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I.G.AZNAURYAN, N.L.TER-ISAAKYAN

ON THF ROLE OF THE QUARK ANOMALOUS MAGNETIC MOMENTS IN THE MAGNETIC DIPOLE TRANSITIONS OF HADRONS

ԵՐԵՎԱՆ 1980 ЕРЕВАН

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И.Г.АЗНАУРЯН, Н.Л.ТЕР-ИСААКЯН

О РОЛИ АНОМАЛЬНЫХ МАГНИТНЫХ МОМЕНТОВ КВАРКОВ В МАГНИТНО-ДИПОЛЬНЫХ ПЕРЕХОДАХ АДРОНОВ

Из данных по ширинам радиационных распадов векторных и псевдоскалярных мезонов, а также магнитных моментов барионов с учетом релятивистских эффектов получены оценки на аномальные магнитные моменты составляющих кварков. Показано, что из этих данных однозначно следует наличие у u - и d -кварков отрицательного аномального магнитного момента, не пропорционального их зарядам, на уровне 3-6% от нормального магнитного момента u -кварка. Величины же пропорционального заряду аномального магнитного момента u и d -кварков и аномального магнитного момента s -кварка при имеющихся экспериментальных данных оказываются плохо определенными.

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The estimates on constituent quarks anomalous magnetic moments are obtained from the data on vector and pseudoscalar mesons radiative decays and baryon magnetic moments, taking into account relativistic effects. It is shown that from these data unambiguously follows the negative value of anomalous magnetic moment of u- and d-quarks nonproportional to their charges at nearly 3-6% level of the u-quark normal magnetic moment. The values of u- and d-quarks anomalous magnetic moments proportional to their charges and anomalous magnetic moment of s-quark turned out to be badly defined from experimental data available.

Yerevan Physics Institute

Yerevan 1980

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1. Introduction

The quark model, both the non-relativistic (see, e.g. [1]) and the relativistic [2], meets with some difficulties when applied to the description of the radiative decays of vector mesons. The disagreement with the experimental data are particularly important for the ratio of the $\rho \to \pi\gamma$ and $\omega \to \pi\gamma$ decay widths, since in this case the initial and final states coincide in mass and spin and the discrepancy between theory and experiment cannot be attributed to the difficulties in the description of these states.

In the previous work we have shown that the experimental data on the ratio of the $\rho(\omega) \to \pi\gamma$ decay widths can be explained in the framework of the two-quark model, if u- and d-quarks are assumed to have anomalous magnetic moment not proportional to their charges (we denote it by $\tilde{\mu}$). Such a magnetic moment naturally arises in the chromodynamics owing to the Fig.1 type diagrams in which a photon interacts with a quark from the quark loop.

The value of $\tilde{\mu}$ was estimated in Ref. [3] from the $\rho(\omega) \to \pi\gamma$ data in the nonrelativistic approximation. The anomalous magnetic moment $\tilde{\mu}$ spoils slightly the agreement between theory and experiment for the ratio of proton and neutron magnetic moments in the naive quark model. In Ref. [3] it was suggested that this discrepancy was connected with the nonrelativistic approximation and that the $\rho(\omega)\to\pi\gamma$ data and nucleon magnetic moments could be described simultaneously taking into account the relativistic effects.

The possibility of describing both $\rho(\omega)\to\pi\gamma$ and $K^*\to K\gamma$ decays widths ratios in the additive quark model introducing quark anomalous magnetic moments was considered in Ref. [4] as well. It was shown there that the anomalous magnetic moments necessary for the description of $\rho(\omega)\to\pi\gamma$ and $K^{*0}\to K^0\gamma$ data bring to the difficulties in the description of both baryon (p, n, Λ) magnetic moments and the other radiative decay widths.

In the present work the relativistic effects are investigated in the framework of the model derived in Refs. [2,5,6].

It is shown that the relativistic description of the radiative decays of vector mesons results in increasing of the comparative weight of quark anomalous magnetic moments as compared to normal ones, so that the smaller than in nonrelativistic approximation value of $\tilde{\mu}$ is required for the description of the ratio $\Gamma(\rho\to\pi\gamma)/\Gamma(\omega\to\pi\gamma)$.

In the nucleon case it was found that the relativistic corrections cancelled the effects produced by anomalous magnetic moment $\tilde{\mu}$, and the simultaneous description of nucleon magnetic moments and $\rho(\omega)\to\pi\gamma$ decays ratio became

possible.

We have made the simultaneous description of the experimental data on the magnetic moments of the baryon octet taking into account the relativistic effects. It is found, independently of the meson data, that the data on the baryon magnetic moments bring to the nonzero value of $\tilde{\mu}$, which coincides with the estimate derived from $\omega(\rho)\to\pi\gamma$ (as well as $\eta'\to\rho(\omega)\gamma$) data by sign and order of magnitude.

The parts of anomalous magnetic moment of u- and d-quarks proportional to their charges $\mu(\mu_{u,d}=Q_{u,d}\,\mu+\tilde{\mu})$ and anomalous magnetic moment of s-quark turned out to be badly defined both from the independent description of baryon magnetic moments and the simultaneous analysis of baryon and meson data.

The difficulties arising in nonrelativistic description of $K^*\to K\gamma$ decays are not eliminated in the relativistic model. Moreover, it is shown that the data on $\omega\to\pi\gamma$, $K^{*0}\to K^0\gamma$ and $K^{*+}\to K^+\gamma$ cannot be simultaneously described if one doesn't assume the considerable difference in ω and K^* (or π and K) wave functions. The simultaneous description of $\rho(\omega)\to\pi\gamma$ and $K^{*0}\to K^0\gamma$ data and of the magnetic moments of Λ-hyperon and proton is found also impossible. It seems to us that most probably the above mentioned discrepancies arise due to the wrong experimental value of $\Gamma(K^{*0}\to K^0\gamma)$.

2. Magnetic-dipole decays of vector and pseudoscalar mesons.

We investigate the relativistic effects in mesons and baryons in the framework of the relativistic invariant model of bound states in the light cone dynamics, which was derived in Refs. [2,5,6]. The magnetic dipole transitions of hadrons in this model may be considered using only the $j_-(q_\perp)$ -component of electromagnetic current at $q_- = 0$, which has the form [6]:

$$j_-^a(q_\perp) = \left(eQ_a + i\frac{e\varkappa_a}{2m_a}\epsilon_{ik}\, q_{\perp i}\, \sigma_k\right) e^{-iq_\perp \tau_a}, \tag{1}$$

where a denotes the type of quark ($u, \dot{d}, s$), eQ_a, m_a and $e\frac{\varkappa_a}{2m_a}$ are quark charge, mass and anomalous magnetic moments, respectively.

Let us write the quark structure of the initial (M_i) and final (M_f) mesons in the form:

$$M_i = \frac{A\bar{a}b + B\bar{c}d}{\sqrt{A^2+B^2}}, \quad M_f = \frac{C\bar{a}b + D\bar{c}d}{\sqrt{C^2+D^2}}. \tag{2}$$

Then, in the approach of Refs. [2,5] we derive for the constants G connected with the vector and pseudoscalar mesons decay widths by the relations

$$\Gamma(V \to P\gamma) = \frac{G^2}{12\pi}\left(\frac{m_V^2 - m_P^2}{2m_V}\right)^3, \quad \Gamma(P \to V\gamma) = \frac{G^2}{4\pi}\left(\frac{m_P^2 - m_V^2}{2m_P}\right)^3 \tag{3}$$

the following expressions:

$$G = \frac{1}{\sqrt{(A^2+B^2)(C^2+D^2)}}\Big\{AC\big(Q_a g_{ab} + Q_b g_{ba} + \varkappa_a g'_{ab} + \varkappa_b g'_{ba}\big) + BD\big(Q_c g_{cd} + Q_d g_{dc} + \varkappa_c g'_{cd} + \varkappa_d g'_{dc}\big)\Big\}, \tag{4}$$

where

$$g_{ab} = \frac{e}{(2\pi)^3}\int\left\{1 - \frac{\varepsilon_a(M_0+m_a+m_b)}{2M_0(\varepsilon_b+m_b)}\left(1 - \frac{m_a^2}{2\kappa\varepsilon_a}\ln\frac{\varepsilon_a+\kappa}{\varepsilon_a-\kappa}\right) + \frac{m_a}{2\kappa}\ln\frac{\varepsilon_a+\kappa}{\varepsilon_a-\kappa}\right\}\frac{\kappa^2}{\varepsilon_a+m_a}\,\phi_i(\kappa^2)\,\phi_f^*(\kappa^2)\,d\kappa, \tag{5}$$

$$g'_{ab} = \frac{e}{(2\pi)^3}\int\left\{1 + \frac{m_a}{\varepsilon_a+m_a}\left(1 + \frac{\varepsilon_a m_a}{2\kappa\varepsilon_b}\ln\frac{\varepsilon_b+\kappa}{\varepsilon_b-\kappa}\right)\right\}\frac{\kappa^2}{2m_a}\cdot \phi_i(\kappa^2)\,\phi_f^*(\kappa^2)\,d\kappa, \tag{6}$$

$\varepsilon_i = \sqrt{m_i^2 + \kappa^2}$, $M_0 = \varepsilon_a + \varepsilon_b$, $\phi_{i,f}(\kappa^2)$ are the wave functions of the initial and final mesons, κ is the 3-momenta introduced in Ref. [2] (see also Ref. [7]), which characterizes the internal motion of quarks in the meson rest frame. The formula (5) at $a = b$ was obtained primarily in Ref. [2].

1. Let us consider the $\omega(\rho) \to \pi\gamma$, $\eta' \to \rho(\omega)\gamma$, $\rho(\omega) \to \eta\gamma$ decays. In order to obtain the simultaneous description of these data it is sufficient to describe the ratios

$$R_{\pi}=\frac{G^2(\omega\to\pi\gamma)}{G^2(\rho\to\pi\gamma)},\quad R_{\eta'}=\frac{G^2(\eta'\to\rho\gamma)}{G^2(\eta'\to\omega\gamma)},\quad R_{\eta}=\frac{G^2(\rho\to\eta\gamma)}{G^2(\omega\to\eta\gamma)} \qquad (7)$$

and the decay width $\Gamma(\omega\to\pi\gamma)$, since the decay ratios $R_1=\dfrac{G(\rho\to\eta\gamma)}{G(\omega\to\pi\gamma)}$ and $R_2=\dfrac{G(\eta'\to\rho\gamma)}{G(\omega\to\pi\gamma)}$ at close values of K_{eff} in π, η and η' are determined only by the mixing angle $\Theta_P\approx 11^\circ$ and are equal to

$$R_1=\frac{\cos\Theta_P+\sqrt{2}\sin\Theta_P}{\sqrt{3}}=0.73,\quad R_2=\frac{-\sin\Theta_P+\sqrt{2}\cos\Theta_P}{\sqrt{3}}=0.63 \qquad (8)$$

in good agreement with experimental data: $(R_1)_{exp}=0.69\pm0.09$ |8,9|, $(R_2)_{exp}<1.18$ |8|.

Let us single out in $\varkappa_u$ and $\varkappa_d$ the terms proportional and non-proportional to the charges of u- and d-quarks:

$$\varkappa_u=\frac{2}{3}\varkappa+\tilde{\varkappa},\qquad \varkappa_d=-\frac{1}{3}\varkappa+\tilde{\varkappa}. \qquad (9)$$

Assuming and making reasonable assumption $\phi_\rho(K^2)=\phi_\omega(K^2)$ we obtain independently of quarks internal motion: $R_{\pi}=R_{\eta'}=R_{\eta}=9$. This prediction for R_{π} contradicts the experimental data: $R_{\pi}=24.4\pm7.1$ [8,10], $R_{\pi}=17.4\pm3.7$ [8,11]. For $R_{\eta'}$ the discrepancy with experiment is less essential: $R_{\eta'}=12.4\pm2.5$ [8]. The experimental data on R_{η} contain large errors: $R_{\eta}=17.2^{+11.1}_{-14.9}$ [9].

In the framework of two-quark structure of mesons the equations $R_{\pi,\eta,\eta'}=9$ can be distorted only by introducing the anomalous magnetic moment $\tilde{\varkappa}$:

$$R_{\pi,\eta,\eta'}=9\left\{\frac{1+\varkappa\,\dfrac{g'_{uu}}{g_{uu}}}{1+(\varkappa+6\tilde{\varkappa})\dfrac{g'_{uu}}{g_{uu}}}\right\}^2. \qquad (10)$$

In non-relativistic approximation when the effective momenta K_{eff} in integrals (5,6) are of the order of zero we have $g_{uu}=g'_{uu}$ and from the data on $R_{\pi,\eta,\eta'}$ we obtain

$$\tilde{\varkappa}=-0.037\pm0.012 \qquad (11)$$

The ratio $\dfrac{g'_{uu}}{g_{uu}}$ increases with increasing of K_{eff} and the value of $\tilde{\varkappa}$ which is necessary for the description of experimental data decreases as compared to the nonrelativistic case.

2. Consider the decays $\omega\to\pi\gamma$ and $K^{*0,+}\to K^{0,+}\gamma$. In the nonrelativistic approximation one can obtain the following relation between the amplitudes of these decays

$$G(\omega\to\pi\gamma)+G(K^{*0}\to K^0\gamma)=G(K^{*+}\to K^+\gamma), \qquad (12)$$

which is independent of quark anomalous magnetic moments and contradicts the experimental data

$$G_{exp}(\omega\to\pi\gamma)=0.77\pm0.02\ \mathrm{GeV}^{-1}\ [8],$$
$$G_{exp}(K^{*0}\to K^0\gamma)=-0.31\pm0.07\ \mathrm{GeV}^{-1}\ [12], \qquad (13)$$
$$G_{exp}(K^{*+}\to K^+\gamma)<0.33\ \mathrm{GeV}^{-1}\ [13].$$

The relativistic corrections don't eliminate this disagreement, if the effective momenta of quarks both in K, π and K^*, ω are close to each other. The simultaneous description of $K^*\to K\gamma$ and $\omega\to\pi\gamma$ one can obtain only supposing that K_{ell} in $G(K^* \to K\gamma)$ are 50% - 70% larger than in $G(\omega \to \pi\gamma)$.

However, one must keep in mind that the experimental data on $K^{*0} \to K^0\gamma$ contain large errors and the discrepancy between theory and experiment may be easily eliminated by taking the two standard deviations larger value of $|G_{exp}(K^{*0} \to K^0\gamma)|$.

Let us also note the following fact. In Ref.[4] the relation

$$\frac{\mu(\Lambda)}{\mu(p)} = \frac{2G(K^{*0} \to K^0\gamma) + G(\omega \to \pi\gamma) - G(\rho \to \pi\gamma)}{G(\rho \to \pi\gamma) + \frac{5}{3}G(\omega \to \pi\gamma)} \qquad (14)$$

was obtained in non-relativistic approximation.

Using the experimental data (13) and the data on $\rho \to \pi\gamma$: $G_{exp}(\rho \to \pi\gamma) = 0.16 \pm 0.02\ GeV^{-1}$ [10] or $G_{exp}(\rho \to \pi\gamma) = 0.19 \pm 0.02\ GeV^{-1}$ [11], we find from (14) the following predictions for $\frac{\mu(\Lambda)}{\mu(p)}$: -0.01 ± 0.1 or -0.03 ± 0.1. The both predictions contradict the experimental value of -0.220 ± 0.002 [14].

The relativistic correction doesn't improve the situation, but in this case also the discrepancy may be eliminated by taking the two standard deviations larger value of $|G_{exp}(K^{*0} \to K^0\gamma)|$. At the same time one has to increase the values of $G_{exp}(\rho \to \pi\gamma)$[11] by 19 standard deviations or to decrease the value of $G_{exp}(\omega \to \pi\gamma)$ by 11 standard deviations if one wants to eliminate the discrepancy between theory and experiment by changing $G_{exp}(\rho \to \pi\gamma)$ or $G_{exp}(\omega \to \pi\gamma)$.

Thus it is reasonable to assume that the experimental data on $\Gamma(K^{*0} \to K^0\gamma)$ are incorrect and new, more precise,

experiments are needed.

Note, that these data were obtained in indirect way using the Primakoff effect in the reaction $K^0 Z \to K^{*0} Z$.

Thus it is sufficient to consider only the ratios R_π, R_η, $R_{\eta'}$ and the data on $\omega \to \pi\gamma$; $K^{*0,+} \to K^{0,+}\gamma$ and $\varphi \to \eta\gamma$ decays, when one makes the quantitative analysis of the data on vector and pseudoscalar meson radiative decays, since the predictions for other decays are determined only by the mixing angles Θ_V and Θ_P. We don't consider the data on VDM-constants, and the constant f_π of $\pi \to \mu\nu$ decay, so long as the expressions both for the electromagnetic current (1), and the quark axial current do not allow the continuation in the time-like region, and the method under consideration cannot be used, generally speaking, to derive these constants.

The data on R_π, R_η, $R_{\eta'}$ ratios determine the value of $\tilde{\varkappa}$, while the data on $\omega \to \pi\gamma$, $K^{*0,+} \to K^{0,+}\gamma$ and $\varphi \to \eta\gamma$ decays turned out to be insufficient to determine the other quantities, which are necessary to describe the data. For this reason in the next section we shall make a simultaneous analysis of these data and the data on the baryon magnetic moments.

3. The baryon magnetic moments.

We use the method derived in Ref.6 to calculate the baryon magnetic moments in the relativistic quark model [2,5,6]. Making calculations we suppose that the baryon wave functions depend only on one variable - the quarks invariant mass M_0.

Such an assumption allows to make some replacements of integration variables, which considerably simplify the results. We obtained the following expressions for baryon anomalous magnetic moments:

$$\frac{\varkappa_p}{2M_p}=\frac{2X_1+Z_1(4\varkappa_u-\varkappa_d)}{6m}, \tag{14.1}$$

$$\frac{\varkappa_n}{2M_n}=\frac{-2Y_1+Z_1(4\varkappa_d-\varkappa_u)}{6m}, \tag{14.2}$$

$$\frac{\varkappa_{\Sigma^+}}{2M_{\Sigma^+}}=\frac{1}{3}\left(\frac{4X_2\frac{m+m_s}{2m}-X_3\frac{m}{m_s}}{2m+m_s}-\frac{2Y_2}{3m}+\frac{2Y_3}{3m_s}\right)+\frac{4Z_2\varkappa_u-Z_3\varkappa_s\frac{m}{m_s}}{6m}, \tag{14.3}$$

$$\frac{\varkappa_{\Sigma^-}}{2M_{\Sigma^-}}=\frac{1}{3}\left(\frac{X_3\frac{m}{m_s}-4X_2\frac{m+m_s}{2m}}{}+\frac{4Y_2}{3m}-\frac{Y_3}{3m_s}\right)+\frac{4Z_2\varkappa_d-Z_3\varkappa_s\frac{m}{m_s}}{6m}, \tag{14.4}$$

$$\frac{\varkappa_\Lambda}{2M_\Lambda}=\frac{-Y_3+3Z_3\varkappa_s}{6m_s}, \tag{14.5}$$

$$\frac{\varkappa_{\Sigma\Lambda}}{M_\Sigma+M_\Lambda}=\frac{\sqrt{3}}{6m}\left[Y_2+Z_2(\varkappa_u-\varkappa_d)\right], \tag{14.6}$$

$$\frac{\varkappa_{\Xi^0}}{2M_{\Xi^0}}=-\frac{1}{9m_s}\left(2\tilde{Y}_2+\frac{m_s}{m}\tilde{Y}_3\right)+\frac{4\varkappa_s\tilde{Z}_2-\varkappa_u\tilde{Z}_3\frac{m_s}{m}}{6m_s}, \tag{14.7}$$

$$\frac{\varkappa_{\Xi^-}}{2M_{\Xi^-}}=\frac{1}{3}\left(\frac{\tilde{X}_3\frac{m_s}{m}-2\tilde{X}_2\frac{m+m_s}{m_s}}{2m_s+m}+\frac{4\tilde{Y}_2}{3m_s}-\frac{\tilde{Y}_3}{3m}\right)+\frac{4\varkappa_s\tilde{Z}_2-Z_3\varkappa_d\frac{m_s}{m}}{6m_s}. \tag{14.8}$$

The Eqs.(14.1) and (14.2) were primarily obtained in Ref./6/ in the case of zero anomalous magnetic moments of

quarks. The values of X_i, Y_i, Z_i $(i=1,2,3)$ are determined by the quark effective momenta in baryons and are equal to unity in the non-relativistic limit. The expressions for X_i, Y_i, Z_i are given in Appendix. $\tilde{X}_i$, $\tilde{Y}_i$ and $\tilde{Z}_i$ can be obtained from X_i, Y_i, Z_i by replacements of $m \rightleftarrows m_s$.

It is well known that the naive quark model predictions are in good agreement with experimental data. Therefore, considering the relativistic effects in nucleons we assume that the effective momenta in X_i, Y_i, Z_i -integrals are small enough and expand the integrands of X_i, Y_i, Z_i in q_i^2/m^2 and $\frac{Q_i^2}{m^2}$ power series, keeping only two first terms (Eq. A.4 of Appendix).

The further calculations we made for the following type of baryon wave functions:

$$\phi_B(M_{oi}^2)=N_i\exp\left\{-\frac{M_{oi}^2}{2\Lambda_B^2}\right\}, \tag{15}$$

where N_i is a normalizing factor, the parameter Λ_B is common for all baryons of the octet. It is easy to see from the M_{oi} expansion in $\frac{q^2}{m^2}$, $\frac{Q^2}{m^2}$ power series, that the mean-square values of quark momenta can be expressed through quark mean-square momentum in nucleon $\bar{q}_1^2\equiv q^2$. The connection between $\bar{q}_i^2$, $\bar{Q}_i^2$ and q_1^2 depends on the concrete form of the M_{oi}^2-dependence of baryon wave function. For the wave function (15) the expansions of X_i, Y_i and Z_i in $\frac{q^2}{m^2}$ power series take the form:

$$X_1 = 1 - \frac{4}{9}\frac{q^2}{m^2}, \quad Y_1 = 1 - \frac{5}{9}\frac{q^2}{m^2}, \quad Z_1 = 1 - \frac{2}{9}\frac{q^2}{m^2},$$

$$X_2 = 1 + \frac{q^2}{m^2}\cdot\frac{2m^2}{(2m+m_s)^2}\left(\frac{m}{m+m_s} - \frac{5m+2m_s}{6m}\right),$$

$$Y_2 = 1 - \frac{q^2}{m^2}\frac{2mm_s}{(2m+m_s)^2}\left(1+\frac{3m}{2m_s}\right), \tag{16}$$

$$Z_2 = 1 - \frac{q^2}{m^2}\frac{(m+m_s)m}{(2m+m_s)^2},$$

$$X_3 = 1 + \frac{q^2}{m^2}\frac{3mm_s}{(2m+m_s)^2}\left(1 - \frac{m}{m_s} - \frac{4m^2}{3m_s^2}\right),$$

$$Y_3 = 1 - \frac{q^2}{m^2}\left(\frac{m}{2m+m_s}\right)^2\left(1+4\frac{m}{m_s}\right), \quad Z_3 = 1 - \frac{q^2}{m^2}\frac{2m^3}{m_s(2m+m_s)^2}.$$

From Eqs.(16) assuming that quark anomalous magnetic moments are small enough, we obtain for the ratio of proton and neutron anomalous magnetic moments:

$$\frac{\varkappa_p}{\varkappa_n} = -\left(1 + \frac{q^2}{9m^2} + \frac{\varkappa}{2} + 3\tilde{\varkappa}\right). \tag{17}$$

The experimental value of this ratio -0.94 disagrees with the prediction (17) in the case of $\varkappa = \tilde{\varkappa} = 0$. The relativistic corrections increase the disagreement. Moreover, the exact calculations show that Eq.(17) correctly reflects the $\frac{q^2}{m^2}$ dependence of $\frac{\varkappa_p}{\varkappa_n}$, and the situation remains unchanged when no assumption about smallness of $\frac{q^2}{m^2}$ is done. So in the model under consideration it is impossible to improve the agreement between theory and experiment for the $\frac{\varkappa_p}{\varkappa_n}$ ratio without introducing quark anomalous magnetic moments. It is interesting that the value $\tilde{\varkappa}$ (10), which was obtained from the meson data changes the ratio (17) into the wanted side.

It is difficult to analyze qualitatively the equations for the other baryons because of large experimental errors and rather complicated dependence on the parameters. Therefore we shall give below the results of the quantitative analysis.

Using Eqs.(14-16) for baryon magnetic moments and Eqs.(3-6) for radiative decays of mesons we made the least square fit of the experimental data available. Keeping in mind that the constituent quark parameters could differ slightly in mesons and nucleons we made both the combined analysis of meson and baryon data and the independent analysis of the baryon magnetic moments data. The meson wave function we suppose to have a form analogous to (15)

$$\Phi_M(M_0^2) = N\exp\left\{-\frac{M_0^2}{2\Lambda_M^2}\right\}, \tag{18}$$

where parameter Λ_M is common for the nonets of vector and pseudoscalar mesons. For nonstrange mesons this parameter can be connected with the mean-square quark momentum in meson: $\langle q^2\rangle_M = \frac{3}{8}\Lambda_M^2$. The results are presented in Tables 1 and 2. The results of the independent analysis of baryon data (I) and combined analysis of meson and baryon data (II) are given in the second and third lines, respectively.

Let us discuss the results obtained. The anomalous magnetic moment $\tilde{\varkappa}$, as has been shown in Section 2, is well defined from $\omega(\rho)\to\pi\gamma$ and $\eta'\to\rho(\omega)\gamma$ data. The value of from independent fit of baryon magnetic moments contains large errors, but coincides by sign and order of magnitude with estimate derived from $\omega(\rho)\to\pi\gamma$, $\eta'\to\rho(\omega)\gamma$ data. The anomalous magnetic moments $\varkappa$ and $\varkappa_s$ turned out badly defined by existing experimental data.

The obtained values of the strange and nonstrange quark masses turned out to be consistent with the values accepted in the naive quark model: $m = \frac{M_N}{3}$, $\frac{m_s}{m} = 1.5 \div 1.7$, however, there is a tendency to larger values of $\frac{m_s}{m}$ ratio. The mean square quark momenta $\frac{\overline{q^2}}{m^2}$ both in mesons and baryons are well defined in combined analysis of the baryon and meson data, the value of $\frac{q^2}{m^2}$ in baryons being small in accordance with the initial assumption. At the same time the value of $\frac{q^2}{m^2}$ obtained from independent analysis of baryon data turned out to be badly defined and the relativistic description of quarks in baryons $\left(\frac{q^2}{m^2} \sim 1\right)$ is possible within the errors. This is due to the cancellation of relativistic corrections and anomalous magnetic moments contribution. The more precise experiments on the baryon magnetic moments will allow to determine the constituent quark parameters: $m, m_s, \varkappa, \tilde{\varkappa}, \varkappa_s, \frac{q^2}{m^2}$ better and answer the question about possibility of simultaneous description of baryon and meson data.

All experimental data, excluding $K^{*0} \to K\gamma$ decay width and Ξ -hyperons magnetic moments, are well described by the obtained set of parameters. Note, that we obtained the experimental value of μ_{Ξ^0} /16/ after the calculations completed and thus it was not included in our least square fit. The $K^{*0} \to K^0\gamma$ decay we have already discussed in Section 2. A simple analysis shows that μ_{Ξ^-} and μ_{Ξ^0} cannot be described in nonrelativistic approximation even if the quark anomalous magnetic moments are introduced (see also /15/). The relativistic corrections (terms of order $\frac{q^2}{m^2}$) change the

values of $\mu_{\Xi^{0,-}}$ in the wanted side. It seems possible to increase the relativistic effects in Ξ as compared to p, n, Σ and Λ by a proper choice of the baryon wave function, and to describe the Ξ - hyperons magnetic moments.

When this work was finished we received a preprint by Kondratyuk and Terent'ev /17/ where the relativistic generalization of a three-particle bound state wave function derived in Ref. /5/ was shown to be incorrect and corresponds to wrong angular moments composition rule. The new method of the relativistic wave function construction was there derived. The calculation shows that our results (Eq.(A.4) and (16)) remain unchanged in linear in $\frac{q^2}{m^2}$ approximation, which is used in our paper.

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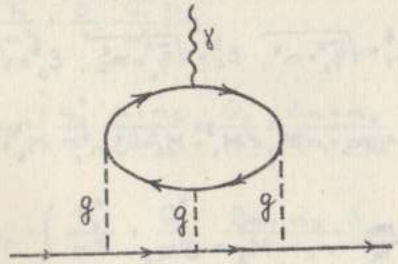

The Figure

APPENDIX A

The quantities X_i, Y_i, Z_i introduced by Eqs.(14.1 - 14.8), which determine the dependence of baryon magnetic moments on relativistic effects has the following form:

$$X_i=\int\gamma_i\frac{|\Phi(M_{0i}^2)|^2}{2M_{0i}/M_i^x}d\Gamma_i,\quad Y_i=\int\frac{\gamma_i}{\frac{3}{2}\eta_i}\frac{|\Phi(M_{0i}^2)|^2}{2M_{0i}/M_i^y}d\Gamma_i,\quad Z_i=\int\beta_i|\Phi(M_{0i}^2)|^2d\Gamma_i \tag{A.1}$$

where the notations correspond mainly to the notations of Ref./6/:

$$\gamma_i=2\frac{\eta_i(1-\eta_i)M_{0i}^2+\eta_i m_i M_{0i}-\frac{1}{2}Q_{i\perp}^2}{Q_{i\perp}^2+[m_i+(1-\eta_i)M_{0i}]^2},\quad \eta_i=\frac{E_{ab}^i+Q_{i3}}{E_{ab}^i+E_c^i}, \tag{A.2}$$

$$\beta_i=1-\frac{Q_{i\perp}^2}{Q_{i\perp}^2+[m_i+(1-\eta_i)M_{0i}]^2},\quad d\Gamma_i=\frac{M_{ab}^i}{2\varepsilon_a^i\varepsilon_b^i}\frac{M_{0i}}{2E_{ab}^iE_c^i}\frac{dq_i\,dQ_i}{(2\pi)^6},$$

$$M_{0i}=E_c^i+E_{ab}^i,\quad M_{ab}^i=\varepsilon_i^a+\varepsilon_i^b,\quad E_c^i=\sqrt{\vec{Q}_i^2+m_i^2},\quad E_{ab}^i=\sqrt{\vec{Q}_i^2+(M_{ab}^i)^2},$$

$$\varepsilon_i^a=\sqrt{\vec{q}_i^2+m^2},\quad \varepsilon_1^b=\sqrt{\vec{q}_1^2+m^2},\quad \varepsilon_2^b=\sqrt{\vec{q}_2^2+m_s^2},\quad \varepsilon_3^b=\sqrt{\vec{q}_3^2+m^2}, \tag{A.3}$$

$$m_1=m_2=m,\quad m_3=m_s,\quad M_1^x=M_1^y=M_2^y=3m,\quad M_2^x=(2m+m_s)\frac{2m}{m+m_s},$$

$$M_3^x=(2m+m_s)\frac{m_s}{m},\qquad M_3^y=3m_s.$$

In the case when the effective momenta which determine the valus of X_i, Y_i, Z_i integrals are small enough, we can expand the integrand in $\frac{q_i^2}{m^2}, \frac{Q_i^2}{m^2}$ power series and obtain the values of X_i, Y_i, Z_i as functions of mean square momenta $\overline{q_i^2}$ and $\overline{Q_i^2}$:

$$X_1=1+\frac{\overline{q_1^2}}{6m^2}-\frac{11}{24}\frac{\overline{Q_1^2}}{m^2},$$

$$X_2=1+\frac{\overline{q_2^2}}{m^2}\frac{m^2}{2m_s(2m+m_s)}-\frac{\overline{Q_2^2}}{m^2}\left[\frac{1}{3}+\frac{mm_s}{2(m+m_s)^2}\right],$$

$$X_3=1+\frac{\overline{q_3^2}}{m^2}\frac{m_s}{2(2m+m_s)}+\frac{\overline{Q_3^2}}{4m^2}\left(\frac{1}{2}-\frac{m}{m_s}-\frac{4m^2}{3m_s^2}\right), \tag{A.4}$$

$$Y_1=1-\frac{5}{12}\frac{\overline{Q_1^2}}{m^2},\qquad Y_2=1-\frac{\overline{Q_2^2}}{3m^2}\left[1+\frac{m}{2(m+m_s)}\right],$$

$$Y_3=1-\frac{\overline{Q_3^2}}{3m^2}\left(\frac{m^2}{m_s^2}+\frac{m}{4m_s}\right),\quad Z_i=1-\frac{\overline{Q_i^2}}{6m_i^2},\qquad i=1,2,3.$$

Let us list for convenience the two first terms of M_{0i} expansion in $\frac{q_i^2}{m^2}$ and $\frac{Q_i^2}{m^2}$ power series:

$$M_{01}=3m+\left[\frac{q_1^2}{m^2}+\frac{3}{4}\frac{Q_1^2}{m^2}\right]m,$$

$$M_{02}=2m+m_s+\left[\frac{q_2^2}{m^2}\frac{m+m_s}{2m_s}+\frac{Q_2^2}{m^2}\frac{2m+m_s}{2(m+m_s)}\right]m, \tag{A.5}$$

$$M_{03}=2m+m_s+\left(\frac{q_3^2}{m^2}+\frac{Q_3^2}{m^2}\frac{2m+m_s}{4m_s}\right)m.$$

Table 1. The constituent quarks parameters obtained from the independent fit of the baryon magnetic moments (I) and from the simultaneous fit of baryon and meson data (II)

	m (Mev)	$\frac{m_s}{m}$	$\varkappa$	$\tilde{\varkappa}$	$\varkappa_s$	$\left(q^2/m^2\right)_B$	$\left(q^2/m^2\right)_M$
I	290 ±I00	3.6 ±2.0	0.029 ±.I8	-0.039 ±.036	-0.36 ±.54	0.35 ±.4	
II	305 ±25	I.9 ±.24	0.0083 ±.033	-0.030 ±.007	-0.062 ±.053	0.2I ±.I2	0.89 ±.24

Table 2. The predictions for the baryon anomalous magnetic moments and meson radiative decay widths corresponding to sets of parameters (I) and (II) of Table 1. The experimental data are presented in the third line (III)

	$\varkappa_p$	$\varkappa_n$	$\varkappa_{\Sigma^+}$	$\varkappa_{\Sigma^-}$	$\varkappa_\Lambda$	$\varkappa_{\Sigma\Lambda}$	$\varkappa_{\Xi^-}$	$\varkappa_{\Xi^0}$	$\Gamma(\omega\to\pi\gamma)$ (Kev)	$R_{\pi(\eta,\eta')}$	$\Gamma(\varphi\to\eta\gamma)$ (Kev)	$\Gamma(K^{*+}\to K^+\gamma)$ (Kev)	$\Gamma(K^{*0}\to K^0\gamma)$ (Kev)
I	I.793 ±.00I	-I.9I3 ±.00I	2.I4 ±.22	-0.74 ±.27	-0.6I3 ±.005	I.7I ±.I6	-0.06 ±.29	-I.46 ±.09					
II	I.793 ±.00I	-I.9I3 ±.00I	I.87 ±.05	-0.45 ±.06	-0.6I4 ±.005	I.62 ±.02	0.I2 ±.06	-I.43 ±.02	822 ±47	I4.7 ±I.9	66 ±I4	I72 ±I4	76 ±9
III	I.793	-I.9I3	2.04 ±.25	-0.70 ±.37	-0.6I4 ±.005	I.82 +.25 -.I8	-I.I4 ±.75	-I.2I ±.06	870 ±50	I6.3 *) ±3.I	65 ±I5	75 ±35	<80

*) The mean value of the available experimental data on R_π , R_η , $R_{\eta'}$ is presented.

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(на английском языке)

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