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MESON RADIATIVE DECAY FORM FACTORS IN A RELATIVISTIC QUARK MODEL AND THEIR CONTRIBUTIONS TO THE CROSS SECTIONS OF ELECTROPRODUCTION OF THESE MESONS

ЦНИИатоминформ
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ՄԵԶՈՆՆԵՐԻ ՖՈՐՄՖԱԿՏՈՐՆԵՐԸ ՌԵԼՅԱՏԻՎԻՍՏԱԿԱՆ ՔՎԱՐԿԱՅԻՆ ՄՈԴԵԼՈՒՄ ԵՎ ՆՐԱՆՑ ՆԵՐԴՐՈՒՄՆԵՐԸ ՄԵԶՈՆՆԵՐԻ ԷԼԵԿՏՐԱԾՆՄԱՆ ԿՏՐՎԱԾՔՆԵՐՈՒՄ

Ռելյատիվիստական քվարկային մոդելում ստացվել են կանխատեսումներ $\omega\to\pi\gamma$, $a_1\to\pi\gamma$, $a_2\to\pi\gamma$, $b_1\to\pi\gamma$ անցումների ֆորմֆակտորների համար $0\le|K^2|\le6$ ԳէՎ^2 տիրույթում, որոնք էապես տարբերվում են միմյանցից և վեկտորական դոմինանտության մոդելի կանխատեսումներից: Գտնվել են այդ ֆորմֆակտորների ներդրումները ω, a_1, a_2, b_1 մեզոնների մեկ-պիոնային փոխանակման միջոցով ընթացող էլեկտրածնման կտրվածքներում: Ցույց է տրված, որ այդ մեզոնների համար կտրվածքների կախումները K^2-ույ խիստ տարբեր են, ինչը մեծ հետաքրքրություն է ներկայացնում փորձարարական հետազոտությունների համար:

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ФОРМФАКТОРЫ РАДИАЦИОННЫХ РАСПАДОВ МЕЗОНОВ В РЕЛЯТИВИСТСКОЙ МОДЕЛИ КВАРКОВ И ИХ ВКЛАДЫ В СЕЧЕНИЯ ЭЛЕКТРОРОЖДЕНИЯ ЭТИХ МЕЗОНОВ

В рамках релятивистской модели кварков получены предсказания для формфакторов переходов $\omega\to\pi\gamma$, $a_1\to\pi\gamma$, $a_2\to\pi\gamma$, $b_1\to\pi\gamma$ при $0\le|k^2|\le 6$ГэВ^2, которые существенно отличаются друг от друга и от предсказаний модели векторной доминантности. Найдены вклады этих формфакторов в сечения электророждения ω, a_1, a_2, b_1- мезонов через однопионный обмен. Показано, что их зависимости от k^2 для этих мезонов сильно различаются, что представляет большой интерес для экспериментального исследования.

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Meson Radiative Decay Form Factors in a Relativistic Quark Model and their Contributions to the Cross Sections of Electroproduction of these Mesons

Within a relativistic quark model predictions for form factors of $\omega\to\pi\gamma$, $a_1\to\pi\gamma$, $a_2\to\pi\gamma$, $b_1\to\pi\gamma$ transitions at $0\le|K^2|\le6GeV^2$ are made, which turned out to be significantly different from each other and from VDM predictions. The contributions of these form factors to the cross sections of ω, a_1, a_2, b_1- meson electroproduction via one-pion exchange are found and it is shown that their K^2- dependence is quite different for these mesons which is of great interest for experimental research.

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1. Introduction

On electron accelerators there is a possibility to measure the form factors of $\omega\to\pi\gamma$, $a_1(1260)\to\pi\gamma$, $a_2(1320)\to\pi\gamma$, $b_1(1235)\to\pi\gamma$ radiative transitions via extraction of the one-pion contribution in the cross sections of the ω, a_1, a_2, b_1 - electroproduction. Such experimental information is of interest for study of meson structure and would be a good test for models describing mesons. These measurements would also allow to obtain independent experimental information on meson radiative decay widths, which is especially important for the $a_1\to\pi\gamma$ transition the width of which (measured by traditional for such decays method using Primakoff effect in experiments on pion scattering on nucleus [1,2]) contains great uncertainties.

In this paper we present the predictions for the $\omega\to\pi\gamma$, $a_1\to\pi\gamma$, $a_2\to\pi\gamma$, $b_1\to\pi\gamma$ transition form factors obtained in the framework of relativistic quark model (RQM) constructed in Refs.[3-6]. This model is based on the physical picture, according to which at relatively large distances the hadrons are bound states of the spatially separated relativistic constituent quarks. There are reasons to hope that the phenomenological model [3-6] based on such a picture gives reliable predictions for form factors at relatively small K^2- (gamma mass $)^2$, because this model allows to obtain a self-consistent description of actually all the meson and baryon static properties concerning electromagnetic and weak decays, and also is successfully used to describe the pion and nucleon form factors at $|K^2|<3-6$ GeV^2 [7-10].

In Sect. 2 formulae for form factors of the considered radiative transitions are derived. Using these formulae, in Sect.3 we have obtained predictions for the form factors. The model parameters characterizing the quark mean square momenta in the a_1, a_2, b_1- mesons are found from experimental data on $\tau\to a_1\nu_\tau$, $a_2\to\pi\gamma$, $b_1\to\pi\gamma$ decay widths which are measured reliably [11-13]. Note, that having obtained the parameters of the model for the a_1- meson from the data on $\tau\to a_1\nu_\tau$ decay we predict the $a_1\to\pi\gamma$ decay width.

It follows from the predictions obtained that the form factors have a nontrivial dependence on K^2, they differ significantly from each other and from VDM predictions. At small $|K^2|$ they fall more rapidly than VDM predictions. Interesting results are obtained under investigation of contributions of the predicted form factors directly into the ω, a_1, a_2, b_1- electroproduction cross sections, which turned out to be quite different for these mesons. For investigation of these contributions in Sect. 3 we introduce the functions $W_1(K^2)$ and $W_2(K^2)$ which are analogous to the structure functions in deep inelastic electroproduction. It appears that in case of a_2- and b_1- electroproduction with increasing $|K^2|$ these functions decrease rapidly and at $|K^2|>1.5$GeV^2 are practically equal to zero. For a_1- electroproduction the function $W_1(K^2)$ does not decrease up to $|K^2|=6$GeV^2 and the function $W_2'(K^2)\sim W_2(K^2)/K^2$ decreases slowly. For ω-electroproduction $W_1(K^2)$ decreases slowly and $W_2'(K^2)$ falls rapidly.

2. Basic Formulae

In view of the fact that the initial formulae of RQM are given repeatedly in our previous papers (see, for example, Refs.[5,6,14]), we start immediately with the matrix element of the electromagnetic current for radiative transitions $A(P)\to\pi(P')+\gamma^{*}(K)$ (in parentheses the momenta of corresponding particles are given), which in the formulation of the model in the infinite momentum frame (IMF) [5,6] has the following form:

$$\langle\pi(P')|J_{\mu}|A(P,\lambda)\rangle\Big|_{P\to\infty} = T(a,b) + C_{\pi}C_{A}C_{\gamma}T(b,a), \qquad (1)$$

where

$$T(a,b)=eQ_{a}\int d\Gamma\; \Phi_{A}(M_0^2)\;\Phi_{\pi}(M_0'^2)\cdot$$
$$\mathrm{Sp}\left\{U^{T}(x_b,\vec{q}\,'_{b\perp})\Gamma_{\pi}U(x_a,\vec{q}\,'_{a\perp})\Gamma_{\mu}U^{+}(x_a,\vec{q}_{a\perp})\Gamma^{\lambda}_{A}U^{+T}(x_b,\vec{q}_{b\perp})\right\}. \qquad (2)$$

In (1,2) it is supposed that the mesons are bound states ab, Q_a, Q_b are charges of the quarks a and b in units e, symbol C denotes C-parity of the particles, λ is initial meson helicity, the quark momenta in the initial and final mesons in IMF are parameterized in the following way:

$$\vec{q}_i = x_i\vec{P} + \vec{q}_{i\perp},\quad \vec{q}\,'_i = x_i\vec{P}\,'_i + \vec{q}\,'_{i\perp},\quad i=a,b,$$
$$x_a=1-x,\quad x_b=x, \qquad (3)$$
$$\vec{q}_{b\perp} = -\vec{q}_{a\perp}=\vec{q}_{\perp},\quad \vec{q}\,'_{b\perp} = -\vec{q}\,'_{a\perp} = \vec{q}\,'_{\perp},\quad \vec{q}\,'_{\perp} = \vec{q}_{\perp} + x\vec{K}_{\perp},$$

and the phase space volume is

$$d\Gamma = \frac{dx\,d\vec{q}_{\perp}}{(2\pi)^3\,2x(1-x)}. \qquad (4)$$

It is also supposed that the model is formulated in a specially chosen IMF, where $P_z \to \infty$ and

$$\vec{p}_\perp = 0,\ K_0 = -K_z = \frac{M_A^2 - M_\pi^2 + K^2}{4P},\ K_y = 0,\ K^2 = -K_x^2 . \qquad (5)$$

The vertex Γ_μ is obtained from the expression $\bar{u}(q'_a)\ \gamma_\mu u(q_a)$ in IMF and has the following components:

$$\Gamma_0 = \Gamma_z = 2P, \Gamma_x = -\frac{2q_x + K_x}{1-x}, \Gamma_y = -\frac{2q_y + i\sigma_z}{1-x} . \qquad (6)$$

According to the results or Refs.[5,6] in relations (1,2) we have taken into account that the vertex function of meson transition to quarks in IMF is obtained from the wave function of quarks in their c.m.s. by spin rotation given by the Melosh matrix:

$$U(x_i, \vec{q}_{i\perp}) = \frac{m + M_0 x_i + i\varepsilon_{1m}\sigma_1(\vec{q}_i)_m}{[(m + M_0 x_i)^2 + \vec{q}_{i\perp}^{\,2}]^{1/2}}, \quad i = a,b. \qquad (7)$$

In formulae (2,7) m is the mass of the quarks a and b, M_0 and M'_0 are invariant masses of the initial and final quarks:

$$M_0^2 = \frac{m^2 + \vec{q}_\perp^{\,2}}{x(1-x)}, \quad M_0'^2 = \frac{m^2 + \vec{q}_\perp'^{\,2}}{x(1-x)} . \qquad (8)$$

Γ_A are spin-orbital parts of the wave functions of mesons in c.m.s. of quarks:

$$\Gamma_\pi = \frac{i\sigma_2}{\sqrt{2}}, \quad \Gamma^\lambda_\omega = \frac{\sigma_2}{\sqrt{2}}\ \vec{\sigma}\vec{e}^{(\lambda)}_\omega, \quad \Gamma^\lambda_{a_1} = [\vec{\sigma}\vec{q}]\vec{e}^{(\lambda)}_{a_1}\frac{\sigma_2}{2},$$

$$\Gamma^\lambda_{b_1} = \vec{q}\vec{e}^{(\lambda)}_{b_1}\frac{i\sigma_2}{\sqrt{2}}, \quad \Gamma^\lambda_{a_2} = (e^{(\lambda)}_{a_2})_{1m} q_1 \sigma_m \frac{\sigma_2}{\sqrt{2}} , \qquad (9)$$

$\Phi_A(M_0^2)$ and $\Phi_\pi(M_0'^2)$ are their radial parts normalized under:

$$\int |\Phi_{\pi(\omega)}(M_0^2)|^2 d\Gamma = \int \frac{\vec{q}_\perp^{\,2}}{2} |\Phi_A(M_0^2)|^2 d\Gamma = 1, \quad A = a_1, a_2, b_1. \quad (10)$$

in numerical calculations we shall use the following form of these functions:

$$\Phi_A(M_0^2) = N_A \exp(-M_0^2/4\beta_A^2), \qquad A = \pi, \omega, a_1, a_2, b_1, \qquad (11)$$

where N_A is the normalization parameter and parameter β_A characterizes the quark mean square momentum. For such parameterization of wave functions for π- and ω- mesons the parameters β_π and β_ω are found from low energy properties of these mesons in Ref. [9]:

$$m = 0.25 \text{ GeV}, \ \beta_\pi = 0.5 \text{ GeV}, \ \beta_\omega = 0.38 \text{ Gev}. \qquad (12)$$

Now turn directly to derivation of the form factors which we define by:

$$\langle\pi(P')|J_\mu|\omega(P,\lambda)\rangle = eF_1(K^2)\varepsilon_{\mu\nu\sigma\rho}[e_\omega^{(\lambda)}(P)]^\nu P^\sigma K^\rho,$$

$$\langle\pi(P')|J_\mu|A(P,\lambda)\rangle = e\Big\{(PKg_{\mu\nu} - P_\mu K_\nu)F_1(K^2) +$$

$$+ (K_\mu K_\nu - K^2 g_{\mu\nu})F_2(K^2)\Big\}[e_A^{(\lambda)}(P)]^\nu, \qquad A = a_1, b_1, \qquad (13)$$

$$\langle\pi(P')|J_\mu|a_2(P,\lambda)\rangle = \sqrt{2}\, eF_1(K^2)\varepsilon_{\mu\nu\sigma\rho}[e_{a_2}^{(\lambda)}(P)]^{\nu\nu'} P^\sigma K^\rho K_{\nu'}.$$

These form factors are related to the $A\to\pi\gamma$ decay widths via

$$\Gamma = \frac{\alpha}{2S_A+1}|F_1(0)|^2\left(\frac{M_A^2 - M_\pi^2}{2M_A}\right)^{2S_A+1}. \qquad (14)$$

Recall that in the RQM considered it is preferable to use the relations (1,2) for "good" components of electromagnetic currents J_0 and J_z, for which, in contrast to the transveree components J_x, J_y, the absence of vacuum fluctuations is guaranteed in the approach considered. Besides, it is undesirable to use longitudinal polarizations of mesons, as in this case the meson wave functions depend on the meson mass which leads to uncertainties in vertices of meson transition to quarks due to difference in the meson mass and the invariant mass of the system of quarks. In order to eliminate these difficulties in this paper we use the mock-hadron method introduced in Ref.[15]. This method assumes a correspondence between Lorentz-invariant amplitudes of real hadrons and those of free quarks. The prescription is to calculate the form factors not for real hadrons but for mock-hadrons consisting of free quarks with wave functions of the bound quarks and masses equal to invariant masses of these quarks, i.e. to M_0 and M_0' for initial and final hadrons. In this case the results obtained for longitudinal and transverse components of current and mesons turn out self-consistent.

Let us demonstrate this for longitudinal and transverse current components on the example of derivation of the $a_1 \to \pi\gamma$ transition form factors. From (13) we have:

$$\frac{\sqrt{2}}{e} \langle\pi|J_{0,z}|a_1(\lambda=1)\rangle\Big|_{P\to\infty} = PK_x F_1(K^2), \qquad (15a)$$

$$\frac{\sqrt{2}}{e} \langle\pi|J_x|a_1(\lambda=1)\rangle\Big|_{P\to\infty} = (M_{a_1}^2 - M_\pi^2 + K^2)F_1(K^2)/2 \ , \qquad (15b)$$

$$\frac{\sqrt{2}}{ie} \langle\pi|J_y|a_1(\lambda=1)\rangle\Big|_{P\to\infty} =(M_{a_1}^2 -M_\pi^2+K^2)F_1(K^2)/2 - K^2F_2(K^2) \ . \qquad (15c)$$

Eqs.(15a) and (15b) are related by the gauge invariance condition which in the IMF (5) gives

$$(M_{a_1}^2 - M_\pi^2 + K^2)J_0/2P = K_x J_x . \qquad (16)$$

This condition is not satisfied in the right hand side of Eq.(1), which does not contain the masses of the hadrons a_1 and π. It is restored when we use mock-hadron prescription as the vertex Γ_μ in Eq.(2), defined by (6), satisfies the condition:

$$(M_0^2 - M_0'^2 + K^2)\Gamma_0/2P = K_x\Gamma_x . \qquad (17)$$

So, the mock-hadron method makes the results obtained by the relations (1,2) for longitudinal and transverse current components consistent with each other and the form factors $F_{1,2}(K^2)$ can be found from these relations, if we use them for the components J_0 and J_x+iJ_y. For transitions $\omega\to\pi\gamma$ and $a_2\to\pi\gamma$, which are described by one form factor, it is enough to use relations (1,2) for the "good" current component J_0. The final formulae for form factors are:

$$F_{jA}(K^2) = \int I_{iA}\Phi_A(M_0^2)\Phi_\pi(M_0'^2)d\Gamma, \quad i = 1,2, \quad A = \omega, a_1, a_2, b_1, \qquad (18)$$

where

$$I_{1a_1} = \frac{m(1-2x)}{\sqrt{2}\,M_0'(1-x)}, \quad I_{2a_1} = \frac{2mq_x}{\sqrt{2}\,M_0'(1-x)K_x}, \quad I_{1b_1} = \frac{2q_x(xq_x+(m^2+\vec{q}_\perp^{\,2})/K_x)}{3x(1-x)M_0M_0'},$$

$$I_{2b_1} = \frac{(xq_x+(m^2+\vec{q}_\perp^{\,2})/K_x)(q_x+2(q_x^2-q_y^2)/K_x) - xq_y^2}{3x(1-x)^2M_0M_0'}, \qquad (19)$$

$$I_{1a_2} = \frac{2q_x(m^2+mM_0/2+2q_y^2)}{(1-x)M_0M_0'(m+M_0/2)K_x}, \quad I_{1\omega} = \frac{2(m^2+mM_0/2+q_y^2)}{(1-x)(m+M_0/2)M_0M_0'} .$$

3. Results

We found the parameters β_{a_2} and β_{b_1} using the formulae (14,18,19) from the $a_2 \to \pi\gamma$ and $b_1 \to \pi\gamma$ decay widths measured with a good accuracy [11,12]:

$$\beta_{a_2} = 0.17 - 0.18 \text{ GeV}, \qquad \beta_{b_1} = 0.3 - 0.44 \text{ GeV}. \tag{20}$$

It turned out that the amplitude $F_1(0)$ of $a_2 \to \pi\gamma$ decay strongly depends on β_{a_2}, so the interval of the values of this parameter is very narrow. In order to find the parameter β_{a_1} we did not use the data on $a_1 \to \pi\gamma$ decay [1,2], which have large errors and strongly depend on the assumptions on the a_1-meson mass and total decay width, but have used the value of $\tau \to a_1 \nu_\tau$ decay width measured with a good accuracy [13]. This decay is defined by the coupling constant of the a_1-meson to weak axial current which is calculated in RQM analogous to the coupling constants of vector mesons to electromagnetic current and has the following form:

$$f_{a_1} = 2\sqrt{3} \int \vec{q}_\perp^{\,2} \Phi_{a_1}(M_0^2) d\Gamma , \tag{21}$$

$$\Gamma(\tau \to a_1 \nu_\tau) = \frac{G_F^2}{16\pi} (f_{a_1}/M_{a_1})^2 \cos^2\theta_C M_\tau^3 (1 - M_{a_1}^2/M_\tau^2)^2 (1 + 2M_{a_1}^2/M_\tau^2), \tag{22}$$

were G_F is Fermi constant, θ_C is Cabibbo angle. Using data on $\tau \to a_1 \nu_\tau$ decay [13], we have found from (21,22) the following interval for β_{a_1}:

$$\beta_{a_1} = 0.52 - 0.61 \text{ GeV}. \qquad (23)$$

Having found the values of the parameter β_{a_1} from the data on $\tau \to a_1 \nu_\tau$ we are able to predict the $a_1 \to \pi\gamma$ decay width:

$$\Gamma(a_1 \to \pi\gamma) = 160 - 250 \text{ keV}. \qquad (24)$$

This prediction does not contradict the experimental data available on $\Gamma(a_1 \to \pi\gamma)$ [1,2], which have large errors and contain uncertainties. It is interesting, however, that it disagrees with VDM predictions: $\Gamma(a_1 \to \pi\gamma) = 1000-1500\text{keV}$ [16,17]. Note in this connection that the predictions for $a_1 \to \pi\gamma$ decay width are obtained in Refs. [18,19] too. They agree with our results and again disagree with VDM.

The predictions on the form factors of $\omega \to \pi\gamma, a_1 \to \pi\gamma$, $a_2 \to \pi\gamma$, $b_1 \to \pi\gamma$ transitions obtained by the formulae (18,19) with the parameters (12,20,23) are given in Fig.1 a,b. The curves for $a_1 \to \pi\gamma$ transition which correspond to the values of β_{a_1} in the interval (23) are quite close to each other. For $a_2 \to \pi\gamma$, $b_1 \to \pi\gamma$ transitions and for the parameters β_{a_2} and β_{b_1} in the intervals (20) they practically coincide. That is why we give our predictions for the mean values of β in these intervals.

We see from the Fig. 1a,b that the form factors have nontrivial dependence on K^2, their behaviour differs significantly from VDM predictions even at small $|K^2|$. The electromagnetic radii corresponding to these form factors are:

$$\langle r^2_{F_{1\omega}} \rangle = 12.5\text{GeV}^2, \quad \langle r^2_{F_{1a_1}} \rangle = 22\text{GeV}^2, \quad \langle r^2_{F_{2a_1}} \rangle = 12\text{GeV}^2,$$

$$\langle r^2_{F_{1b_1}} \rangle = 18\text{GeV}^2, \quad \langle r^2_{F_{2b_1}} \rangle = 20\text{GeV}^2, \quad \langle r^2_{F_{1a_2}} \rangle = 21\text{GeV}^2,$$

whereas $\langle r^2_{VDM}\rangle$=10GeV^2. Recall that the RQM predictions for the pion form factors [7-9] agree well with experiment up to 6GeV^2 and reproduce the VDM behaviour up to 2-3GeV^2.

The QCD sum rules predictions for $a_1\to\pi\gamma$ transition form factors [20] are given for comparison in Fig.1a. As these predictions are semiqualitative we can say that their agreement with our results is not bad: the predictions for F_2 agree qualitatively with our results, and the predictions for F_1 are close to ours up to 1.5 GeV^2.

Now consider the contributions of our obtained form factors directly to the cross sections of the ω, a_1, a_2, b_1-mesons electroproduction via one- pion exchange. With this aim let us define the functions $W_1(K^2)$ and $W_2(K^2)$ by:

$$W_{\mu\nu}\equiv \frac{1}{e^2}\sum_{\lambda} \langle\pi(P')|J_\mu|A(P,\lambda)\rangle \,|\langle\pi(P')|J_\nu|A(P,\lambda)\rangle|^* = \\ =W_{1A}\left(-g_{\mu\nu}+K_\mu K_\nu/K^2\right) + \frac{W_{2A}}{M_A^2}\left(P_\mu-(PK)K_\mu/K^2\right)\left(P_\nu-(PK)K_\nu/K^2\right). \qquad (25)$$

If we introduce also lepton tensor

$$L^e_{\mu\nu} = 2\left[k'_\mu k_\nu + k'_\nu k_\mu - (kk'-m_e^2)g_{\mu\nu}\right], \qquad (26)$$

where k and k' are momenta of initial and final electrons then the cross section of A-meson electroproduction on any target via one pion exchange is defined by:

$$d\sigma \sim L^e_{\mu\nu}W_{\mu\nu} = 2|K^2|\left\{W_{1A}+W'_{2A}\frac{8}{M_A^2}\left[(Pk)(Pk')/M_A^2+K^2/4\right]\right\}, \qquad (27)$$

where $W'_2= W_2M_A^2/4|K^2|$. For clarity let us give the expression

(27) near the threshold of A-meson production:

$$d\sigma_{\text{пор}} \sim 2|K^2|\left\{W_{1A} + W'_{2A}\,\frac{8\varepsilon\varepsilon'}{M_A^2}\cos^2\frac{\theta}{2}\right\}, \qquad (28)$$

where ε and ε' are energies of initial and final electrons, θ is electron scattering angle.

The functions W_1 and W'_2 are related to form factors by

$$W_{1\omega} = M_\omega^2\, X|F_{1\omega}|^2 , \quad W'_{2\omega} = (M_\omega^4/4)|F_{1\omega}|^2, \qquad (29a)$$

$$W_{1A} = \left[(M_A^2 - t + K^2)F_1(K^2)/2 - K^2F_2(K^2)\right]^2, \quad A = a_1, b_1, \qquad (29b)$$

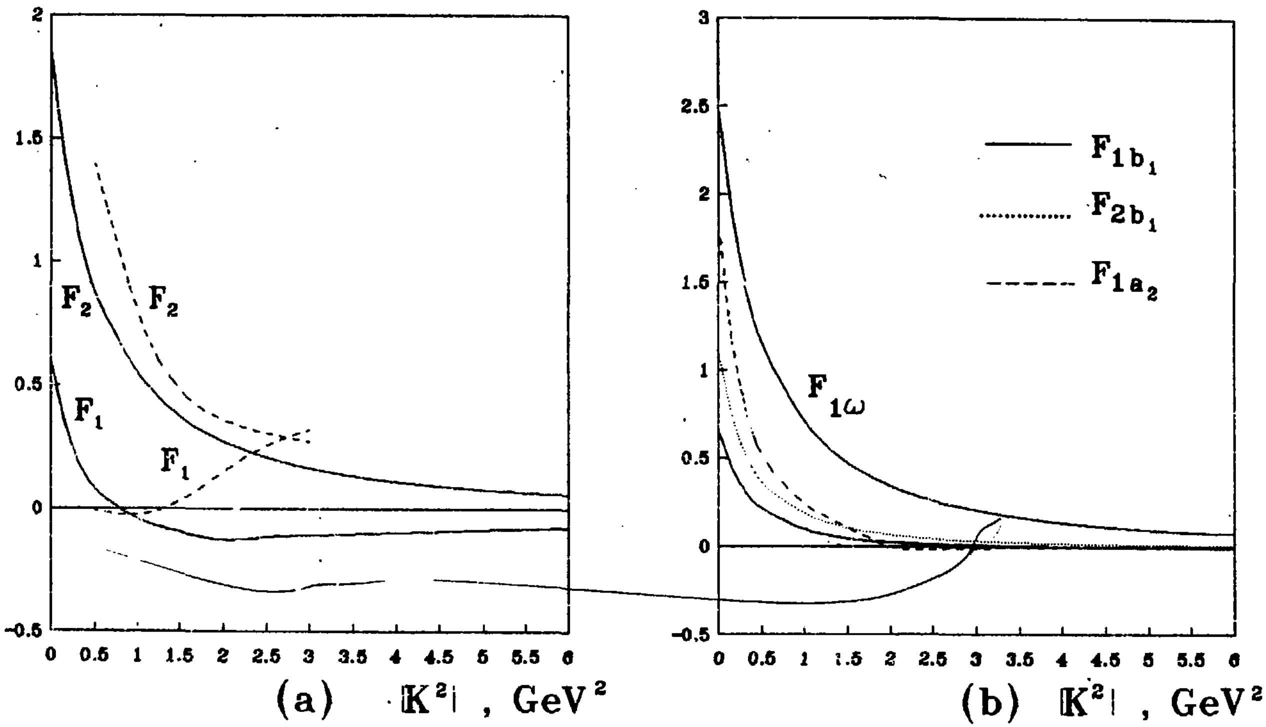
$$W'_{2A} = (M_A^4/4)\left[|F_1(K^2)|^2 - (K^2/M_A^2)|F_2(K^2)|^2\right], \quad A = a_1, b_1, \qquad (29c)$$

$$W_{1a_2} = X^2M_{a_2}^2\,|F_1(K^2)|^2, \quad W'_{2a_2} = (X/4)M_{a_2}^4\,|F_1(K^2)|^2, \qquad (29d)$$

where $t = p'^2$ is transferred momentum in the vertex of photon transition to A-meson via one-pion exchange, $X=[(M_A^2-t-K^2)^2-4tK^2]/4M_A^2$. Note that at $K^2=t=0$ $W_{1A} = W'_{2A}$. The functions W_1 and W'_2 at t=0 obtained with our predicted form factors are represented in Fig.2a,b. For convenience of comparison and for visual demonstration of K^2-dependence of these functions the curves are given for the ratios $W_1(K^2)/W_1(0)$ and $W'_2(K^2)/W'_2(0)$. We see that K^2-dependence of the functions $W_1(K^2)$ and $W'_2(K^2)$ for a_1-electroproduction differs principally from that for a_2 and b_1-electroproduction. These functions for a_2, b_1-electroproduction with increasing $|K^2|$ decrease rapidly and at $|K^2|>1.5\text{GeV}^2$ are practically equal to zero, whereas for a_1-electroproduction the situation is different: in the considered region of K^2 the function $W_1(K^2)$ does not decrease (for β_{a_1} =0,57-0.61GeV it even increases with $|K^2|$) and $W'_2(K^2)$ decreases slowly. As to the ω-electroproduction, the function $W_1(K^2)$ decreases slowly and

$W_2'(K^2)$ decreases rapidly. It is interesting to note that if we use VDM-predictions for the $\omega\to\pi\gamma$ transition form factor then the function $W_1(K^2)$ is a constant one and does not decrease with increasing $|K^2|$.

In conclusion we express our grateful to J. L. Rosner who has drawn our attention to the problem considered and to S.V. Esaybegyan and N.L. Ter-Isaakyan for helpful discussions.


2
1.5
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0.5
0
-0.5
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
F2
F2
F1
F1
(a) |K²| , GeV²
3
2.5
2
1.5
1
0.5
0
-0.5
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
F1b1
F2b1
F1a2
F1ω
(b) |K²| , GeV²

Fig.1

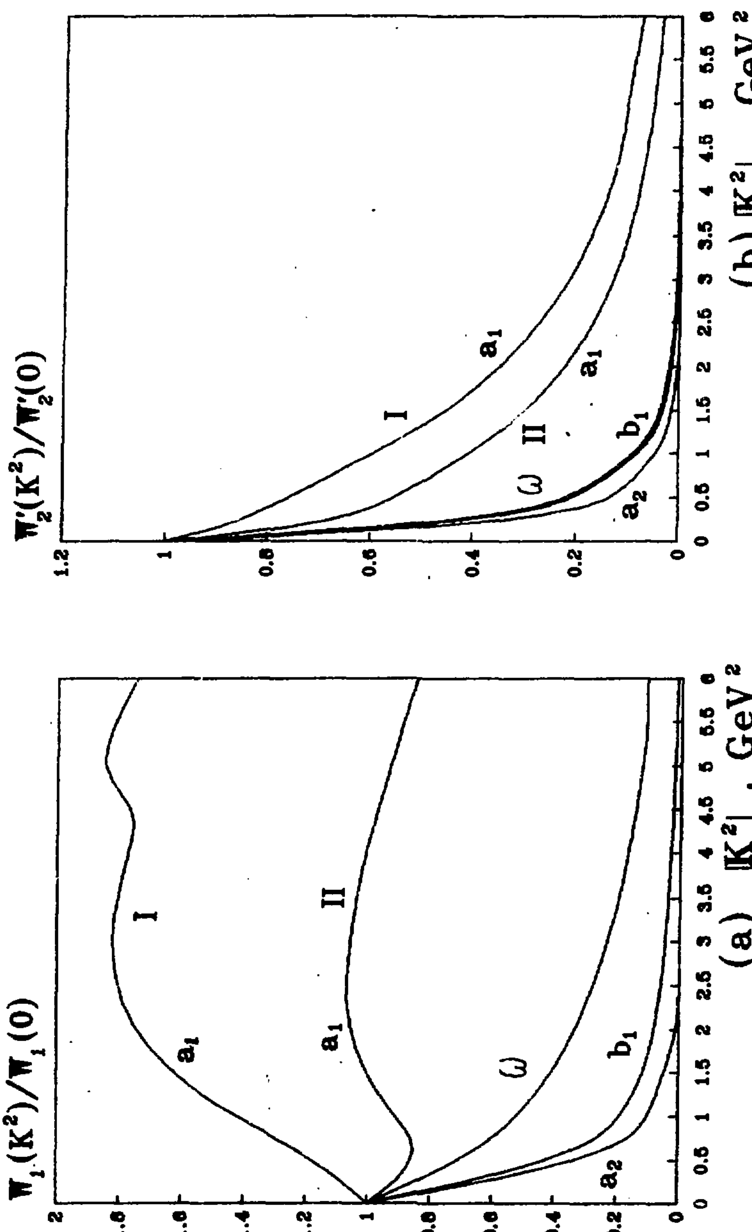
W_1(K^2)/W_1(0)
I
II
a_1
a_1
ω
b_1
a_2
(a) |K^2| , GeV^2
W'_2(K^2)/W'_2(0)
I
II
a_1
a_1
ω
b_1
a_2
(b) |K^2| , GeV^2

Fig.2

Figure Captions

Fig.1 RQM predictions for form factors in units GeV^{-1} · for ω, a_1, b_1-mesons and GeV^{-2} for a_2-meson. a) $a_1 \to \pi\gamma$ transition: full lines give our predictions, dotted lines are QCD sum rules predictions [20]. b) Our predictions for $\omega \to \pi\gamma$, $a_2 \to \pi\gamma$, $b_1 \to \pi\gamma$ transitions.

Fig.2 RQM predictions for functions $W_1(K^2)$ and $W_2'(K^2)$, defined by Eqs.(25,27). Curves I and II are obtained using boundery values of β_{a_1} from interval (23).

References

1. Zielinski M., Berg D., Chandlee C. et.al. Phys. Rev. Lett., 1984, v.52, p.1195.
2. Zielinski M. Phis. Rev. Lett., 1987, v.58, p.2002.
3. Terent'ev M.V. Yad. Fiz. 1976, v.24, p.207.
4. Berestetski V.B., Terent'ev M.V. Yad. Fiz. 1976, v.24, p.1044.
5. Aznaurian I.G., Bagdasarian A.S., Ter-Isaakian N.L. Phys. Lett., v.112B, p.393.
6. Aznauryan I.G., Bagdasaryan A.S., Ter-Isaakyan N.L. Yad. Fiz. 1982, v.36, p.1278.
7. Bagdasaryan A.S., Esaybegyan S.V., Ter-Isaakyan N.L. Yad. Fiz. 1983, v.38, p.402.
8. Bagdasaryan A.S., Esaybegyan S.V., Ter-Isaakyan N.L. Yad. Fiz. 1985, v.42, p.440.
9. Aznauryan I.G.,Esaybegyan S.V., Oganessyan K.A., Ter-Isaakyan N.L. Preprint YERPHI-1185(62)-89, Yerevan, 1989.
10. Aznauryan I.G., Bagdasaryan A.S., Esaybegyan S.V., Ter-Isaakyan N.L. Preprint YERPHI-1070(33)-88, Yerevan, 1988.
11. Cihangir S., Berg D., Biel Y. et.al. Phys. Lett., 1982, v.117B, p.119.
12. Collick B., Heppelmann S., Joyce T. et.al. Phys. Rev. Lett., 1984, v.53, p.2374.
13. Wagner B. et.al. Z.Phys., 1980,v.C3, p.193.
14. Aznauryan I.G., Oganessyan K.A. Yad. Fiz. 1988, v.47, p.1731.
15. Hayne C., Isgur N. Phys. Rev., 1982, v.D25, p.1944.

16. Babcock J., Rosner J.L. Phys. Rev., 1976, v.D14, p.1286.

17. Rosner J.L. Phys. Rev., 1981, v.D23, p.1127.

18. Godfrey S., Isgur N. Phys. Rev., 1985, v.D32, p.189.

19. Ishida S., Yamada K., Oda M. Phys. Rev., 1989, v.D40, p.1497.

20. Ioffe B.L., Smilga A.V. Nucl. Phys., 1983, v.B216. p.373.

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ФОРМФАКТОРЫ РАДИАЦИОННЫХ РАСПАДОВ МЕЗОНОВ В РЕЛЯТИВИСТСКОЙ МОДЕЛИ КВАРКОВ И ИХ ВКЛАДЫ В СЕЧЕНИЯ ЭЛЕКТРОРОЖДЕНИЯ ЭТИХ МЕЗОНОВ.

(на английском языке, перевод И.Г.Азнаурян)

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