_2,x_1,x_3), \qquad T_\Lambda(x_1,x_2,x_3) = -T_\Lambda(x_2,x_1,x_3),$$

$$A_\Lambda(x_1,x_2,x_3) = A_\Lambda(x_2,x_1,x_3), \quad \int_0^1 d_3x\, A_\Lambda(x) = -1, \quad \int_0^1 d_3x\, x_1\, T_\Lambda(x) = 1\,. \tag{21}$$

The equivalent definition has the form

$$|\Lambda^\uparrow\rangle = \int_0^1 \frac{d_3x}{4\sqrt{6}}\{f_\Lambda(V_\Lambda(x) - A_\Lambda(x))\ |u_1^\uparrow\, d_2^\downarrow\, s_3^\uparrow\rangle +$$

$$+ f_\Lambda(V_\Lambda(x) + A_\Lambda(x))\ |u_1^\downarrow\, d_2^\uparrow\, s_3^\uparrow\rangle - 2f_\Lambda^T\, T_\Lambda(x)\ |u_1^\uparrow\, d_2^\uparrow\, s_3^\downarrow\rangle\}\,. \tag{22}$$

In the exact SU(3)-symmetry limit one has the following relations between the nucleon and Λ-hyperon wave functions:

$$f_\Lambda\varphi_\Lambda(123) = -\sqrt{\frac{2}{3}}\ f_N\left\{\varphi_N(321) + \frac{1}{2}\varphi_N(123)\right\}, \tag{23}$$

$$f_\Lambda^T T_\Lambda(123)=\frac{1}{4}\sqrt{\frac{2}{3}}\,f_N\{\varphi_N(132)-\varphi_N(231)\},$$

$$f_\Lambda^T T_\Lambda(123)=f_\Lambda\{\varphi_\Lambda(231)-\varphi_\Lambda(132)\}. \qquad (24)$$

To determine the properties of the wave function $\varphi_\Lambda(x)\equiv V_\Lambda(x)-A_\Lambda(x)$, the following correlators have been considered:

$$I_\Lambda^{(n)}(q,z)=i\int dx\, e^{iqx}\langle 0|\,T\{J_\tau^{(n)}(x)\,\bar J_{\tau'}^{(1)}(0)\}\;|0\rangle\,\hat z_{\tau'\tau}=(zq)^{n+4}I_\Lambda^{(n)}(q^2),$$

$$J_\tau^{(n)}(x)=\varepsilon^{ijk}[D^{n_1}u(x)]^i\,C\hat z(1-\gamma_5)\;[D^{n_2}d(x)]^j[D^{n_3}(1+\gamma_5)\,s(x)]_\tau^k,$$

$$\bar J_{\tau'}^{(1)}(0)=\varepsilon^{ijk}\{\bar u^i(0)(1-\gamma_5)\,\hat z C\bar d^j(0)-\bar d^i(0)(1-\gamma_5)\,\hat z C\bar u^j(0)\}\left[\bar s(0)\,\frac{1-\gamma_5}{2}\overleftarrow{D}\right]_{\tau'}^k+$$

$$+\frac{1}{2}\varepsilon^{ijk}\{\bar u^i(0)(1-\gamma_5)\,\hat z C\overleftarrow{D}\bar d^j(0)-\bar d^i(0)(1-\gamma_5)\,\hat z C\overleftarrow{D}\bar u^j(0)\}\left[\bar s(0)\,\frac{1-\gamma_5}{2}\right]_{\tau'}^k-$$

$$-\frac{1}{2}\varepsilon^{ijk}\Big\{\bar u^i(0)(1-\gamma_5)\,\hat z C\overleftarrow{D}\bar s^j(0)\left[\bar d(0)\,\frac{1-\gamma_5}{2}\right]_{\tau'}^k-\bar d^i(0)(1-\gamma_5)\,\hat z C\overleftarrow{D}\,\bar s^j(0)\times$$

$$\times\left[\bar u(0)\,\frac{1-\gamma_5}{2}\right]_{\tau'}^k\Big\}. \qquad (25)$$

The spectral density was chosen in the standard form:

$$\frac{1}{\pi}\,\mathrm{Im}\,I_\Lambda^{(n)}(s)=8r_\Lambda^{(n)}\,\delta(s-M_\Lambda^2)+\binom{\text{next}}{\text{reson.}}+\frac{\varepsilon_1^{(n)}}{480\pi^4}s\,\theta(s-s_n),$$

$$r_\Lambda^{(n)}=|f_\Lambda|^2\,\varphi_\Lambda^{(n)}\left\{\varphi_\Lambda^{(001)}+\frac{1}{2}\varphi_\Lambda^{(100)}+\frac{1}{2}\,\frac{f_\Lambda^T}{f_\Lambda}\,(T_\Lambda^{(100)}-T_\Lambda^{(010)})\right\}. \qquad (26)$$

The corresponding sum rules have the form (7) with the replacement: $4r_\Sigma^{(n)}\to 8r_\Lambda^{(n)}$, $M_\Sigma^2\to M_\Lambda^2$, $\gamma_i^{(n)}\to\varepsilon_i^{(n)}$ and the coefficients $\varepsilon_i^{(n)}$ are given in Table 6a. The results obtained by fitting these sum rules are presented in Table 6b. The moment values of the model wave function $\varphi_\Lambda(x)=V_\Lambda(x)-A_\Lambda(x)$

$$\varphi_\Lambda(x)=\varphi_{as}(x)\;42\,[\,0.44x_1^2+0.08x_2^2+0.34x_3^2-0.56x_1x_2-$$

$$-0.24x_3(x_1+x_2)-0.10(x_1-x_2)\,]. \qquad (27)$$

are also given therein. The constant f_Λ is equal

$$|f_\Lambda|\simeq 0.63\cdot 10^{-2}\ \mathrm{GeV}^2,\qquad f_\Lambda/f_N\simeq 1.26. \qquad (28)$$

The following correlators have been used for finding the wave

function $T_\Lambda(x)$:

$$K_\Lambda^{(n)}(q,z)=i\int dx\, e^{iqx}\langle 0|\,T\{T_\tau^{(n)}(x)\,\bar J_{\tau'}^{(1)}(0)\}\;|0\rangle\,\hat z_{\tau'\tau}=(zq)^{n+4}K_\Lambda^{(n)}(q^2),$$

$$T_\tau^{(n)}(x)=\varepsilon^{ijk}[D^{n_1}u(x)]^i\,C\hat z\gamma_\mu(1+\gamma_5)\;[D^{n_2}d(x)]^j[\gamma_\mu(1-\gamma_5)\,D^{n_3}s(x)]_\tau^k, \qquad (29)$$

The current $\bar J_{\tau'}^{(1)}(0)$ is the same as in (25). The spectral density has the form

$$\frac{1}{\pi}\,\mathrm{Im}\;K_\Lambda^{(n)}(s)=16R_\Lambda^{(n)}\,\delta(s-s_n)+\binom{\text{next}}{\text{reson.}}+\frac{\sigma_1^{(n)}}{480\pi^4}s\,\theta(s-s_n),$$

$$R_\Lambda^{(n)}=|f_\Lambda f_\Lambda^T|\;T_\Lambda^{(n)}\left\{\varphi_\Lambda^{(001)}+\frac{1}{2}\varphi_\Lambda^{(100)}+\frac{1}{2}\,\frac{f_\Lambda^T}{f_\Lambda}(T_\Lambda^{(100)}-T_\Lambda^{(010)})\right\}. \qquad (30)$$

The sum rules have the form (7) with the replacement: $4r_\Sigma^{(n)}\to 8R_\Lambda^{(n)}$, $M_\Sigma^2\to M_\Lambda^2$, $\gamma_i^{(n)}\to\sigma_i^{(n)}$ and the coefficients $\sigma_i^{(n)}$ are given in Table 7a.

The standard fitting procedure is ineffective in this case. The reason is that the scale of power corrections in the sum rules for $T_\Lambda^{(n)}$ is too large and, as a result, these sum rules have low sensitivity to the Λ-hyperon contributions. However, it is possible to find out such linear combinations of various sum rules in which the power corrections are of acceptable magnitude. For instance, the following linear combinations have better sensitivity to the Λ-hyperon contributions:

$$\varphi_\Lambda^{(100)}-2T_\Lambda^{(100)};\quad \varphi_\Lambda^{(001)}-2T_\Lambda^{(100)};\quad \varphi_\Lambda^{(000)}-2T_\Lambda^{(100)};$$

$$\varphi_\Lambda^{(000)}-4T_\Lambda^{(100)};\quad \varphi_\Lambda^{(000)}-2T_\Lambda^{(200)};\quad \varphi_\Lambda^{(100)}-2T_\Lambda^{(200)};\ \text{and so on.} \qquad (31)$$

The results which were obtained by fitting these sum rules are presented in Table 7b. The moments of the model wave function

$$T_\Lambda(x)=\varphi_{as}(x)\;42\,[\,1.2(x_2^2-x_1^2)+1.4(x_1-x_2)\,]. \qquad (32)$$

are given also therein. The constant f_Λ^T is equal

$$|f_\Lambda^T|\simeq(0.1\pm 0.01)\,|f_\Lambda|\simeq 0.063\cdot 10^{-2}\ \mathrm{GeV}^2. \qquad (33)$$

It is seen from Table 6b that in the $|u_1^\uparrow d_2^\downarrow s_3^\uparrow\rangle$-component of the Λ-hyperon wave function, the u-quark carries $\simeq 31\%$ of the total longitudinal momentum while the d- and s-quarks carry $\simeq 17\%$ and $\simeq 52\%$ correspondingly. The profiles of the wave functions $\varphi_N(x)$, $\varphi_\Sigma(x)$ and $\varphi_\Xi(x)$ are presented in Figs 7, 8 and 9 correspondingly.

5. THE ELECTROMAGNETIC FORMFACTORS OF HYPERONS

These formfactors can be measured in the e^+e^--annihilation, $e^+e^-\to\bar{B}B$. There is no need to do a new calculations of the Feynman diagrams for these formfactors, because one can use the results [6] for the nucleon formfactors.

The asymptopia of the nucleon formfactors has the form:

$$Q^4F_1^N(Q^2)=(4\pi\bar{\alpha}_s)^2\frac{|f_N|^2}{54}I,$$

$$I=\int_0^1 d_3x\, d_3y\left\{2\sum_{i=1}^{7}e_i\,T_i(x,y)+\sum_{i=8}^{14}e_i\,T_i(x,y)\right\}, \qquad (34)$$

where e_i is the charge of those quark which interacts with the photon in the given diagram, $e_u=2/3$, $e_d=e_s=-1/3$. The explicit form of various diagrams and $T_i(x,y)$ are given in [6]. (For the reader convenience we present these results below in Table 8.)

Comparing the explicit forms of the proton and Σ^+-hyperon states:

$$|p^\uparrow\rangle=f_N\int_0^1\frac{d_3x}{4\sqrt{6}}\{\varphi_N(x)\,|u_1^\uparrow u_2^\downarrow d_3^\uparrow\rangle-T_N(x)\,|u_1^\uparrow u_2^\uparrow d_3^\downarrow\rangle\},$$

$$|\Sigma^{+\uparrow}\rangle=f_\Sigma\int_0^1\frac{d_3x}{4\sqrt{6}}\left\{\varphi_\Sigma(x)\,|u_1^\uparrow u_2^\downarrow s_3^\uparrow\rangle-\frac{f_\Sigma^T}{f_\Sigma}\,T_\Sigma(x)\,|u_1^\uparrow u_2^\uparrow s_3^\downarrow\rangle\right\}, \qquad (35)$$

one can establish the correspondence:

$$f_N\to f_\Sigma,\quad \varphi_N(x)\to\varphi_\Sigma(x),\quad T_N(x)\to\frac{f_\Sigma^T}{f_\Sigma}T_\Sigma(x). \qquad (36)$$

Using (36) one can obtain the Σ^+-hyperon formfactors as follows.

a) Let us present the electromagnetic current in the form:

$$J_\mu^\gamma=\frac{1}{2}J_\mu^v+\frac{1}{6}J_\mu^0-\frac{1}{3}J_\mu^s,$$

$$J_\mu^v=\bar{u}\gamma_\mu u-\bar{d}\gamma_\mu d,\quad J_\mu^0=\bar{u}\gamma_\mu u+\bar{d}\gamma_\mu d,\quad J_\mu^s=\bar{s}\gamma_\mu s.$$

b) Because there is no d-quarks in the Σ^+-state, the formfactors of the currents J_μ^v and J_μ^0 coincide. The formfactor of the current J_μ^v is obtained from (34) by the replacement (36) and with $e_u=1$, $e_s=0$. Using the explicit form of $T_i(x,y)$ from Table 8 and (8), (9), (13) and (14), one obtains (here and below $\bar{\alpha}_s=0.3$):

$$Q^4F_{1\Sigma}^v=Q^4F_{1\Sigma}^0\simeq 1.836\ \mathrm{GeV}^4,\qquad I_\Sigma^v=I_\Sigma^0\simeq 2.682\cdot 10^5. \qquad (37)$$

Like the nucleon formfactors, nearly all the contribution (37) originates from the № 9 and 10 diagrams (which are equal to each other) while all the rest diagrams nearly cancel in the sum.

c) The formfactor of the current J_μ^s is obtained from (34) by the replacement (36) and with $e_u=0$, $e_s=1$ (i. e., accounting only for those diagrams № 7, 12, 13 and 14 where the photon interacts with the s-quark). One obtains

$$Q^4F_{1\Sigma}^s\simeq 0.107\ \mathrm{GeV}^4,\qquad I_\Sigma^s\simeq 0.156\cdot 10^5, \qquad (38)$$

(nearly all the contribution (38) gives the diagram № 13 while the summary contribution of № 7, 12 and 14 diagrams is much smaller). The formfactors of $\Sigma^{\pm,0}$-hyperons have the form:

$$Q^4F_1^{\Sigma^+}=Q^4\left[\frac{1}{2}F_{1\Sigma}^v+\frac{1}{6}F_{1\Sigma}^0-\frac{1}{3}F_{1\Sigma}^s\right]\simeq 1.19\ \mathrm{GeV}^4,$$

$$Q^4F_1^{\Sigma^0}=Q^4\left[\frac{1}{6}F_{1\Sigma}^0-\frac{1}{3}F_{1\Sigma}^s\right]\simeq 0.27\ \mathrm{GeV}^4; \qquad (39)$$

$$Q^4F_1^{\Sigma^-}=Q^4\left[-\frac{1}{2}F_{1\Sigma}^v+\frac{1}{6}F_{1\Sigma}^0-\frac{1}{3}F_{1\Sigma}^s\right]\simeq -0.647\ \mathrm{GeV}^4,$$

$$\frac{F_1^{\Sigma^0}(Q^2)}{F_1^{\Sigma^+}(Q^2)}\simeq 0.23,\qquad \frac{F_1^{\Sigma^-}(Q^2)}{F_1^{\Sigma^+}(Q^2)}\simeq -0.55,\qquad \frac{F_1^{\Sigma^+}(Q^2)}{F_1^{p}(Q^2)}\simeq 1.25, \qquad (40)$$

Let us point out that $F_1^{\Sigma^+}(Q^2)=F_1^p(Q^2)$ in the SU(3)-symmetry limit. (We expect that the ratios (40) have better accuracy than the absolute values (39).)

The Ξ^0 and Ξ^--hyperon formfactors can be obtained in a similar way using the replacement: $f_N\to f_\Xi$, $\varphi_N(x)\to\varphi_\Xi(x)$, $T_N(x)\to T_\Xi(x)f_\Xi^T/f_\Xi$. Using the explicit form (18) — (20) one obtains:

$$Q^4F_1^{\Xi^0}(Q^2)\simeq -0.515\ \mathrm{GeV}^4,\qquad I_{\Xi^0}\simeq -0.752\cdot 10^5,$$

$$Q^4F_1^{\Xi^-}(Q^2)\simeq -0.595\ \mathrm{GeV}^4,\qquad I_{\Xi^-}\simeq -0.87\cdot 10^5, \qquad (41)$$

$$\frac{F_1^{\Xi^0}(Q^2)}{F_1^{\Xi^-}(Q^2)} \simeq 0.865\,, \quad \frac{F_1^{\Xi^-}(Q^2)}{F_1^{\Sigma^-}(Q^2)} \simeq 0.92\,, \quad \frac{F_1^{\Xi^0}(Q^2)}{F_1^{n}(Q^2)} \simeq 1.15\,,$$

In the SU(3)-symmetry limit: $F_1^{\Xi^-} = F_1^{\Sigma^-}$, $F_1^{\Xi^0} = F_1^{n}$.

Not going into details, we present below the result for the Λ-hyperon formfactor:

$$Q^4 F_1^{\Lambda}(Q^2) = (4\pi\bar{\alpha}_s)^2 \frac{|f_\Lambda|^2}{54} \frac{2}{3} I_\Lambda\,,$$

$$I_\Lambda = \int_0^1 d_3x\, d_3y \left\{ \sum_{i=1}^{5} T_i^{\Lambda}(x,y) + 2(-T_7^{\Lambda}(x,y) + T_9^{\Lambda}(x,y)) - \sum_{i=10}^{14} T_i^{\Lambda}(x,y) \right\}. \quad (42)$$

The expressions $T_i^{\Lambda}(x,y)$ are obtained from the nucleon's $T_i(x,y)$, Table 8, by the replacement:

$$\varphi_N(x) \to \varphi_\Lambda(x)\,, \quad T_N(x) \to \frac{f_\Lambda^T}{f_\Lambda} T_\Lambda(x)\,.$$

Using the explicit form (27), (28), (32) and (33) one obtains

$$Q^4 F_1^{\Lambda}(Q^2) \simeq -0.23\,\text{GeV}^4, \quad I_\Lambda \simeq -0.33\cdot 10^5,$$

$$2\frac{F_1^{\Lambda}(Q^2)}{F_1^{n}(Q^2)} \simeq 1.03\,, \quad \frac{F_1^{\Lambda}(Q^2)}{F_1^{\Sigma^0}(Q^2)} \simeq -0.85 \quad (43)$$

(the main contribution give the diagrams № 7, 12 and 14). In the SU(3)-symmetry limit: $F_1^{\Lambda}(Q^2) = -F_1^{\Sigma^0}(Q^2) = \frac{1}{2} F_1^{n}(Q^2)$.

The transition formfactor $\gamma\Sigma\Lambda$ has the form

$$Q^4 F_{\Sigma\Lambda} = \frac{f_\Lambda f_\Sigma}{\sqrt{2}} \frac{(4\pi\bar{\alpha}_s)^2}{54} I_{\Sigma\Lambda}\,,$$

$$I_{\Sigma\Lambda} = \int_0^1 d_3x\, d_3y \{2(T_1^{\Sigma\Lambda}(x,y) + T_9^{\Sigma\Lambda}(x,y)) -$$

$$-[(T_3^{\Sigma\Lambda}(x,y) + T_4^{\Sigma\Lambda}(x,y) + T_5^{\Sigma\Lambda}(x,y)) + (x \leftrightarrow y)]\}. \quad (44)$$

The expressions $T_i^{\Sigma\Lambda}(x,y)$ are obtained from the nucleon's $T_i(x,y)$, Table 8, by the replacement

$$\varphi_N(x) \to \varphi_\Sigma(x)\,, \quad \varphi_N(y) \to \varphi_\Lambda(y)\,,$$

$$T_N(x) \to \frac{f_\Sigma^T}{f_\Sigma} T_\Sigma(x)\,, \quad T_N(y) \to \frac{f_\Lambda^T}{f_\Lambda} T_\Lambda(y)\,. \quad (45)$$

The term $(x \leftrightarrow y)$ in (44) means the replacement of denominators in the expressions for $T_i(x,y)$ in Table 8: $(1/D_i(x,y)) \to (1/D_i(y,x))$. Substituting into (44) and (45) the Σ- and Λ-hyperon wave functions, one obtains

$$Q^4 F_{\Sigma\Lambda}(Q^2) \simeq 0.54\,\text{GeV}^4, \quad I_{\Sigma\Lambda} \simeq 0.9\cdot 10^5,$$

$$-F_{\Sigma\Lambda}(Q^2)/\sqrt{3}\, F_\Lambda(Q^2) \simeq 1.35\,. \quad (46)$$

In the SU(3)-limit: $F_{\Sigma\Lambda}(Q^2) = \sqrt{3}\, F_{\Sigma^0}(Q^2) = -\sqrt{3}\, F_\Lambda(Q^2)$.

6. DISCUSSION

Comparing the sum rules for the nucleon wave function [1] with those for the hyperon ones (see above) we see that SU(3)-symmetry breaking terms give considerable contributions into sum rules (typically $\simeq 20 \div 40\%$). These terms determine corrections to the spectral densities in the corresponding correlators. One should remember however, that these are the total symmetry breaking contributions. These summary contributions describe both effects due to changes in hadron masses and changes of their wave functions. For this reason, it is possible that large symmetry-breaking corrections in the right (theoretical) part of sum rules describe mainly the effects due to changes of hyperon masses (as compared with the nucleon mass), while changes in the hyperon wave functions can be considerably smaller.

As one can see from the previous sections, just this case is realized in sum rules which determine the values of the hyperon wave functions at the origin (the constants f_i). In spite of that symmetry-breaking contributions are not small in these sum rules, but values of the hyperon wave functions at the origin remain nearly the same as in the SU(3)-symmetry limit:

$$f_N \simeq 0.5\cdot 10^{-2}\,\text{GeV}^2, \quad f_\Sigma \simeq 0.51\cdot 10^{-2}\,\text{GeV}^2, \quad f_\Xi \simeq 0.53\cdot 10^{-2}\,\text{GeV}^2.$$

At the same time, the form of the dimensionless wave function $\varphi_i(x)$ changes considerably. Let us consider, for example, the following components of wave functions:

$$|P^\uparrow\rangle \to |u^\uparrow(x_1)\, u^\downarrow(x_2)\, d^\uparrow(x_3)\rangle,$$

$$|\Sigma^\uparrow\rangle \to |u^\uparrow(x_1)\, u^\downarrow(x_2)\, s^\uparrow(x_3)\rangle,$$

$$|\Xi^{\uparrow}\rangle \to |s^{\uparrow}(x_1)\, s^{\downarrow}(x_2)\, d^{\uparrow}(x_3)\rangle,$$

and compare the values of their first moments:

$$|P\rangle:\{\langle x_1\rangle:\langle x_2\rangle:\langle x_3\rangle \simeq (58:19:23)\,\%\}, \tag{47}$$

$$|\Sigma\rangle:\{\langle x_1\rangle:\langle x_2\rangle:\langle x_3\rangle \simeq (54:16:30)\,\%\}, \tag{48}$$

$$|\Xi\rangle:\{\langle x_1\rangle:\langle x_2\rangle:\langle x_3\rangle \simeq (58:23:19)\,\%\}. \tag{49}$$

Comparing (47) with (48) we see that when d-quark in the proton is replaced by s-quark of the Σ-hyperon the momentum fraction it carries out increases. This is characteristic for the meson wave functions also [4]. It is interesting that after replacement of two proton u-quarks by two Ξ-hyperon s-quarks, the momentum fractions carried by three quarks remained the same, but the second and third quark exchanged their momentum fractions.

The calculation of the hyperon electromagnetic formfactors has shown that typical SU(3)-symmetry breaking effects are $\simeq 10 \div 30\%$ (all the ratios (50) are equal to unity in the SU(3)-limit):

$$\frac{F_1^{\Sigma^+}}{F_1^{p}} \simeq 1.25\,; \quad \frac{-2F_1^{\Sigma^0}}{F_1^{n}} \simeq 1.21\,; \quad \frac{F_1^{\Xi^0}}{F_1^{n}} \simeq 1.15\,; \quad \frac{F_1^{\Xi^-}}{F_1^{\Sigma^-}} \simeq 0.92\,;$$

$$\frac{2F_1^{\Lambda}}{F_1^{n}} \simeq 1.03\,; \quad \frac{-F_1^{\Lambda}}{F_1^{\Sigma^0}} \simeq 0.85\,; \quad \frac{-F_1^{\Sigma\Lambda}}{\sqrt{3}\;F_1^{\Lambda}} \simeq 1.35\,; \tag{50}$$

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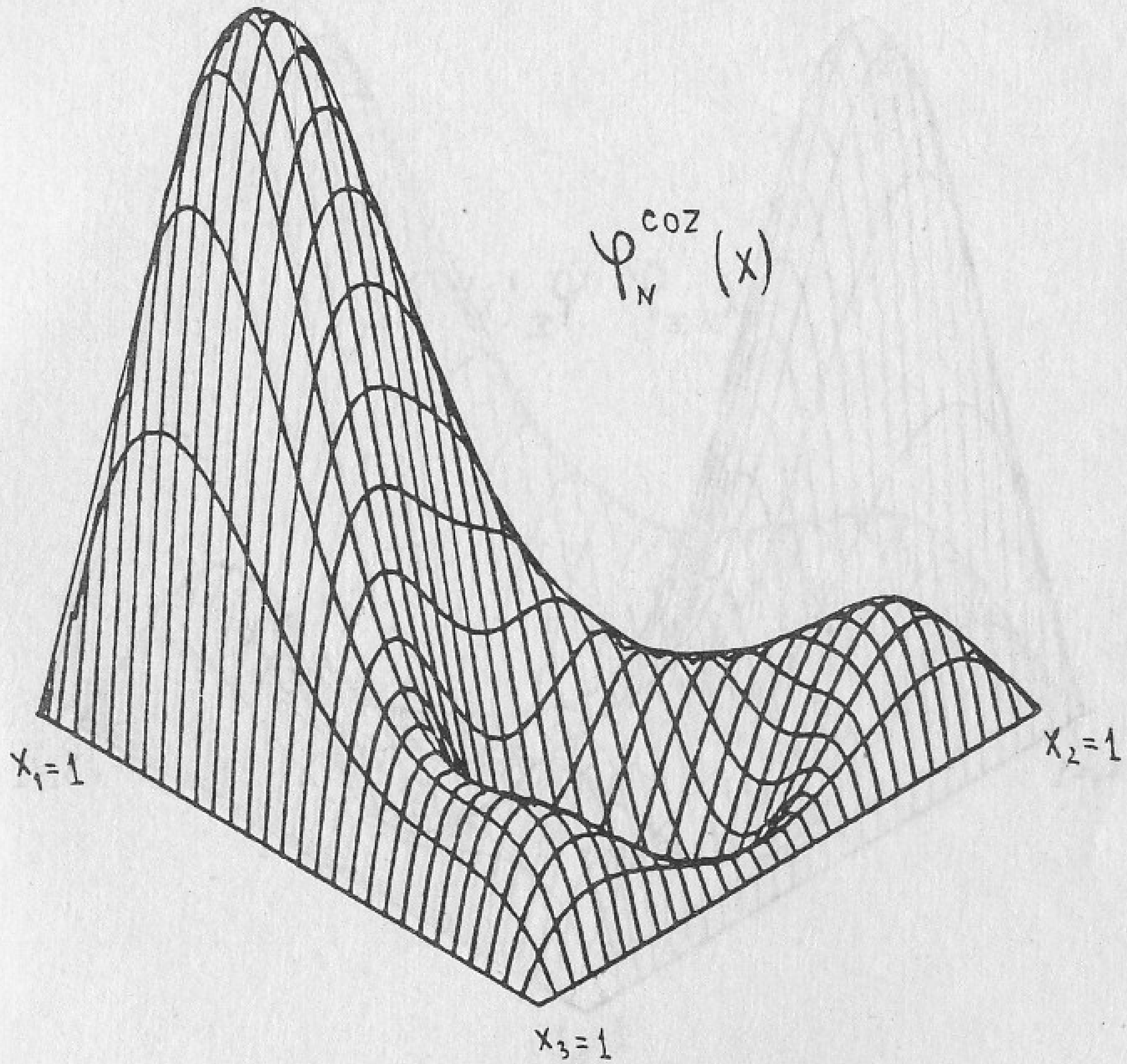


Fig. 7.

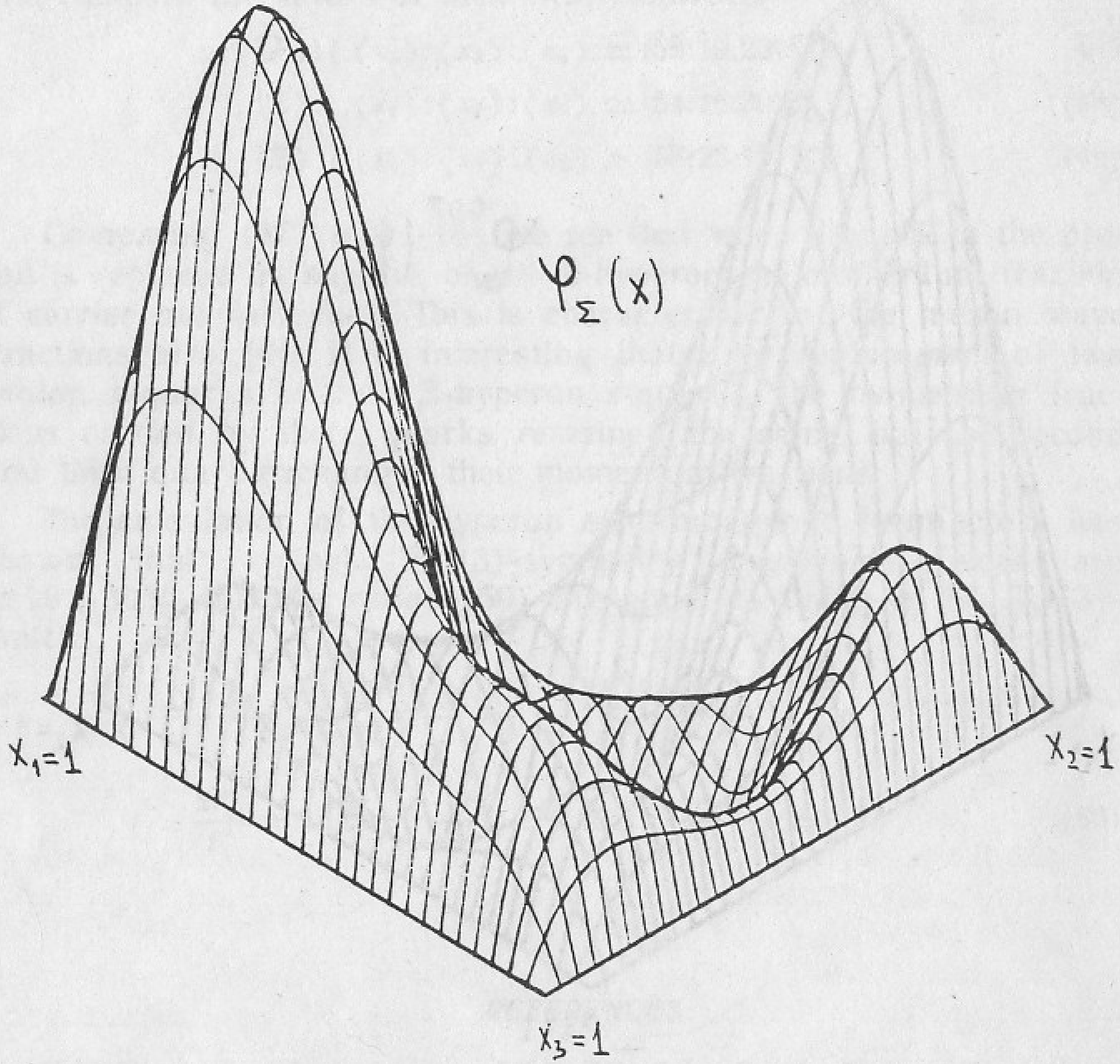


Fig. 8.

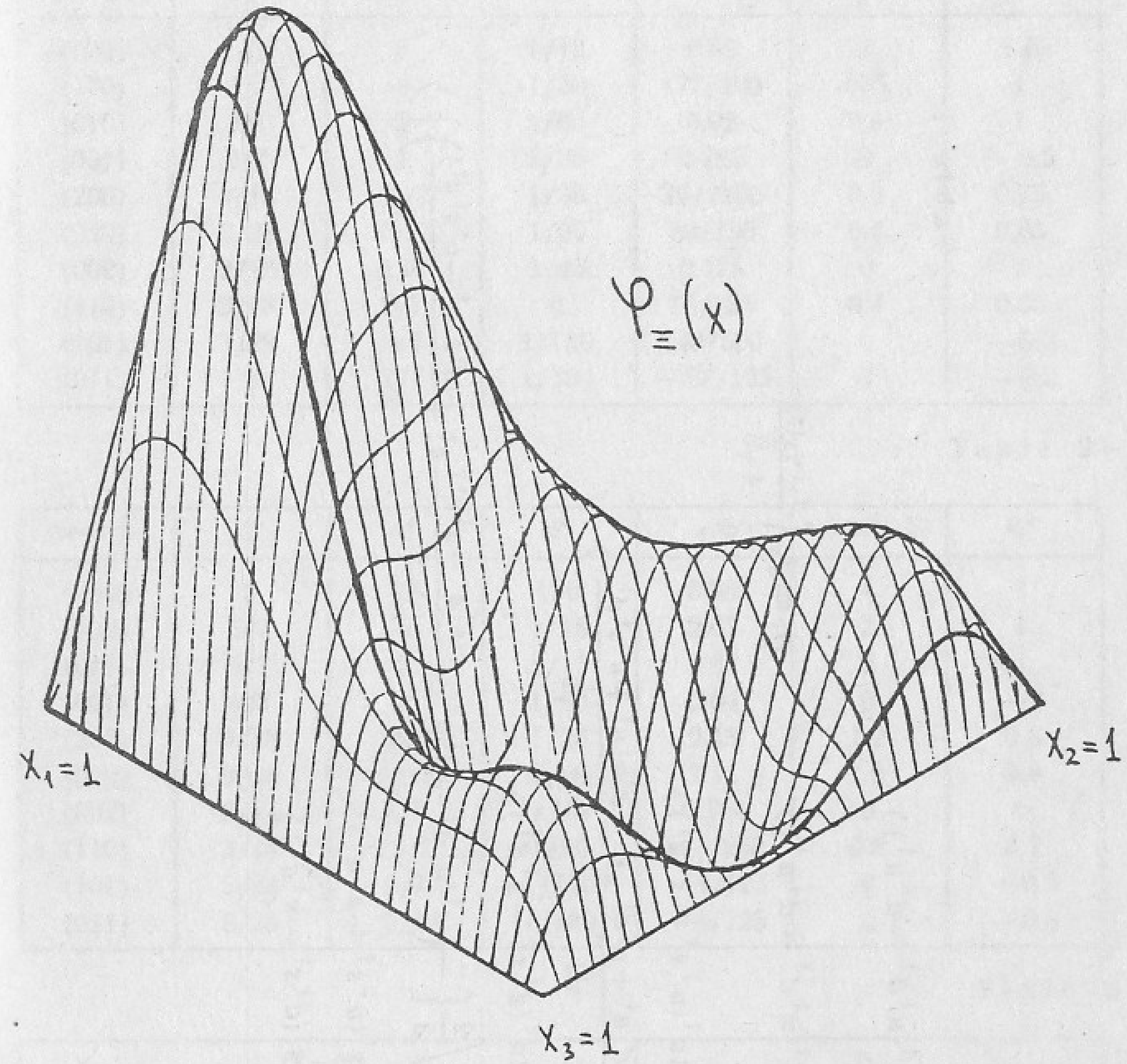


Fig. 9.

Table 1

$$|p\rangle = A_0\cdot|u^\uparrow(u^\downarrow d^\uparrow - d^\downarrow u^\uparrow)\rangle$$

$$|n\rangle = A_0\cdot|d^\uparrow(u^\downarrow d^\uparrow - d^\downarrow u^\uparrow)\rangle \qquad A_0 \equiv f_N\int_0^1 \frac{d_3x\,\varphi_N(x)}{4\sqrt{6}}$$

$$|\Sigma^+\rangle = A_0\cdot|u^\uparrow(u^\downarrow s^\uparrow - s^\downarrow u^\uparrow)\rangle$$

$$|\Sigma^0\rangle = A_0\cdot\left|\frac{d^\uparrow u^\downarrow + u^\uparrow d^\downarrow}{\sqrt{2}}s^\uparrow - \frac{d^\uparrow s^\downarrow u^\uparrow + u^\uparrow s^\downarrow d^\uparrow}{\sqrt{2}}\right\rangle$$

$$|\Sigma^-\rangle = A_0\cdot|d^\uparrow(d^\downarrow s^\uparrow - s^\downarrow d^\uparrow)\rangle$$

$$|\Lambda^0\rangle = A_0\left|-\sqrt{\frac{2}{3}}\left\{-\left(s^\uparrow(u^\downarrow d^\uparrow - d^\downarrow u^\uparrow) + \frac{(u^\uparrow d^\downarrow - d^\uparrow u^\downarrow)}{2}s^\uparrow + \frac{(d^\uparrow s^\downarrow u^\uparrow - u^\uparrow s^\downarrow d^\uparrow)}{2}\right)\right\}\right\rangle$$

$$|\Xi^0\rangle = A_0\cdot|s^\uparrow(u^\downarrow s^\uparrow - s^\downarrow u^\uparrow)\rangle$$

$$|\Xi^-\rangle = A_0\cdot|s^\uparrow(d^\downarrow s^\uparrow - s^\downarrow d^\uparrow)\rangle$$

Table 2a

Moments	$\gamma_1^{(n)}$	$\gamma_2^{(n)}$	$\gamma_3^{(n)}$	$\gamma_4^{(n)}$	$\gamma_5^{(n)}$	$\gamma_6^{(n)}$
(000)	1	6	1/12	2.69	2	1.5
(100)	3/7	3	1/30	477/200	6/5	1
(010)	2/7	2	1/60	0.02	0.8	1
(001)	2/7	1	1/30	0.285	0	−0.5
(200)	3/14	12/7	1/36	391/200	0.8	0.75
(020)	3/28	6/7	1/90	39/750	0.4	0.65
(002)	3/28	2/7	1/45	0.175	0	0
(110)	3/28	6/7	0	18/125	0.4	0.55
(101)	3/28	3/7	1/180	143/500	0	−0.3
(011)	1/14	2/7	1/180	−22/125	0	−0.2

Table 2b

Moments	$\kappa_1^{(n)}$	$\kappa_2^{(n)}$	$\kappa_3^{(n)}$	$\kappa_4^{(n)}$	$\kappa_5^{(n)}$	$\kappa_6^{(n)}$
(000)	2	12	1/6	5.38	4	1
(100)	5/7	5	1/15	2.67	2	1
(010)	5/7	5	1/15	2.67	2	1
(001)	4/7	2	1/30	0.04	0	−1
(200)	9/28	18/7	1/20	2.13	1.2	0.8
(020)	9/28	18/7	1/20	2.13	1.2	0.8
(002)	3/14	4/7	1/45	0.104	0	0
(110)	3/14	12/7	1/90	143/250	0.8	0.7
(101)	5/28	5/7	1/180	−4/125	0	−0.5
(011)	5/28	5/7	1/180	−4/125	0	−0.5

Table 3

	$(V-A)_\Sigma$			T_Σ		
Moments	Sum Rules	Best Fit	Model	Sum Rules	Best Fit	Model
(000)	1	1	1	1	1	1
(100)	0.50−0.64	0.58	0.54	0.31−0.43	0.37	0.375
(010)	0.10−0.17	0.13	0.16	0.31−0.43	0.37	0.375
(001)	0.24−0.32	0.28	0.30	—	—	0.25
(200)	0.31−0.38	0.34	0.345	0.19−0.25	0.22	0.22
(020)	0.05−0.08	0.07	0.055	0.19−0.25	0.22	0.22
(002)	0.13−0.165	0.15	0.14	0.10−0.13	0.12	0.11
(110)	0.05−0.08	0.07	0.07	0.06−0.09	0.07	0.085
(101)	0.10−0.13	0.10	0.125	—	—	0.07
(011)	—	—	0.035	—	—	0.07

Table 4a

Moments	$\delta_1^{(n)}$	$\delta_2^{(n)}$	$\delta_3^{(n)}$	$\delta_4^{(n)}$	$\delta_5^{(n)}$	$\delta_6^{(n)}$
(000)	1	9	1/12	2.78	2	0.5
(100)	3/7	4	1/30	2.37	1.2	1
(010)	2/7	2	1/60	0.17	0	−1
(001)	2/7	3	1/30	0.24	0.8	0.5
(200)	3/14	15/7	1/36	973/500	0.8	0.75
(020)	3/28	5/7	1/90	53/500	0	−0.3
(002)	3/28	9/7	1/45	23/125	0.4	0.35
(110)	3/28	5/7	0	27/125	0	−0.3
(101)	3/28	8/7	1/180	26/125	0.4	0.55
(011)	1/14	4/7	1/180	-57/375	0	−0.4

Table 4b

Moments	$\rho_1^{(n)}$	$\rho_2^{(n)}$	$\rho_3^{(n)}$	$\rho_4^{(n)}$	$\rho_5^{(n)}$	$\rho_6^{(n)}$
(000)	2	18	1/6	5.56	4	2
(100)	5/7	6	1/15	2.61	1.2	0.25
(010)	5/7	6	1/15	2.61	1.2	0.25
(001)	4/7	6	1/30	0.34	1.6	1.5
(200)	9/28	20/7	1/20	2.13	0.8	0.6
(020)	9/28	20/7	1/20	2.13	0.8	0.6
(002)	3/14	18/7	1/45	53/250	0.8	1
(110)	3/14	10/7	1/90	0.416	0	−0.6
(101)	5/28	12/7	1/180	0.064	0.4	0.25
(011)	5/28	12/7	1/180	0.064	0.4	0.25

Table 5

	$(V-A)_\Xi$			T_Ξ		
Moments	Sum Rules	Best Fit	Model	Sum Rules	Best Fit	Model
(000)	1	1	1	1	1	1
(100)	0.53−0.66	0.60	0.58	0.36−0.46	0.41	0.415
(010)	—	—	0.23	0.36−0.46	0.41	0.415
(001)	0.12−0.20	0.16	0.19	0.11−0.18	0.14	0.17
(200)	0.33−0.40	0.37	0.37	0.22−0.27	0.25	0.24
(020)	—	—	0.10	0.22−0.27	0.25	0.24
(002)	0.07−0.10	0.09	0.07	0.05−0.08	0.07	0.06
(110)	0.08−0.12	0.10	0.11	0.09−0.12	0.105	0.12
(101)	0.07−0.11	0.09	0.10	—	—	0.055
(011)	—	—	0.02	—	—	0.055

Table 6a

Moments	$\varepsilon_1^{(n)}$	$\varepsilon_2^{(n)}$	$\varepsilon_3^{(n)}$	$\varepsilon_4^{(n)}$	$\varepsilon_5^{(n)}$	$\varepsilon_6^{(n)}$
(000)	3	12	1/4	10.23	2	−1/2
(100)	1	5	1/10	3.405	6/5	0
(010)	6/7	4	1/20	0.39	4/5	0
(001)	8/7	3	1/10	6.435	0	−1/2
(200)	3/7	18/7	13/180	2.617	4/5	3/20
(020)	9/28	12/7	1/30	0.324	2/5	1/20
(002)	15/28	8/7	7/90	5.165	0	0
(110)	1/4	10/7	1/90	-0.208	2/5	3/20
(101)	9/28	1	1/60	0.996	0	−3/10
(011)	2/7	6/7	1/180	0.274	0	−1/5

Table 6b

	$(V-A)_\Lambda$		
Moments	Sum Rules	Best Fit	Model
(000)	1	1	1
(100)	0.27−0.34	0.31	0.31
(010)	—	—	0.17
(001)	0.48−0.57	0.52	0.52
(200)	0.16−0.18	0.17	0.18
(020)	0.06−0.08	0.07	0.06
(002)	0.28−0.35	0.31	0.32
(110)	—	—	0.02
(101)	0.09−0.12	0.11	0.11
(011)	—	—	0.09

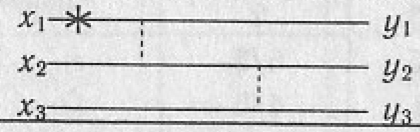
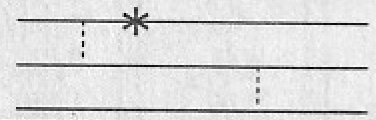
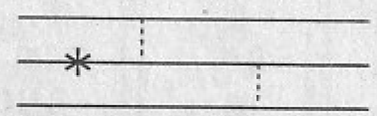
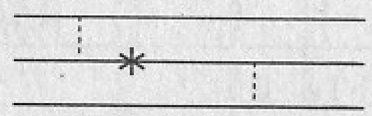
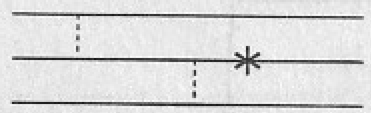
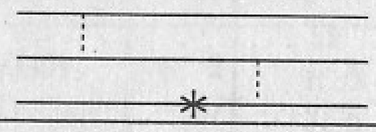
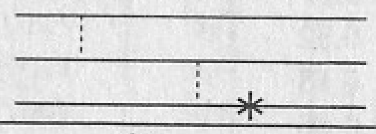
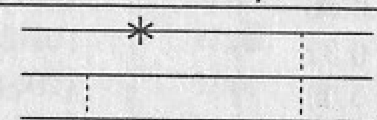
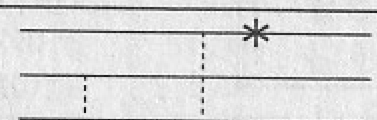
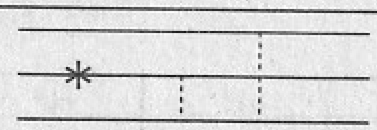
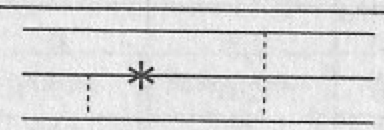
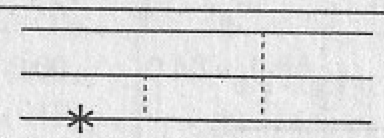
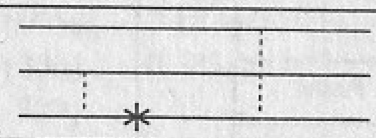
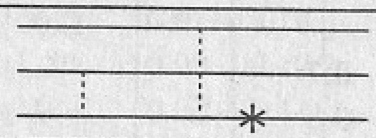
Table 7a

Moments	$\sigma_1^{(n)}$	$\sigma_2^{(n)}$	$\sigma_3^{(n)}$	$\sigma_4^{(n)}$	$\sigma_5^{(n)}$	$\sigma_6^{(n)}$
(100)	2/7	2	0	707/150	2/5	0
(200)	3/14	12/7	1/90	949/250	2/5	−1/5
(101)	1/14	2/7	−1/90	344/375	0	1/5

Table 7b

	T_Λ		
Moments	Sum Rules	Best Fit	Model
(100)	1	1	1
(200)	0.65−0.82	—	0.7
(101)	0.27−0.34	—	0.3

Table 8

i	Diagram	$T_i(x, y)$
1		$\frac{(V(x)-A(x))(\dot{V}(y)-\dot{A}(y))+4\,T(x)\dot{T}(y)}{(1-x_1)^2x_3(1-y_1)^2y_3}$
2		0
3		$\frac{-4\,T(x)\dot{T}(y)}{x_1(1-x_2)\,x_3y_1(1-y_1)\,y_3}$
4		$\frac{(V(x)-A(x))(\dot{V}(y)-\dot{A}(y))}{x_1x_3(1-x_3)\,y_1(1-y_1)\,y_3}$
5		$\frac{-(V(x)+A(x))(\dot{V}(y)+\dot{A}(y))}{x_1x_3(1-x_3)\,y_1(1-y_2)\,y_3}$
6		0
7		$\frac{(V(x)-A(x))(\dot{V}(y)-\dot{A}(y))+(V(x)+A(x))(\dot{V}(y)+\dot{A}(y))}{x_1(1-x_3)^2y_1(1-y_3)^2}$
8		0
9		$\frac{(V(x)-A(x))(\dot{V}(y)-\dot{A}(y))+4\,T(x)\dot{T}(y)}{(1-x_1)^2x_2(1-y_1)^2y_2}$
10		$\frac{(V(x)+A(x))(\dot{V}(y)+\dot{A}(y))+4\,T(x)\dot{T}(y)}{x_1(1-x_2)^2y_1(1-y_2)^2}$
11		0
12		$\frac{-(V(x)+A(x))(\dot{V}(y)+\dot{A}(y))}{x_1x_2(1-x_3)\,y_1y_2(1-y_2)}$
13		$\frac{4\,T(x)\dot{T}(y)}{x_1(1-x_1)\,x_2y_1y_2(1-y_2)}$
14		$\frac{-(V(x)-A(x))(\dot{V}(y)-\dot{A}(y))}{x_1(1-x_1)\,x_2y_1y_2(1-y_3)}$

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